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ESTIMATING LAND PRODUCTION POTENTIAL FOR BARLEY IN DAMGHAN PLAIN OF IRAN

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ABSTRACT

This investigation was conducted to estimate the potential of barley production. The methodology was based on simulation model developed by FAO for calculating crop potential maximum biomass and yield. The study area is located in south of Damghan city, Semnan province northeastern-Iran. The land suitability class was determined by using Storie method and Square method. The results of physical evaluation revealed that the most important limitations for crop production in the area are the salinity, alkalinity, acidity, high lime and drainage. For determining the accuracy of the applied land suitability evaluation methods, yield potential of irrigated barley, climatic conditions situation of the region were first evaluated. In the next step land production potential (predicted performance of barley) was calculated by using irrigated yield potential and soil limitation factors. Finally the evaluated performance was compared with farmers performance. Regarding FAO model, barley production potential under favorable soil and climatic conditions was estimated about 8812.70 kg ha^{-1}. The good accordance between eestimated yield potential and observed yield potential in Square Root method (SR) approve that this method has more accuracy and efficiency than another one.

Keywords: barley, land evaluation, production potential, Damghan, FAO.

INTRODUCTION

The ability of the world's natural resources to provide the needs of its growing population is a fundamental issue for the international community. Limits to the productive capacity of land resources are set by climate, soil and landform conditions and by the use and management applied to the land.

Sustainable management of land resources requires sound policies and planning based on knowledge of these resources, the demands of the use to which the resources are put, and the interactions between land and land use. So it is very important for agriculture development planning to take land resources assessment. Different empirical model to predict land productivity for crops under a wide range of weather and soil conditions have been described (FAO, 1975; DE Wit *et al*., 1987; Thomsson *et al*., 1991; Tang *et al*., 1992; Daroussin *al*., 1993). Most of these models are designed to use available climatic and soil information as statistical averages and generalized crop phenology.

The Food and Agriculture Organization of the United Nations (FAO) developed a methodological framework to assess food production, which widely known as the Agro-ecological zoning (AEZ) methodology (FAO, 1987-90). In this paper, the land suitability evaluation for barley was conducted with objective of production potential estimation, using different methods in Damghan plain of Iran.

MATERIAL AND METHODS

Study area

The study area is located in the south of Damghan Plain and in Semnan province of Iran. This study was carried out in an area including 5400 ha between 36 º 02 ´ 31.6″ - 36 º 08 ´- 28.5″ of the northern latitude and 54º 21 ´56.7″ 'E- 54 º 27 ´24.1″ of the eastern longitude in the form of surveying at a semi-detailed surveying level for determination of soil characteristics and illustration of soil maps.

Methodology

The soil characteristics were studied by topographic map (scale: 1:50000) in the range of 5400 ha. The 100 profiles as a regular network in the area was drilled and dissected. Soil classification was done based on American soil classification. To investigate the qualitative land suitability, Storie and Square Root methods were used. Based on these methods, land suitability classes were determined for wheat crop. According to the results of measured land index in parametric method suggested by Sys *et al*., (1991), lands having indexes >75 are in S_1 (very suitable) class. On the basis of this method, land indexes in ranges of 50-75, 25-50 and <25 are classified as S_2 (moderate suitable), S_3 (marginal suitable) and N (non-suitable) classes, respectively (Table-1).The Storie and SR method (Storie and Earl. R. 1976) are used for calculating the land index (I). Then, using FAO 's growth model were calculated gross biomass production and the net biomass for wheat crop. Potential values were determined using a form of photosynthesis model which calculates crop photosynthesis response to temperature and radiation averaged over a growing season. Anticipated yields were derived from these values by employing yield-reducing factors related to moisture stress, climation and soil constraints. The anticipated (corrected) yield for each map unit was compared to the maximum potential yield obtainable in the Damghan plain of Iran. The maximum gross biomass production (bgm) were calculated from the following equation:

$$bgm = f.\ b_o + (1-f).\ bc$$

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where

b_o = maximum gross biomass in cloudy day
bc = maximum biomass production in sunny day
f = rate of cloudy days (1- n/N)
$(1-f_0)$ = rate of sunny days (n/N)

