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Comparison of AEZ, Wageningen and Albero Models for Maize Potential Production Prediction in Northwest of IRAN

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ABSTRACT: World population increase and cultivatable land degradation in recent decades, have caused more attention to increasing production in area unit and the land suitability evaluation. In this regard estimation of the yield potential are the most important process. The aim of this study is comparing models of Wageningen, FAO and Albero in determining of Maize yield potential, using corrected and in corrected indices. To achieve these aims the soil morphological, physical and chemical characteristics were studied in10 land units with1100 hectares extension, which have located in East Azarbayjan province between 46°37' 63. 35 "to 47°42' 30.13"east longitude and 38° 7' 43.42" to 38° 9' 24.51" north latitude. The soils have the aridic moisture regime borders to xeric and mesic temperature regime and were classified in Aridisols order based on keys to soil taxonomy (2014). The calculated coefficient of determination between observed and predicted production in FAO, Wageningen and Albero from MicroLESS decision system were0.42, 0.43and 0.76 respectively. Also 0.39 and 0.34 using in corrected indices with FAO system and wageningen model. The results showed that Albero model has relatively higher Coefficient of determination (p=1%). To verify the accuracy of these models GSDER index were used that values for FAO, Wageningen and Albero were2.01, 2.24, 1.15 respectively, while using in corrected indices for FAO and Wageningen refer to 2.33 and 2.42 accuracy values. Finally, it can be concluded that Albero model with high accuracy of 1.15 is an effective model by less computational input.

Keywords: potential production, AEZ, Wageningen and Albero models.

INTRODUCTION

The use of soil as future trustee and main platform in producing agricultural products must be based on scientific and accurate principles until be used in producing of vegetable productions and as a stable source of supplying human needs. Therefore use of lands must be according to their talents and capabilities to meanwhile supplying the needs of the human and maintaining for the future (FAO, 1976). In this manner estimation of yield potential can be the most important issue for the farmer and land maintenance (FAO, 1976). To estimate the yield potential, numerous methods and models have been developed for land suitability evaluation, that FAO method is the most widely used one (Ayubi and Jalalian 2010 in persian). In Agro-ecological zoning (AEZ) of the FAO method firstly the radiant-heat potential is the estimated and then with multiplying in soil index yield potential can be concluded (Sys et al. 1991a), which also Wageningen and Albero models, are able to estimate the radiant-heat potential. Wageningen model is a mechanism model that has been quoted by Allen *et al* (1998) and the effective features, environmental conditions and carbon dioxide assimilation are used to predicting the radiant-heat potential (Allen *et al.* 1998).

Wageningen model simulates production in potential level (Nasir Mahalati 2000 in persian) and canopy photosynthesis will be the basis of the plant dry matter production rate estimation. The amount is related to absorbed energy by green canopy that is obeying the input radiation and leaf area of plant. Potential by this model is lower and through the FAO model is more than actual production of farmers. There is a higher correlation Between the potential production and actual one when using the Wageningen model (Khaghani 2008 in persian). But some studies describe more accuracy of the FAO method than Wageningen model (Etedali *et al* 2012 in persian), while Albero model is determining land suitability by helping multivariate regression techniques as one of the subsidiary of Micro LEES decision system (De la Rosa *et al.* 1981)and is the first predicting method by computer progam that evaluates wheat, maize and cotton in a good managmental condition and climate has no negative role in production. The objectives of the present study was not only applying of AEZ and Wageningen models by corrected and in corrected indices but also Albero model for Maize yield potential determination was used and also the results were compared by actual production.

