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Quadratic Functions for Wheat cv. Shiroudi Productions from Water Stress Conditions

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Abstract

This study was conducted to develop production function of winter wheat (cv. Shiroudi) under water stress condition in Moghan (north-west of Iran) climate condition. The experimental treatments were based on irrigation events as two (I1), three (I2), four (I3) and five (I4) irrigation during wheat growing season. Results revealed the applying four and five irrigation events produced similar grain, biological, straw yields, 1000-grain weight and harvest index. The grain yield ranged from 5.8 to 6.9 t ha-1, straw yield were from 5.6 to 6.4 t ha-1 and biological yield ranged from 12.1 to 13.3 t ha-1. Based on the findings of the present study, there are four irrigation events with normal irrigation are sufficient for wheat cv. Shiroudi to obtain optimum production in Moghan and similar climate conditions. Production polynomial models as a function of applied water were worked out by regression analysis for grain, straw and biological yields, harvest index and 1000-grain weight. These functions can be applied to predict grain, straw and biological yields of wheat by available water for irrigation.

Keywords: Winter wheat, Wheat yield, Limited irrigation, Irrigation management

INTRODUCTION

Winter wheat (*Triticum aestivum* L.) is the main food grain produced in Iran being grown on 7000000 ha [4]. Evapotranspiration and irrigation water requirement during wheat growing season in Moghan (north-west part of Iran, located at 39º 39' N, 47º 55' E) climate conditions are 5935 and 4311 m3 ha-1, respectively [11,12]. Therefore, wheat should be irrigated to produce the optimum production. Preceding research revealed that proper irrigation management is the principle factor that affect yield and yield components of wheat in arid and semiarid areas. The sensitive growth stages of wheat to irrigation were recognized for Iran climates conditions [1]. Therefore, the highest yield acquired from plots with irrigation prior to sowing, at the stem elongation; flowering and milking stages. While the lowest yield and 1000-grain weight (TGW) obtained from plots with irrigation only prior to wheat sowing. Experiments showed that irrigation with two events in month produced the highest yield and applying full irrigation with high frequency, did not enhance wheat yield [3]. Also, Another experiments showed that wheat irrigation at the sensitive stages to water stress increased grain yield (GY) as two to five times relative to non-irrigated wheat [13]. The conducted researches showed that applying water stress at the sensitive stages of wheat, reduced yield [8, 10]. Irrigation at the booting and healing of spring wheat should be applied and therefore water stress should be avoided at these stages to achieve optimum yield [16]. On the other hand, the most sensitive stage to water stress in wheat is the anthesis to grain development period [7]. Harvest index is one of the principal indices of water stress that describe crop yield responses to different levels of water stress in arid and semiarid environments. The water stress conditions affect wheat harvest index. Water stress at the grain filling stage affects harvest index of wheat [14]. For high-yielding wheat cultivars, the ranges of harvest index are from 38 to 50% [10]. An experiment showed that for reducing evapotranspiration until one-half, harvest index was approximately constant for irrigated spring wheat by line source sprinkler under water stress conditions [6]. Relationship between crop yield and water applied under water stress conditions is presented by the water-yield function. This function can be expressed as a second or third order polynomial [5]. In addition, percent yield reduction can be related to percent evapotranspiration deficit as a production function [2]. Recently, a two-degree of the regression polynomial for wheat cv. Tajan in semiarid environment was developed [12].

Since suitable management for irrigation practices of wheat is not well recognized in the Moghan, north-west of Iran. The objective of the this study was to acquire production function of winter wheat (cv. Shiroudi) under water stress condition in the Moghan enviroment condition. The results can be applied to plan wheat production under water stress environment.