Potential net biomass and dry matter yield values were computed using procedures adapted from those described by the FAO. Amount of the Net Biomass (Bn) was obtained from following the equation:

$$Bn = \frac{0.36.bgm..KLAI}{(1/L) + 0.25.Ct}$$

Ct = respiratory coefficient
L = days to ripening
KLAI = correction factor for Leaf Area Index
bgm = maximum gross biomass

The next step to determine the production yield was used following equation:

$$Y = Bn * HI$$

Where Y = product yield
Bn = rating of total pure biomass
Hi = index of product harvest

The final land production potential (LPP) has been calculated using an equation where the effects of climate, soil, topography and selected land characteristics on crop production have been combined.

The LLP obtained by multiplying a land physical index (I) with Potential of product yield (Determination of both indices implies matching of land characteristics with the wheat requirements) (Sys *et al*., 1993).

RESULTS

Research showed that the barley growth cycle on Damghan plain was from 12 Oct (Planting) to 31 May (Harvest) (Table-1). The results of land suitability evaluation for barley cultivation are shown in the Table-2. This table illustrates changes range amongst different classes in land units based on the Storie method and Square Root method that were S_2 - S_3-N1-N_2 and S_2- S_3-N_2, respectively. Figures 1, 2 shows the maps of land suitability classes in the region by means of different methods. Regarding to FAO model, the estimated temperature and radiation potential of wheat yield was about 8812.70 kg ha^{-1} (Table-3). The estimated LPP values for the study area by SR and Storie methods varied between 264.40 to 6149.5 and 60.800 to 5048.80 kg ha^{-1}, respectively (Table-4). The lowest values by Square Root were found in the map unit 3.1 where soil conditions were unfavorable due to high salinity and alkalinity. This unit is located in the southern part of the study area. The higher estimated LPP values by same method are located northern side of the study area. Table-4 and Figures 1 to 4 shows correlation between estimated yield, observed yield and land index in different methods. The correlation coefficient between the mentioned parameters in SR method (R^2 = 0.998) were higher than Storie method (R^2 = 0.990).

Table-1. The barley growth cycle on Damghan plain of Iran region.

Plant	Planting to stability	Vegetative stage	Flowering stage	Ripening	stage harvest	Growing cycle
Barley	12Oct-11Nov	11Nov-30 Mar	30Mar-30 Apr	30Apr-31May	31 May	231 Day

Table-2. Results of the qualitative suitability evaluation of different land series for barley by using SR and Storie methods.

Land units	Method	
	SR Land class	Storie Land class
1.1	S2s	S3s
1.2	S2s	S3s
1.3	S3n	N1n
2.1	S3n	N1n
2.2	S2n	S3n
2.3	S2ns	S2ns
3.1	N2n	N2n
3.2	N2n	N2n
3.3	N2n	N2n

Table-3. The estimation of barley production potential on Damghan plain.

Estimation of maximum biomass production	Wheat
Maximum leaf photosynthesis (kg/ha/h)	20
Maximum biomass production in sunny day (kgCH2O/ha/day)	336.65
Maximum biomass production in cloudy day (kgCH2O/ha/day)	172.20
Rate of cloudy days (1- n/N)	0.37
Rate of sunny days (n/N)	0.63
Maximum biomass production bgm = (kgCH2O/ha/day)	275.55
Estimation of maximum net biomass production	
Respiration for Non-logum (C30)	0.0108
Respiration coffecient (Ct)	0.0039
Days to ripening (L)	231
KLAI	1
Bn (kg/ha)	18734
(HI)	0.42
Y (Kg/h/DM)	7868.50
Y (Kg/h/WM)	8812.70

Y=Yield, DM= Dry material, WM= Wet material, HI= Harvest Index, Bn= Net biomas, bgm= Maximum gross biomass

Table-4. Results of the observed and estimated yield for barley, using SR, Storie methods.

