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Qualitative and Quantitative Management of Irrigation Water in Arid Region

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Abstract. In recently time, the process of large extraction of ground water, and advancing saline water in sweet water (Intrusion) sources have led to increasing saline water. Water shortage and qualitative decrease of water sources and soil in southern Khorasan province (in east of Iran) are the major causes of decreased production. This research intended to investigate the production of wheat cultivars in salinity and deficit irrigation conditions. The determination of water-salinity optimum production, its function for wheat varieties, obtaining water use efficiency under these conditions by means of production assessment indicators, and providing iso-yield curves for wheat varieties, in order to apply for agricultural water resources management programming in Southern Khorasan were carried out in farming years 2010-2011. The research program consisted of three levels of the salinity of irrigation water (S1, S2, S3 =1.4, 4.5, 9.6 dS/m, respectively), two wheat varieties (Ghods and Roshan) and four levels of irrigation water (I1, I2, I3, I4 =26.7, 40.1, 53.4, 66.7 cm, respectively). The experiment had three replications according to a randomized complete block design with split plot layout (factorial form), which considered water quality as main plot and water quantity as sub plot. Then, obtained data were estimated based on different forms of production functions (Linear, Cobb-Douglas, Quadratic and Transcendental) and data value .Optimum production function for each wheat variety was also estimated which led to the following results: First, quadratic production functions for both Ghods and Roshan wheat were recognized as optimum production functions in Birjand region. Second, it was recommended to irrigate the wheat in this region on the basis of 75% of water requirements, and devote the preserved 25% water to neighboring areas. Third, the effect of deficit irrigation on decreasing the production was more than that of the salinity of irrigation water, and the total effects of salinity and deficit water together were less than the sum effects of each factor in isolation. Fourth, the investigation of production assessment indicators showed that, in all level treatments, Roshan wheat in relation to both salinity and water deficit might be proved to be more resistant than Ghods wheat; therefore, it was recommended, to use Roshan wheat in this area in order to obtain higher yield under salinity and deficit irrigation conditions.

Key words: Arid Region, Deficit Irrigation, Saline Water, Wheat

1. Introduction

Water shortage and qualitative decrease of water sources and soil in southern Khorasan province (in east of Iran) are the major causes of decreased production. The method of deficit irrigation with the help of saline water is the management solution for adjustment of drought condition and water scarcity (English, 1991). In this way of management solution the object is economical efficiency and not only the minimization of yield (Brumbelow et al, 2009). Production functions of corn and cotton under effect of saline water and saline soils determined by Russo and Bakker (1986). This consideration showed that nonlinear function (second order) was much better than the two linear parts function of Mass and Hoffman that shows the relation among yield response and saline water and soil moisture. The production function of maize crop for second degree of deficit irrigation and by different levels of salinities was considered by Igbadun et al (2007) and the results showed that for reaching the maximum yield by the use of saline water, we must use the higher amount of

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water (Nasseri and Fallahi, 2007). The problem of qualities and quantities of irrigation water in Birjand region has create always some difficulties for the farmers and engineers, therefore the aim of this paper is to estimate a function that shows the relation among the crop production function of wheat cultivars and qualities and quantities of irrigation water.

2. Material and Methods

This research paper was conducted in Birjand region (East of Iran) carried out in farming years 2010-2011. The research program consisted of three levels of the salinity of irrigation water (S1, S2, S3 =1.4, 4.5, 9.6 dS/m, respectively), two wheat varieties (Ghods and Roshan) and four levels of irrigation water (I1, I2, I3, I4 =26.7, 40.1, 53.4, 66.7 cm, respectively). The experiment had three replications according to a randomized complete block design with split plot layout (factorial form), which considered water quality as main plot and water quantity as sub plot.

For irrigation programming and different distribution of irrigation water, in the soil moisture basis referred to (1) comparison of result of iteration to the result without water stress the arrangement was made by multiplication of iteration coefficients to the soil moisture deficit as given below equation (Fereres and Soriano, 2007):

$$SMD = \left(W_{fc} - W_i\right).A_s.D.C \quad (1)$$

SMD= Soil moisture deficit (mm), W_{fc}= the weight percentage of moisture in field capacity,

W_i=The weight percentage of moisture, A_s = Specific densities of soil moisture (gr/cm^3),

D=the root depth of plant (mm), C- The iteration coefficient in percentage.