METHODS AND MATERIALS

The study area with 1100 hectares extension is Located between 38 ° 7' 44"to 38 ° 9? 25" north latitude and 46 ° 37' 36" to 46 ° 42' 52" longitude in northeast of Tabriz in the east Azarbaijan. The area with mean annual temperature of 13.6°C and 241.8mm rainfall have aridic borders to xeric and mesic soil moisture and temperature regims respectively. Soil morphological, physical and chemical properties of 10 soil profiles in 10 land units were studied and classified based on keys to soil taxonomy (2014) in Aridisols and suborders of calcids, cambids, gypsids and salids with different families (Fig. 1). Also for determination of maize potential production different models of AEZ, Wageningen and Albero were used, which are described as follows:

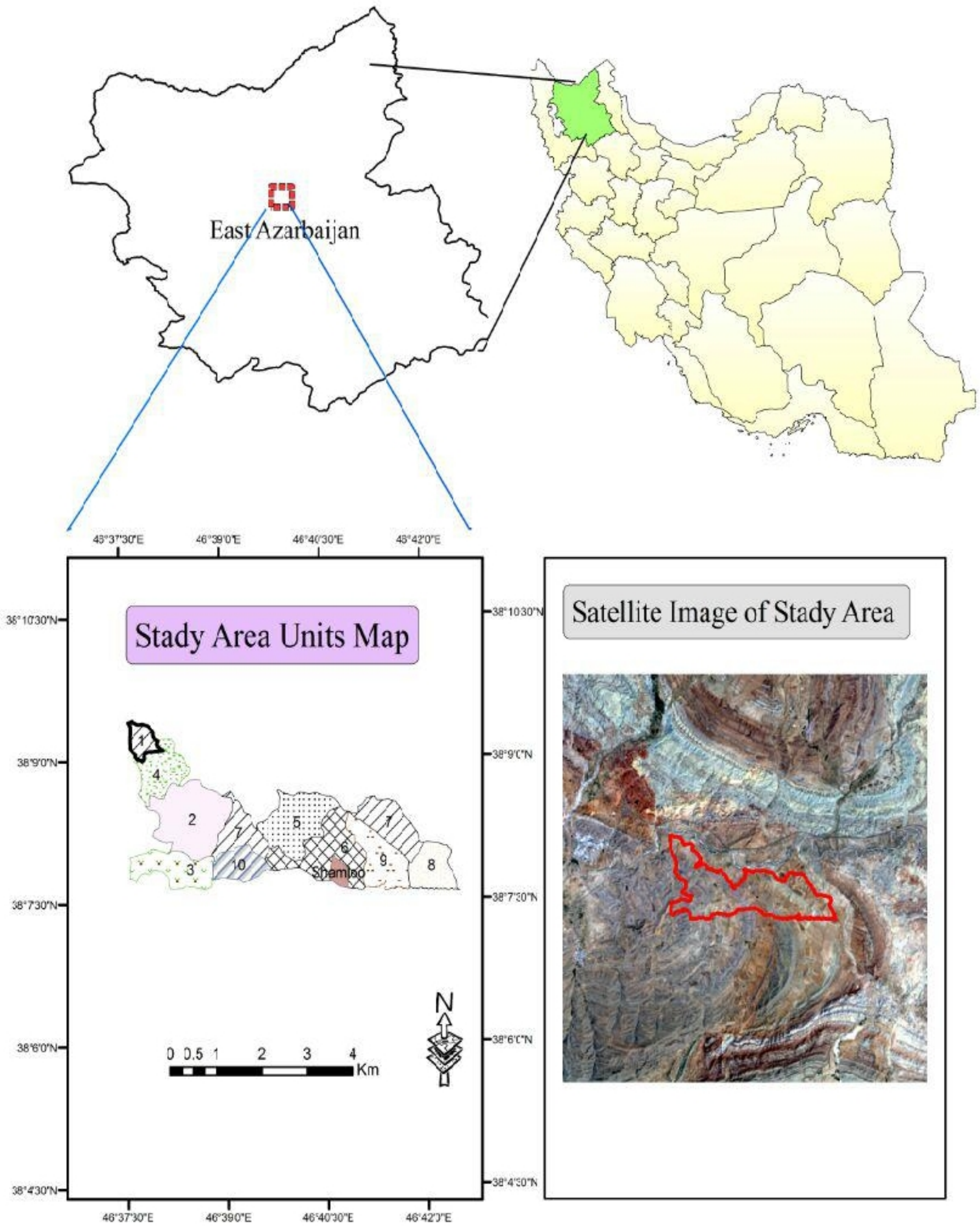

Fig. 1. Land units of study area.