MATERIALS and METHODS

The field experiments were conducted in a semi-arid climate region located at the Agricultural Research Center of Moghan, north-west of Iran with latitude 39º 39' N, longitude 47º 55' E and 32 m above mean sea level. The field soil was clay loam with average soil water contents at wilting point (WP), field capacity (FC), saturated limit and total available water (TAW) as 22%, 32%, 50% and 91 mm m-1, respectively. The average air temperature during the wheat-growing season were from 5 ºC to 17 ºC. The cumulative pan evaporation and rainfall were measured 640 and 165 mm, respectively (Figure 1). Total evapotranspiration and irrigation water requirement during wheat growing season were 5935 and 4311 m3 ha -1, respectively (Figure 1).

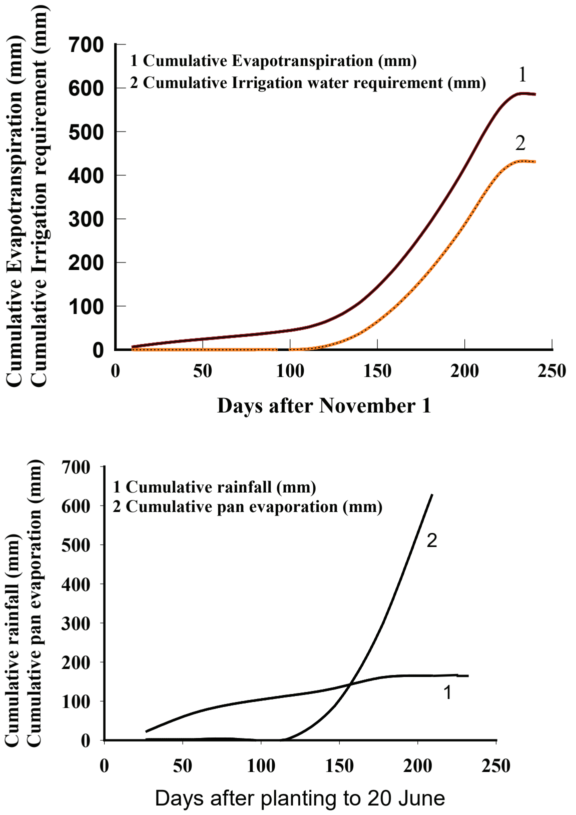

Figure 1. Evapotranspiration, irrigation water requirement, cumulative pan evaporation and rainfall for wheat growing season.

Winter wheat (*Triticum aestivum* L.) cv. Shiroudi was sown at seeding rate of 160 kg ha-1 on six rows with 8 m long and 20 cm apart (8×1.2 m2 plots) on 24 Nov. The experimental treatments were based on irrigation events during wheat growing season. Four treatments comprising two, three, four and five irrigation events were laid out in completely randomized blocks with three replications (Table 1 and Figure 2).

Table 1. Treatment combinations for obtaining production functions for wheat cv. Shiroudi under water stress conditions.

Treatments	Abbreviations
Two irrigation at the sowing and stem elongation.	I1
IE1+ irrigation at the flowering stage.	I2
IE2+ irrigation at the dough stage.	I3
Full irrigation (with the five irrigation events).	I4

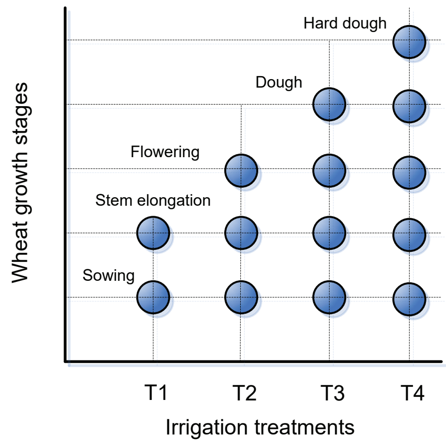

Figure 2. Irrigation treatments for obtaining production functions of wheat cv. Shiroudi.