2.1. Determine the optimal production function

With the use of collected data from the plot design and estimation of production function of saline water, the crop yield influenced by amount and salinity of irrigated water and the other element of production function remains constant as shows in the below relation:

$$Y = f\left(I, Ec_w, / X\right) \quad (2)$$

Y=crop yield (kg/ha), I=amount of irrigation (cm), ECw=electrical conductivity of irrigation water (dS/m), X=the constant vector of other elements, influenced in the crop yield.

The mentioned function in various forms of simple linear eq., logarithmic linear, second order quadratic eq. and transcendental in this experiment was estimated as bellows(Saadatmand et al, 2007):

$$Y = a_0 + a_1 I + a_2 EC_w \quad \text{Simple linear eq.} \quad (3)$$

$$Y = a_0 I^{a1} EC^{a2}{}_w \quad \text{Cobb Douglas eq.} \quad (4)$$

$$Y = a_0 + a_1 I + a_2 I^2 + a_3 EC_w + a_4 EC_w{}^2 + a_5 IEC_w \quad \text{Quadratic eq.} \quad (5)$$

$$Y = a_0 I^{a1} EC_w{}^{a2} e^{(a_3 I + a_4 EC_w)} \quad \text{Transcendental eq.} \quad (6)$$

The collected data from the experimental plot fitted on the mentioned function by SAS software and the optimized function for wheat cultivars specified and then the estimation of influence of any individual water salinity and water tension.

3. Results and Discussion

In table (1) the average seasonal salinity of irrigation water (S) and the values of irrigation water depths(I), also the average yield(V) production (t/ha) of wheat cultivars under the mentioned treatment were as below:

Table. 1: The comparison of average seed yield of wheat cultivars (t/ha) under different treatments

Treatments	Salinity level (s)			Irrigation depth level (I)				Wheat cultivars(v)	
	S_1	S_2	S_3	I_1	I_2	I_3	I_4	V_1	V_2
Seeds yield (t/ha)	3.5845a	3.1936b	2.6359c	1.8308c	3.2335b	3.6918a	3.7959a	2.7597b	3.5163a
$LSD_{(P<.05)}$	0.2255			0.1423				0.1006	

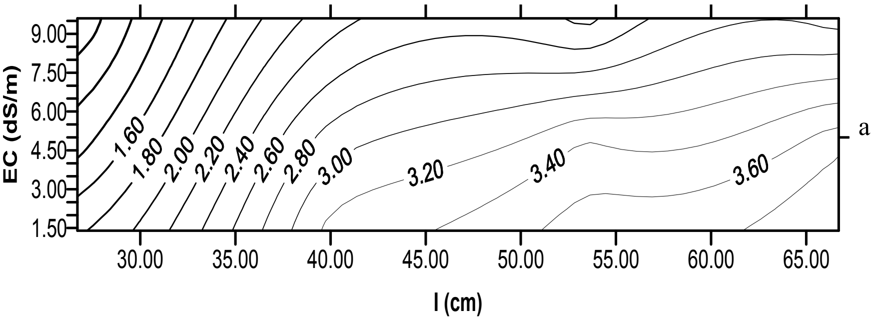
From the table (1) from irrigation water salinity point of view (s) the highest seed yield is belong to S1 treatment by 3.5845 (t/ha) and lowest average seed yield war belong to S3 treatment by 2.6359 (t/ha).From the irrigation depth (I) point of view the highest yield was belong to I4 treatment by the average yield of 3.7959 (t/ha) and its lowest was belong to I1 treatment by the average yield of 1.8308 (t/ha). The meaning les diversity treatment of I3, I4 showed that the excess irrigation (I4 by 125% more than crop water requirement) did not showed any meaning full effect in seed yield and therefore it does not suggested, Shani et al (2007) study also proves this fact.

Average yield of wheat cultivars kept them into different group, since the Ghods cultivar of wheat showed 21% reduction on yield compare to Roshan cultivar, therefore the resistant of Roshan cultivar of wheat to water salinities and water stress is higher than Ghods in the region.

The regression coefficients of production functions (R2) in the forms of simple linear, log linear, quadratic and transcendental for Ghods wheat cultivar were 0.94, 0.96, 0.87, 0.82 respectively and for the Roshan cultivar of wheat were 0.92, 0.94, 0.87, 0.80 respectively. Comparison of these coefficients showed that the fitness of quadratic function and transcendental function (in both wheat cultivars) were more than the other functioning. But since the regression coefficients of quadratic function for both wheat cultivars showed the higher values and more meaning full (same of study Tolk and Howell, 2008), therefore quadratic eq. for production function towards water amount and its salinity for Ghods and Roshan cultivars in Birjand region represents the optimize production function.