A. Estimation of production potential by AEZ method

The yield potential is estimating the quantitative land evaluation and this estimation is done by amounts of supply and demand (Sys *et al.* 1991b). For calculating the yield potential first the wheat thermal production is beeing estimated based on genetic potential and plant physiology, using climatic data such as solar radiation and temperature degree, amount of biomass production of plant.

$$Y = 0.36\ bgm.\ KLAI.\ Hi / [(1 / L) + 0.25\ Ct] \quad ...(1)$$

In this equation, Y is the thermal - radiation potential (kg per hectare), bgm is Maximum gross biomass production rate (Kg per hectare per hour), KLAI is the ratio of maximum gross biomass production rate when leaf index area is 5 to when it is not 5, Hi is Harvest index and L is the length of days during growing period (in days)

B. Estimation of production potential by Wageningen method

This method estimates the radiation - heat potential using radiation and temperature as input variables.

Usually time period for calculations is considered 10 days.

Ultimately at the end of the considered period the weight of the leaves, stem, seeds and roots is calculated by obtained results as follows.

$$TDW=WLV+WST+WGR+WRT \quad ...(2)$$

In this equation WLV is weight of leaves, WST stem weight, WGR grain weight and WRT root weight according to kg per hectare.

The summation of temperature degree at the first decade is calculated using average daily temperature and threshold temperature degree as follows:

$$T_{sum} = days \times (T_{mean} - T_{threshold}) \quad ...(3)$$

In this equation T_{mean} is total temperature degree of specified period, Days is the number of days in period, T mean is average daily temperature and $T_{threshold}$ is the temperature threshold.

following equation is used for obtaining the gross CO_2 assimilation:

$$interception=1-e-(0.8LAI) \quad ...(4)$$

In this equation Interception is the amount of light absorbed by the plant in specific LAI and LAI is leaf index eraea of plant at that stage.

The amount of GASS is reachable due to the amount of absorbed light calculated on recent relationship and daily assimilation potential as follows:

$$GASS= DPGASS \times interception \times days \quad ...(5)$$

In this equation GASS is assimilation with unit of Kg CH_2O / ha. days, DPGASS is daily assimilation potential, Interception is the absorption of light in the specified LAI and Days is the number of days in the relevant period.

In continues a part of established energy in the process of assimilation is used for maintaining the existing structure. The amount of breathing losses depends on the chemical composition of the plant structure materials. Both of the growth and maintenance respiration (MRES) increase when the protein materials are more.

$$MRES = RM \times TDML \times days \quad ...(6)$$

In this equation MRES is maintenance breathing of the period, RM is relative maintenance respiration rate in 20 c(Kg CH_2O / Kg DM. day) and TDML is total Live dry matter (Kg/ha).

Assimilation products available for weight increase (ASAG) is obtained from the difference between the gross assimilation (GASS) and the maintenance respiration (MRES):

$$ASAG = GASS - MRES \quad ...(7)$$

Primary assimilates have to be converted into structural plant material. Scince such conversion entails a loss of energy, the conversion efficiency (EC) is less than 1. For vegetative material of average composition Ec is 0.7.

The rate of dry matter increase (DMI) is obtained from following equation:

$$DMI = ASAG \times EC \quad ...(8)$$

In this equation DMI is the amount of dry matter increase (Kg CH_2O / ha.days) and Ec is coefficient efficiency (Kg DM / Kg CH_2O)

C. Estimation of production potential by Albero model

This model forecasts the amount of land production in quantities way and by help multiple regression method (De la Rosa *et al.,* 1981). Production of any type of crops (Y) is estimated by multiple regression equations (Chapman and Murphy 1991). This model is the first production prediction method by computer program that evaluated Products in this model is including wheat, Maize and cotton, which is designed with high management default and Without the influence of climatic conditions. This model is in continuation of statistical results of people like Simonson (1938) and Stori (1950) in agriculture science and land evaluation.