Land units	area	%	SR		Storie		Observed yield (kg/ha)
			Land index	Estimated yield (kg/ha)	Land index	Estimated yield (kg/ha)	
1.1	868.32	16.08	60.60	5340.50	49.00	4318.22	5100
1.2	316.44	5.86	69.31	6108.10	56.65	4992.40	5750
1.3	507.60	9.40	30.50	2687.87	18.60	1639.20	2250
2.1	986.04	18.26	37.50	3304.80	23.50	2071.00	2870
2.2	457.38	8.47	50.20	4424.0	36.10	3181.40	4050
2.3	369.90	6.85	69.78	6149.50	57.29	5048.80	5870
3.1	844.02	15.63	3.00	264.40	0.69	60.800	0.00
3.2	738.18	13.67	5.78	509.40	1.96	172.70	0.00
3.3	312.12	5.78	6.46	569.30	2.10	185.00	0.00

Table-5. Results of the statistics analysis observed, yield with land index and estimated yield for barley, using SR, Storie methods.

Method	Crop	Regression	R^2	Regression	R^2
		Observed yield and estimated yield		Observed yield and land index	
SR	Barley	y =1.025x- 469.9	$R^2 = 0.998$	y = 0.011x + 5.243	$R^2 = 0.998$
Storie	Barley	y = 1.190x + 9.770	$R^2 = 0.990$	y = 0.009x + 0.174	$R^2 = 0.990$

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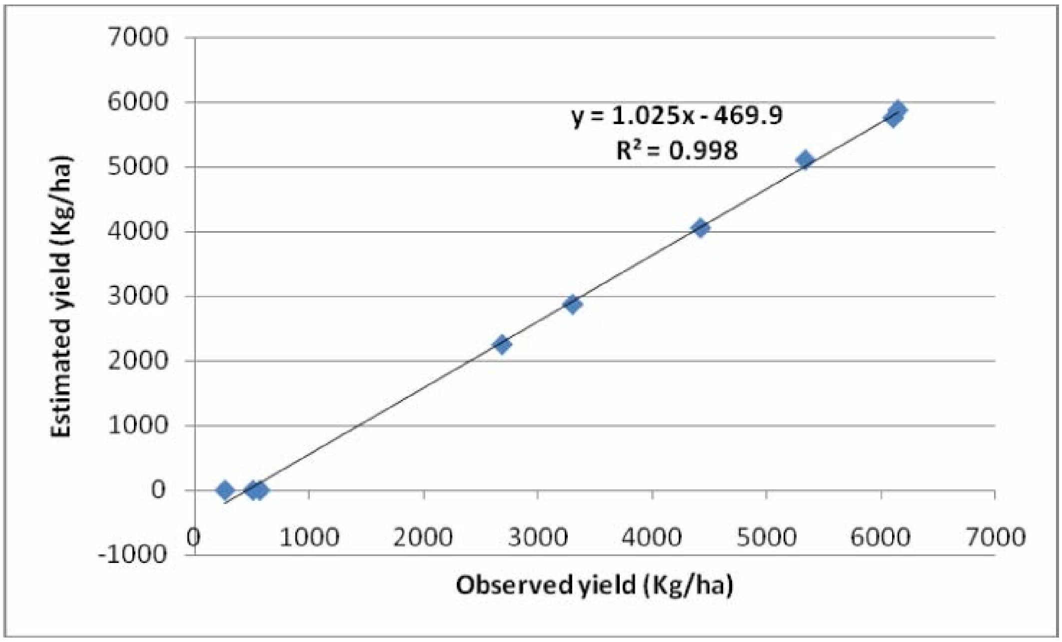

Figure-1. The regression of observed yield, estimated yield for barley using SR method.