All plots were uniformly irrigated by surface irrigation method with 75 mm of water, after seeding practice. A connected-flow meter to a siphon was applied to measure irrigation water. Fertilizer of N as urea was applied to the soil as 100 and 200 kg ha-1, before 2th and 3th irrigation events, respectively. Plots were harvested for biological, grain and straw yields, after maturity in the on half of June. Harvest index (HI) was estimated based on grain and biological yields as following:

HI (%)= Grain yield (kg ha^{-1})/Biological yield (kg ha^{-1}) (1)

RESULTS and DISCUSSION

One of the important components of wheat yield is 1000-grain weight. The produced TGW from Irrigation treatments of I2, I3 and I4 were similar (=43.2 g) and the lowest one was 39 g produced by I1 (Figure 3). This finding agrees with results of [1,12] reported applying five events of irrigation produced the highest 1000-grain weight.

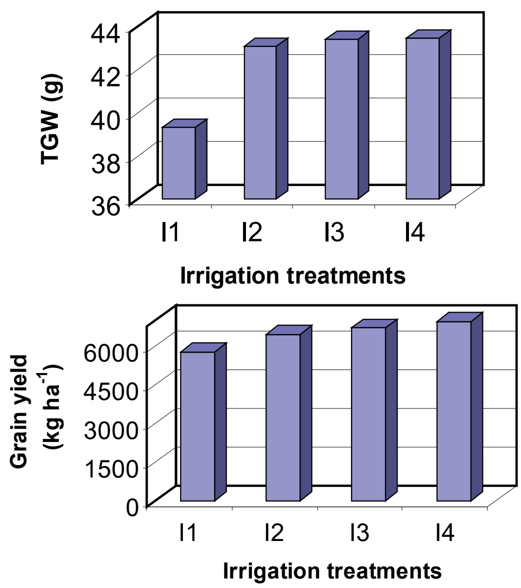

Figure 3. The 1000-grain weight and grain yield of wheat from irrigation treatments.

Grain yields from irritation treatments plots of I1, I2, I3 and I4 were achieved as 5.8, 6.4, 6.7 and 6.9 t ha-1, respectively (Figure 3). In other words, irrigation with two, three and four events produced yields decrease as 16, 7 and 3% relative to yield from full irrigation with five event. It seems there are three or four irrigation events (I2 or I3) with normal rainfall had sufficient efficiency to produce optimum grain yield of wheat cv. Shiroudi.

Applying I1 to I4 produced the lowest (=12.1 t ha-1) and the highest (=13.3 t ha-1) biological yield, respectively (Figure 4). The highest (=6.4 t ha-1) and lowest (=5.6 t ha-1) straw yields produced by applying I4 and I3 treatments (Figure 4). The biological yield is evidently affected by grain and straw yields of wheat.

Generally, HI is directly related to the grain yield and is inversely related to the biological yield. In this study, the highest and lowest HI were 54 and 48% achieved from plots with I3 and I1, respectively (Figure 5). The HI values ranges are in accordance with those reported by other researchers [10,12].

By regression analysis [9], production functions for the 1000-grain weight, grain, straw and biological yields; and harvest index of wheat as a function of applied water were obtained (Table 2).

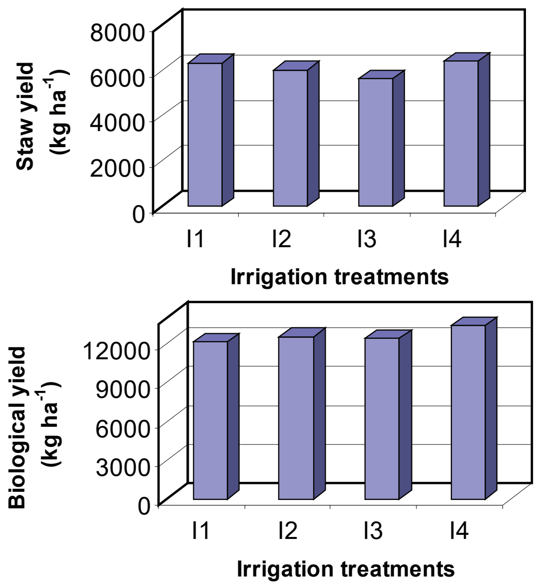

Figure 4. Straw and grain yields of wheat from irrigation treatments.