The work way of this model can be as follows, that 7 features like impressive depth of soil, clay amount, Hydromorphic depth forms, Carbon amounts, salinity, cation exchange capacity and exchangeable sodium percentage enter the model in order to X1 to X7 as inputs and the amount of production for each unit is calculated for each specified crop.

RESULTS AND DISCUSSION

The results were reported as:
The Information of Maize growth cycle (Table 2), the values of required variables for calculating termal-radiatin potential for Maize production (Table 3), the characteristics of soil and landscape on weighted average way (Table 4) and the relative suitability degree (Table 5).

Table 2: Different stages of growth cycle of maize in studying region (local information).

Crop	Land making and cultivation	Growth period	Antheisis	Maturity	Harvest	Growth cycle	Growth cycle(days)
Maize	10 May	10May up tp 15 June	15 June up to 27 August	27 August up to 21 September	21 September	10 May up to 21 September	134

Table 3: The amounts of require variables for calculating thermal-radiation yield potential of Maize.

Parameters	Information	Parameters	Information
Crop	Maize	Leaf index area(m^2/m^2)	3.5
Photosynthesis group	C_4 and group 4	Harvest index	0.35
growth cycle start	10 may	Bo	246.36
End of growth cycle	21 September	Bc	467.56
Growth cycle period	134 days	F	0.203
Growth cycle average temperature	16.15	Y	8918.44
Maximum photosynthesis rate	20	bgm	864.38

Table 4: Weight average of soil characteristics by using of weight coefficients for determining the suitability class.

Land unit	ESP %	EC)(dS/m	Gypsum (%)	CCE (%)	%Particle >2mm	Clay (%)	Silt (%)	Sand (%)	Slope (%)	Texture class	Soil depth (cm)	Flooding	Drainage
1	10.1	0.92	2.21	19.25	7.04	34.87	27.13	38	0	CL	>150	F0	average
2	4.98	1.44	1.02	14.11	6.88	31.49	32.59	35.92	1	CL	>150	F0	Good
3	4.95	26.18	8.67	12.84	3.96	39.3	35.63	25.07	1	CL	>150	F0	Good
4	5.91	1.35	1.62	18.77	6.49	29.05	32.95	38	3	CL	>150	F0	Good
5	8.1	4.14	8.01	16.72	6.08	26.97	20.2	52.83	6	SCL	>150	F0	Good
6	7.48	1.4	4.54	19.15	3.88	38.3	32.8	28.91	3	CL	>150	F0	Good
7	9.87	2.2	1.84	19.77	10	35.15	25.91	38.93	10	CL	>150	F0	Good
8	10.34	15.88	6.91	22.15	7.44	29.27	30.35	40.37	3	CL	>150	F0	Relatively good
9	6.65	7.32	8.24	17.49	3.9	33.51	27.82	38.68	2	CL	>150	F0	Average
10	4.73	0.73	1.8	16.32	3.96	39.86	41.66	18.48	4	SiCL	>150	F0	Good

Table 5: Suitability degrees of land characteristics for Maize.

Land units	Drainage	Slope (%)	ESP (%)	EC (dS/m)	Gypsum (%)	CCE (%)	Particles> 2mm	Texture	Climate index
1	95	100	92	97.7	93.95	74.38	91.63	98.03	69.77
2	100	95	96.89	96.4	97.45	85.99	91.77	96.73	69.77
3	100	95	96.91	20.97	665.54	87.4	94.2	99.73	69.66
4	100	72.5	96.31	96.63	95.95	75.56	92.09	95.79	69.66
5	100	40	94.86	84.3	68.29	80.7	92.43	89.65	69.66
6	100	72.5	95.33	96.5	82.75	74.63	94.27	99.37	69.66
7	100	23.94	92.3	94	95.4	70.08	89.17	98.13	69.66
8	95	72.5	91.66	23.9	72.88	67.13	91.3	95.87	69.66
9	95	85	95.84	68.4	67.33	78.78	94.25	97.5	69.66
10	100	85	97.04	98.18	95.5	87.7	94.2	99.95	69.66