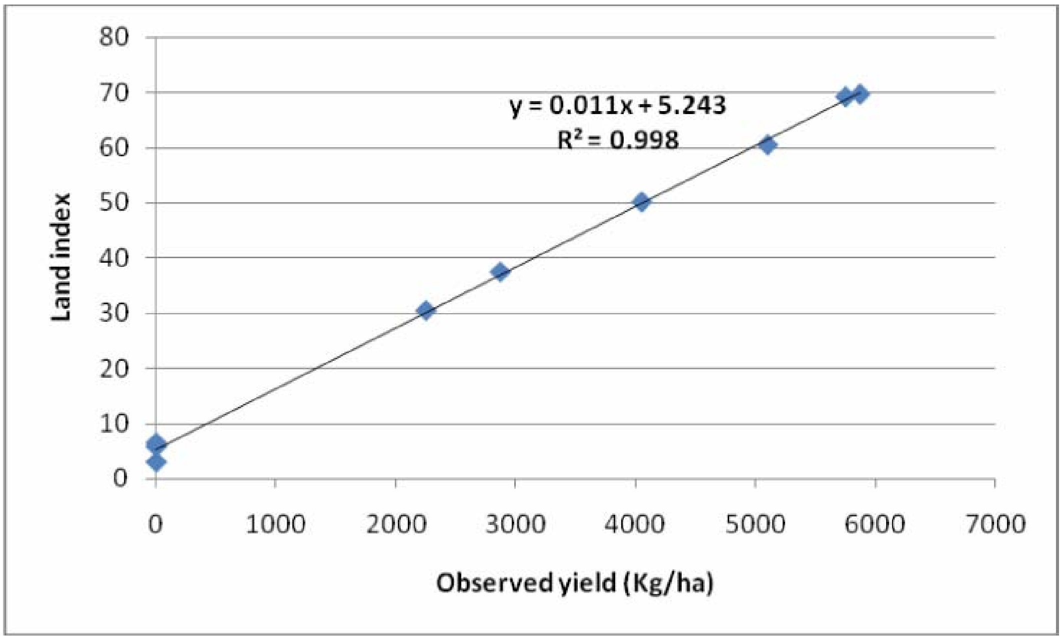

Figure-2. The regression of observed yield and land index for barley using SR method.

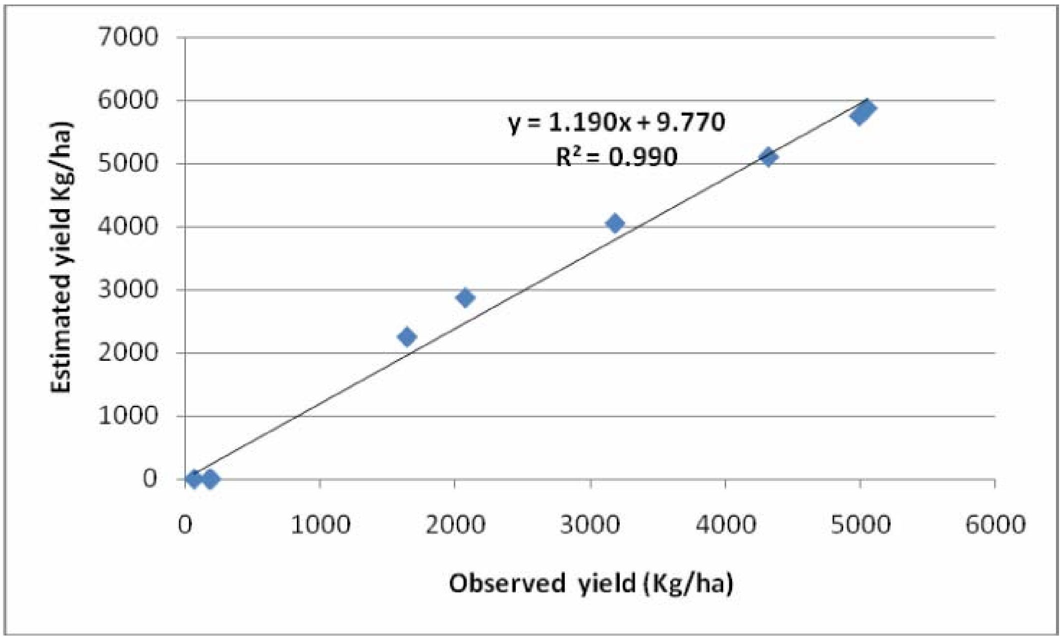

Figure-3. The regression of observed yield and estimated yield for barley, using Storie method.