Table 2. Production functions of wheat cv. Shiroudi.

I1 n = 3	GY= 0.00025 W2 R2 = 0.97	SY=0.00027 W2 R2 = 0.97	BY=0.00052 W2 R2 = 0.99	TGW=0.0081 W R2 = 0.99	HI= 0.0099 W R2 = 0.97
I2 n = 3	GY= 0.00019 W2 R2 = 0.99	SY =0.00018 W2 R2 = 0.99	BY= 0.00037 W2 R2 = 0.99	TGW = 0.0074 W R2 = 0.99	HI= 0.0089 W R2 = 0.99
I3 n = 3	GY= 0.00014 W2 R2 = 0.98 GY=0.00012 W2 R2 = 0.99	SY = 0.00012 W2 R2 = 0.98	BY= 0.00026 W2 R2 = 0.98	TGW = 0.0064 W R2 = 0.99	HI= 0.0079 W R2 = 0.99
I4 n = 3	GY=0.00012 W2 R2 = 0.99	SY = 0.00011 W2 R2 = 0.99	BY= 0.00023 W2 R2 = 0.99	TGW =0.0060 W R2 = 0.99	HI=0.0069 W R2 = 0.98
All treatments n = 12	GY=1.74W+0.00011W2 R2 = 0.82	SY =1.9007W+0.00014 W2 R2 = 0.98	BY=3.6414W-0.0003 W2 R2 = 0.99	TGW =0.0066W R2 = 0.98	HI=0.0080 W R2 = 0.97
GY, W, TGW, BY, SY and HI are the grain yield, applied water, 1000-grain weight, biological yield, straw yield and harvest index, respectively.					

Wheat production functions were explained by applied water by quadratic functions. The function shapes are in accordance with reported functions [5]. The observed and predicted values by acquired functions are compared for grain, biological and straw yields, harvest index and 1000-grain weight of wheat (Figure 6).