Soil depth, flooding and drainage make no limitation in these soils, so the suitability degree of these characteristics are 100 that makes no difference in results. Studding soils are classified in Aridisols according to soil temperature and moisture regimes based on keys to S.T. (2014). Studying on local farmers in formation showed that there is no difference between the amount of used inputs among the farms but the differences observed in terms of management actions.

Yield potential (Table 6) in Khajegregion is estimated from 7545 to 9721 kg per hectare with corrected indices and 1105/88 to 7545/89 with in corrected indices by wageningen method and from 1983/1 to 14454/3 with corrected indices and from 1983/1 to 13531/51 with incorrected indices by FAO method and from 4000 to 8200 by Albero. Maize production potential variation range using Wageningen is more in comparing to other methods refers to overestimation of this model in high amounts, and lawstimation of method in low amounts, which is visible by observation of 1:1 line in respective diagrams. The amounts of observed and predicted productions by each model with corrected and incorrected indices is presented in Table 6.

Table 6: Observed production and predicted yield potential by both methods and by corrected and incorrected indices.

Land units	Observed production(kg/ha)	potential production (Wageningen-incorrected)kg/ha	Potential production (FAO-incorrected index)kg/ha	Potential production (Wageningen-corrected)kg/ha	Potential production (Albero)kg/ha	Potential production (FAO-corrected index)kg/ha
1	5070	12071.3	6731.63	13541.11	7500	7545
2	-	13531.51	7545.69	14454.3	7800	8053.35
3	4400	2374.93	1324.38	1484.13	7600	820.49
4	5060	11804.29	6582.70	11262.13	8200	6278.5
5	2710	6208.4	3462.13	3184.16	4000	1774.76
6	5160	11319.71	6312.47	11062.22	7800	6162.64
7	4410	1754.41	9783.5	1754.41	7500	9721
8	2710	1983.1	1105.88	1983.1	6100	1105.88
9	-	10476.88	5842.47	10716.78	7000	5975.35
10	4480	13259.63	7394.27	14283.17	7900	7964.16

Table 7: The land quantitive suitability classes in different units.

Land units	Quantitive suitability (Wageningen-incorrected index)	Quantitive suitability (Wageningen-corrected index)	Quantitive suitability(Albero)	Quantitive suitability class (FAO-incorrected index)	Quantitive suitability class (FAO-corrected index)
1	S1	S1	S1	S1	S1
2	S1	S1	S1	S1	S1
3	N	N	S1	N	N
4	S1	S1	S1	S2	S2
5	S2	N	N	N	N
6	S1	S1	S1	S2	S2
7	N	N	S1	S1	S1
8	N	N	S2	N	N
9	S1	S1	S1	S2	S2
10	S1	S1	S1	S1	S1

Table 8: Extention of each suitability class for observed production and FAO and Wageningen methods (ha).

N	S3	S2	S1	Evaluation method
647	87	284	-	Observed
471	-	-	622	Wageningen-corrected index
334	-	138	622	Wgeningen-incorrected index
309	-	338	447	FAO-corrected index
309	-	338	447	FAO-incorrected index
138	-	75	338	Albero

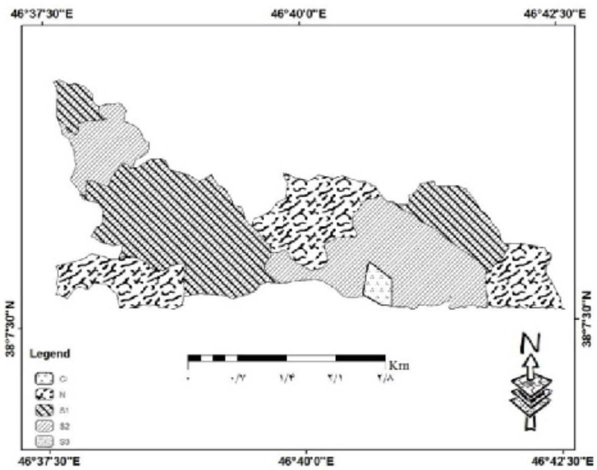

Fig. 2. Land potential production map by FAO models with corrected index.