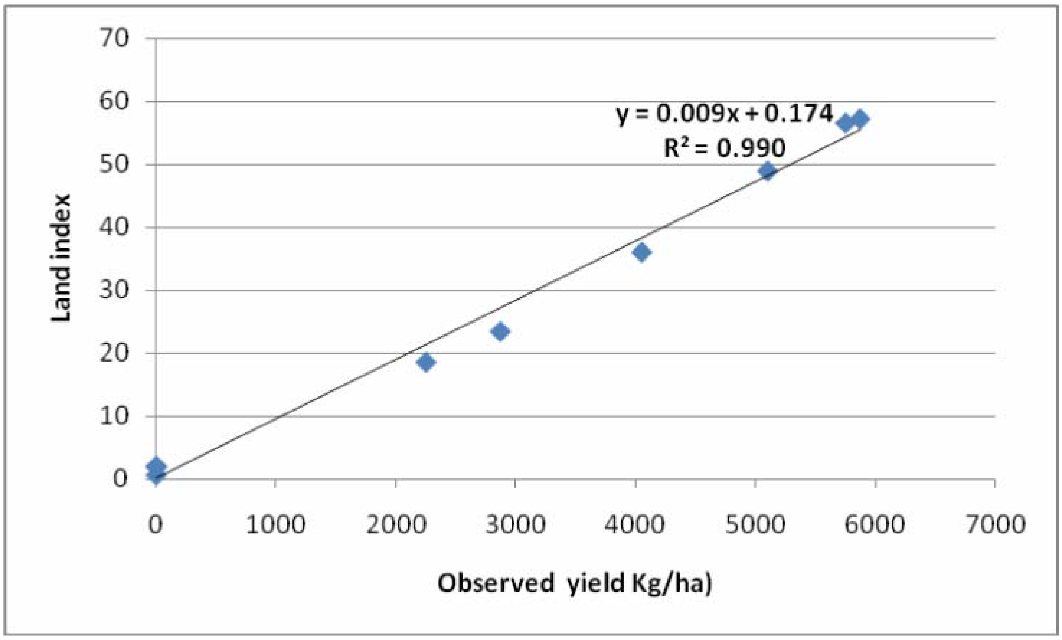

Figure-4. The regression of observed yield and land index for barley, using Storie method.

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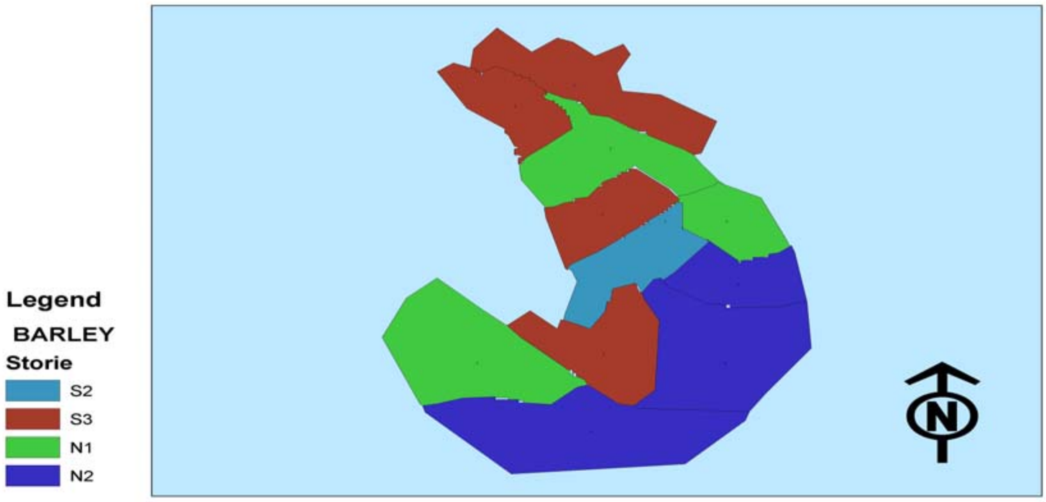

Figure-5. Qualitative land suitability evaluation by Storie method.