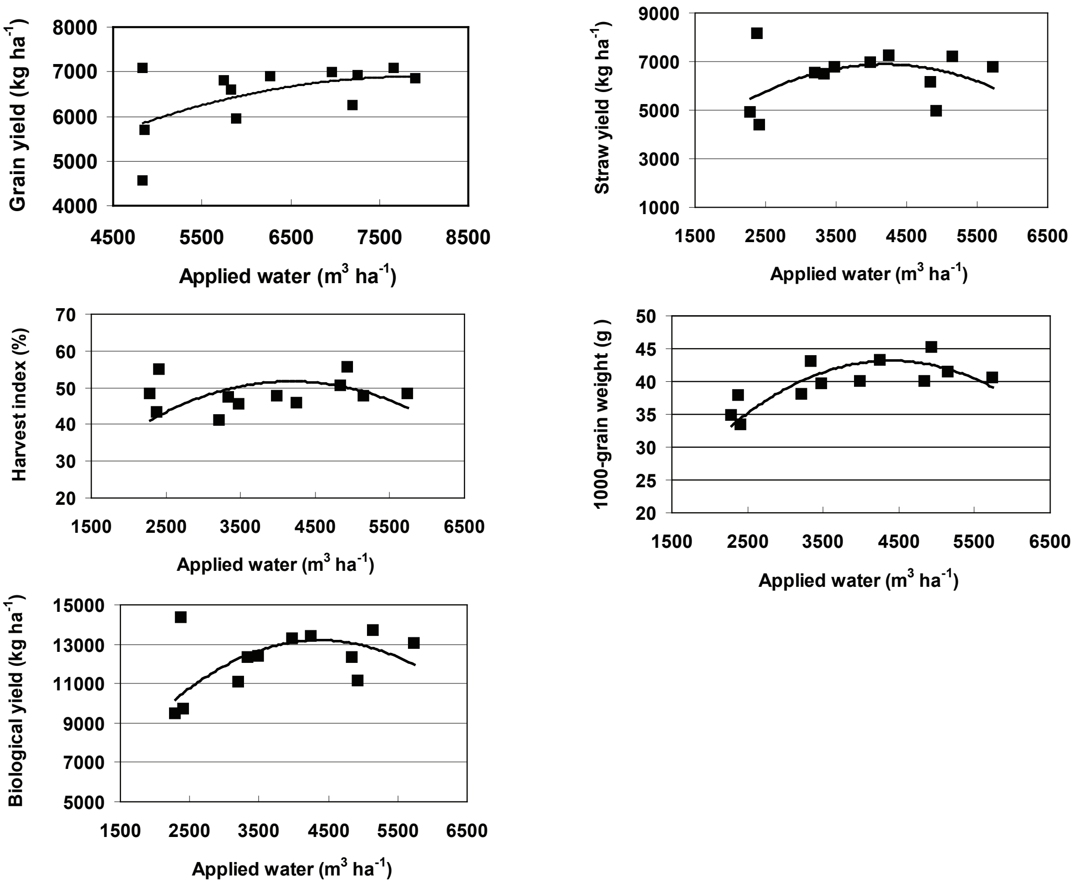

Figure 6. Measured and predicted values of grain, biological and straw yields, harvest index and 1000-grain weight of wheat cv. Shiroudi.

There are well agreements were observed between measured and predicted values. These functions can be applied to predict grain, straw and biological yields of wheat by available water for irrigation. Wheat production, harvest index and 1000- grain weight from applied water was obtained for prediction practice (Table 2 and Figure 7).

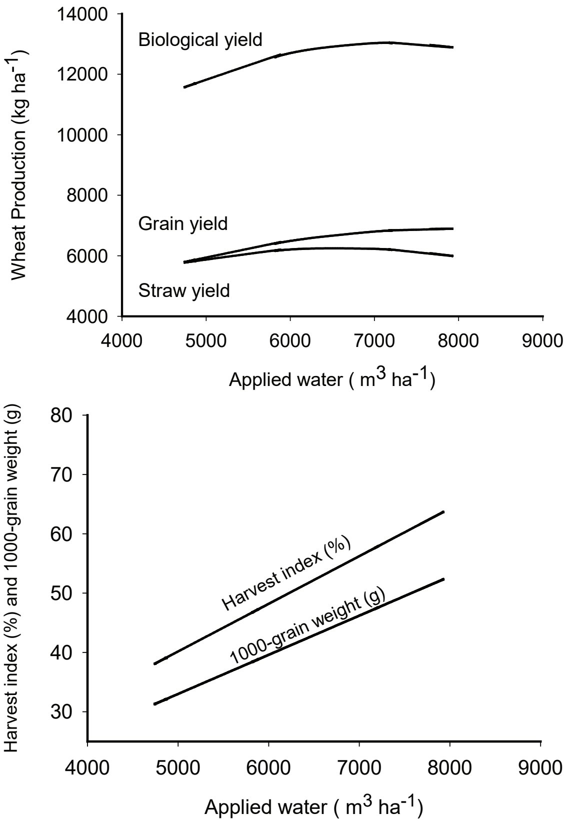

Figure 7. Wheat production, harvest index and 1000- grain weight versus applied water

CONLUSION

Production models of winter wheat (cv. Shiroudi) as a function of applied water in Moghan (north-west of Iran) climate condition were acquired in this study. Acquired models could be applied to predict grain, straw and biological yields as a function of applied water in investigated and or similar environment. In addition, results showed that the applying four and five irrigation events produced similar grain, biological, straw yields, 1000-grain weight and harvest index. Therefore, there are four irrigation events with normal rainfall are sufficient to obtain optimum production in Moghan and similar climate condition for wheat cv. Shiroudi. The interaction effects of water and fertilizer stresses on wheat cv. Shiroudi are needed to investigate by a designed research. Also, the economic analysis needs to evaluate experimental treatments.

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