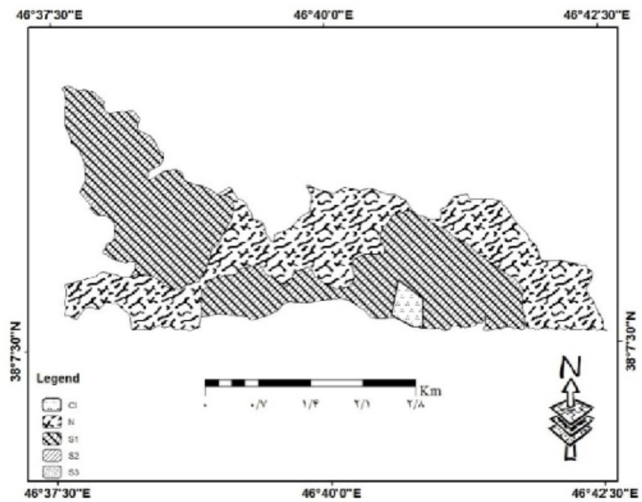

Fig. 3. Land potential production map by Wgeningen models with corrected index.

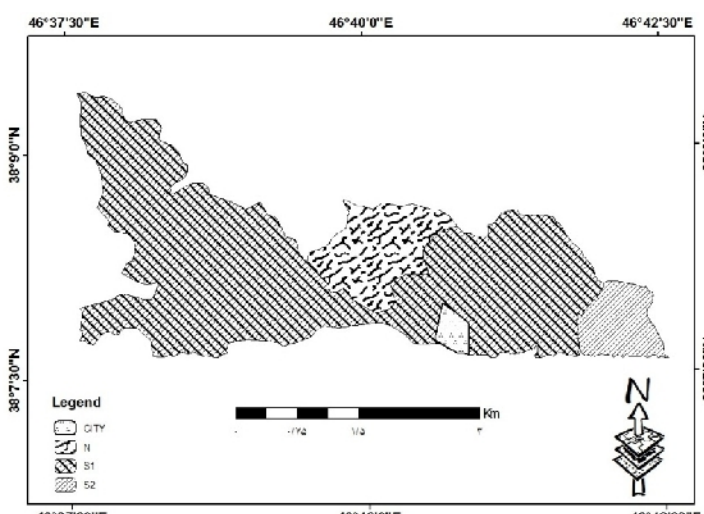

Fig. 4. Land potential production map by Albero models.

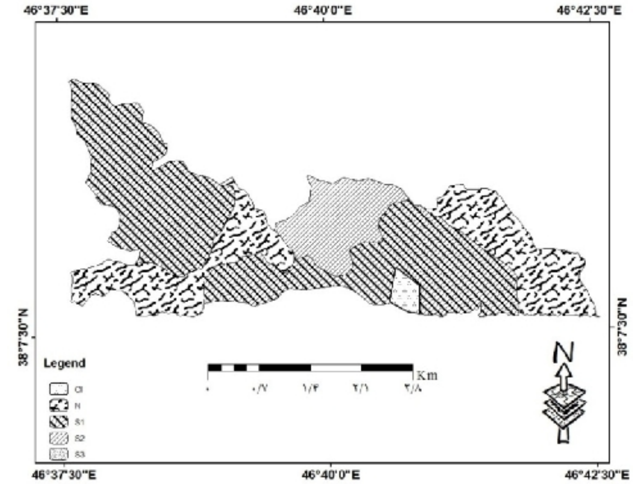

Fig. 5. Land potential production map by Wgeningen modelswith incorrected index.