Another application of simultaneous usage of saline water and deficit irrigation studies are the various combination of irrigation water salinities and irrigation water depth which results the iso-yield curves. In fig (1) the iso-yield curves were showed, that represents by usage of defined depth of irrigation water, whatever the irrigation water salinity increases the yield will reduce, and by a constant value of ECW, increase of irrigation depth will increase the crop yield and if we study the both factor simultaneously for reaching a specific yield we have to use different values of I and ECW. For example in Ghods cultivar (a) by using the irrigation depth equal to 40cm and irrigation water salinity equal to 2ds/m the production yield is 3.2 t/ha, by increase of irrigation depth up to 60cm and irrigation water salinity equal to 6ds/m the crop yield will be the same as mentioned earlier. Therefore the crop yield is the function of irrigation water depth and its salinities, and consideration of each factor individually is not consider with the reality, Datta and Dayal (2000) study also proves this fact.

The production function has more credibility than other statistical methods, because this test is based on actual data (Brumbelow et al, 2009). In addition, computer models of default that are defined for specific areas if the production function has no default (Tolk and Howell, 2008).



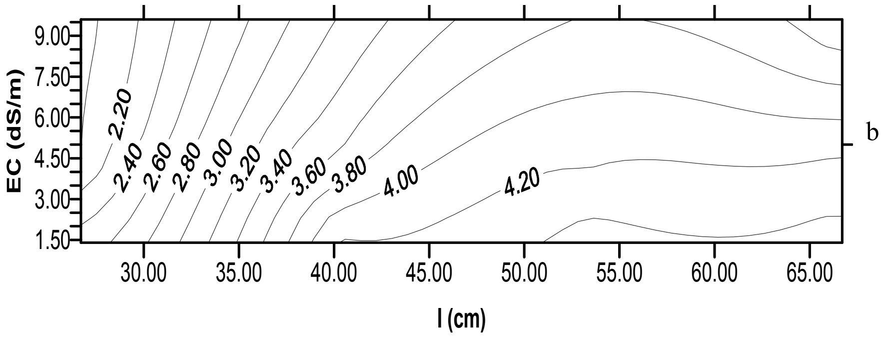


Fig. 1: Iso- yield of Ghods (a) and Roshan (b) cultivars of wheat

4. Conclusion

The important results of this research study are simultaneous effects of irrigation water salinities and water deficiencies and estimation of their related production function are as follows:

1- The results showed that (production function water salinity and yield) follow the quadratic equations and quadratic equations for production function of Ghods and Roshan cultivars of wheat as an optimized function was represented for Birjand region. (The coefficients of these functions are different for both cultivars of wheat).

2- Since we doesn't have the remarkable reduction of yield by decrease of 25% of consumption Water use of crop (75%) level of irrigation for both Ghods and Roshan cultivars of wheat, the suggestion is consumption use of water by wheat is distributed by this amount and the conserve water to get use for other area, and therefore the efficiency of consumption use of water will increase.

3- The iso-yield curves shows that by increase of irrigation water depth one can use the water with higher salinity, without change of yield, but there is a bond for replacement of quality and quality of water. In iso-yield curves, their bonds is a point that the tangential line which touches the curve was parallel to I axis from this point on wards whatever the amount of irrigation water get increase (In constant salinity) the production yield will not increase and is the waste of capital.

4- The statistical comparison showed that the production yield of Roshan cultivar of wheat (under experimental treatments) was more that Ghods cultivar and Roshan cultivar showed more resistance against tension of water salinities and water deficiencies than Ghods cultivar. Therefore for reaching the higher production yield under simultaneous irrigation water salinity and deficit irrigation conditions, we have to select higher resistive cultivars like Roshan in the region. But there is a suggestion for further research works in this regards.

5- The production function has more credibility than other statistical methods, Because this test is based on actual data (Brumbelow et al, 2009). In addition, computer models of default that are defined for specific areas if the production function has no default (Tolk and Howell, 2008).

6- If you use saltwater in certain years when rainfall is not the ability to reduce soil salinity. It is recommended for measuring the salinity at the beginning of each season, soil leaching using fresh water can be programmed. To be maintained in the longer term agricultural sustainability.

7- In this study, the production functions of water - salinity on wheat grain yield were evaluated. Further research is recommended in the production functions of water - salinity for yield components is also examined.

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