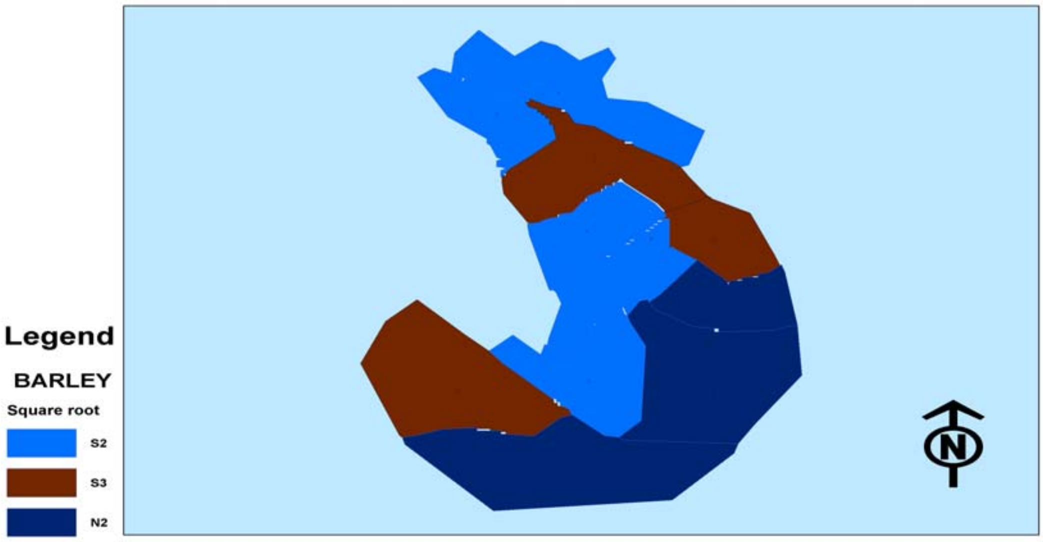

Figure-6. Qualitative land suitability evaluation SR method.

DISCUSSIONS

Regarding FAO model (SYS, *et al*., 1990), barley production potential under favorable soil and climatic conditions was estimated about 8812.70 $kg.ha^{-1}$. The good accordance between eestimated yield potential and observed yield potential in SR method approve that this method has more accuracy and efficiency than another one. The estimated statistic correlation between estimated yield and observed yield in SR method emphasize this subject ($R^2 = 0.9974$). The land index has a strong impact on the estimated land production potential. The higher correlation between observed yield and land index suggest that results of SR method are closer to reality than another one. Similarly, Mandal *et al*., (2002) reported that land index calculated by SR method was highly correlated with actual cotton yield in Nagpur district in India. Ashraf *et al*., (2011), Jafarzadeh *et al*., (2006), Shahbzi and Jafarzadeh (2004) and Behzad, *et al*., (2009) emphasized on SR method and suggests that the use of SR is more appropriate for evaluation of the qualitative land suitability than others. This study showed that observed yield was lower than estimated yield that can be caused by low management and other factors which are effective on the barley production. The considerable variability of soil characteristics over short distances will undoubtedly also lead to important local differences in barley productivity. The land physical evaluation by Square method emphasized that majority of map units were markedly suitable for barley cultivation. If the chemicals and physical soil conditions are not improved by adapted management, barley yield will be seriously affected. Results of the production model estimates, suggest the upper limit of the production capability of the available soil and climatic resources for this region. With regard to our results and other studies, we recommend that SR method is more appropriate for land suitability evaluation and estimating land production potential.

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