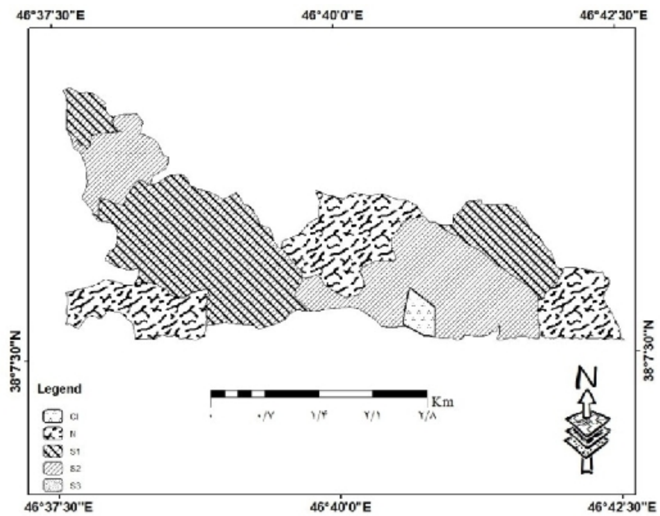

Fig. 6. Land potential production map by FAO models with incorrected index.

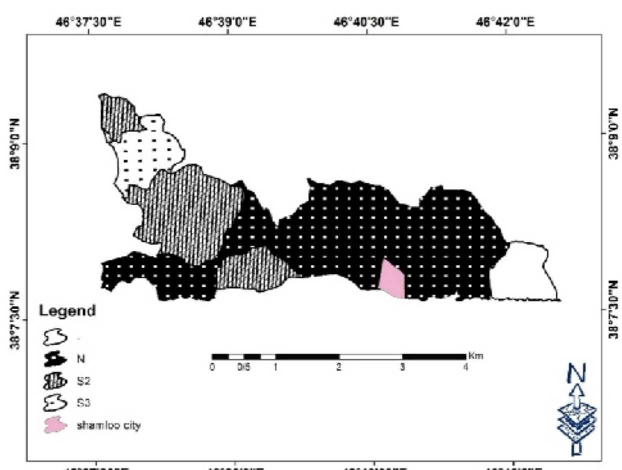

Fig. 7. Observed yield map.

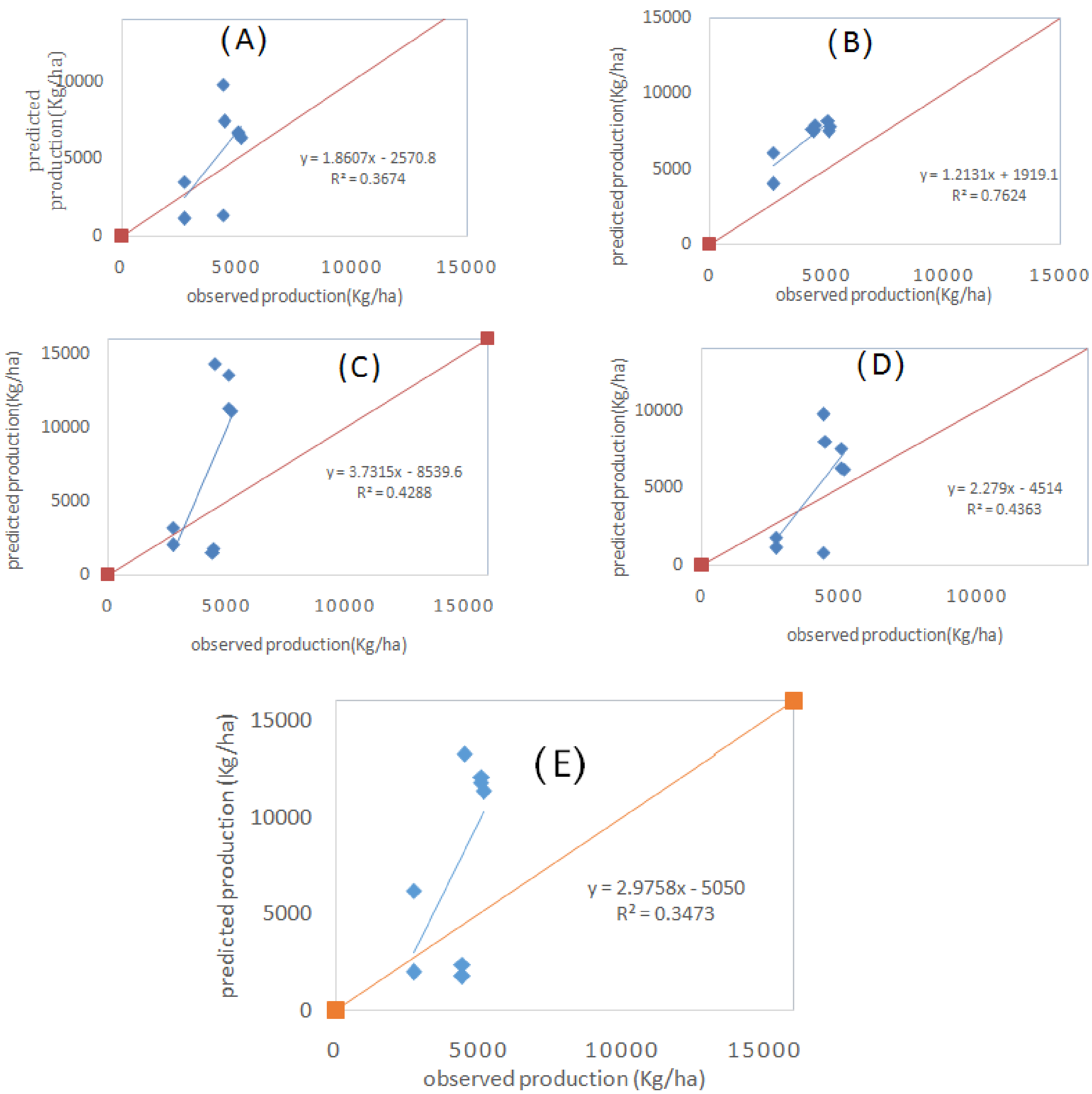

Fig. 8. Relationship between observed production and predicted production by Albero model.

The relationship between predicted production for Maize (calculated in three methods FAO, Wageningen and Albero) and the observed production are presented in Fig. 8, A to E. The mentioned determination Coefficients are 0.43 and 0.36 in FAO model with corrected and in corrected indices and 0.42 and 0.34 in Wageningen model with corrected and in corrected indices and 0.76 in Albero model. Also if the number of observations and profiles increase and instead of mothly information, decade information is used the determination coefficients will increase (sys 1991).

CONCLUSION

Calculated determination Coefficient between the observed and productions confirms that the Albero model has higher accuracy than other methods in estimating yield potential at 5% probability level, also the results of comparison of methods accuracy by GSDER index showed higher accuracy of Albero model than other methods.

Low determination coefficients of FAO and Wageningen methods justify 43 and 42 % of Maize yield potential changes in Khajeh region and the rest is related to management features and other unknown factors (other features that have not been considered in selected models). Halder (2013) did qualitative and quantitative land suitability evaluation for cultivation of rice and wheat by using GIS and remote sensing system in Indian's Bengal region. He showed the characteristics of soil like phosphorus, nitrogen, potassium, soil pH, organic matter and soil texture as effective characteristics in these plants growth. The results showed that this model justifies at least 95 percent of potential yield changes in the studying region. Potential production had difference with farmers records (table7) that it's probably by differences in performance of methods structure. Although in this research evaluation may carried out at the same management level, while the farm management by farmers is different, and this difference is visible in both methods. In calculation of the potential production, the management is considered at the highest level and does not create any restrictions. Farajnia (1386), introduced poor irrigation, not fighting against weed, unproper cultivation history and lack of supply of toxins, pesticides and fertilizers and others as effective in management level.

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