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Use of CROPGRO-soybean to simulate biomass and grain yield of soybean (*Glycine max* L.) in different planting dates

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Abstract

In order to investigation of CROPGRO-Soybean model under four sowing date management in some of growth unlimited cultivars of soybean in Karaj, this experiment carry out as a randomized complete block design in split plot arrangement with four replications in 2010. Treatments were different planting date 19 May, 29 May, 9 Jun, 19 Jun as main plot and four growth limited cultivars of soybean (Wiliams and Zan) as sub plot. Result showed that variety dimension of RMSE for biomass had 356.41-1207.33. Also variety dimension of Wilmot coefficient (d) calculated between 0.898-0.989. The Wiliams cv in planting date 19 May with RMSE= 356.41 kg/ha and d=0.989 have been highest of model coefficient efficiency. In all of treatments variety dimension of R^2 curve 1:1 measured and predicted rates, equal to 0.855-0.988 and correlation coefficient at ($p< 1\%$) was significant .The variety dimension of RMSE for grain yield all of the treatments had 151.94-880.66 kg/ha. Also variety dimension of d coefficient calculated between 0.505-880.66 kg/ha.

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Introduction

Agronomists have always been interested in finding out ways and means to estimate crop yield in advance to the extent possible. Simulation models have been used successfully to forecast productivity of cropping systems under various weather, management and policy scenarios. Soybean is one of the major grain oil crops throughout the world (Sinclair *et al.*, 1991). Potential grain yield of soybean in world determined about 6 ton per hectare and in Iran equal to 2.6 ton per hectare (FAO, 2007) therefore for precise evaluate of growth limited factors need to mechanistic model (Penning de Vries *et al.*, 1989.

The modeler still has to integrate knowledge from a spectrum of disciplines and to specify interactions of different nature, namely, physical, chemical, biological (Stockle and Nelson, 1994). The complexity of the system is further increased by variability of climate and soil characteristics, genetic diversity and field management (Penning de Vries *et al.*, 1989). Soybean-CROPGRO has been used extensively to evaluate the effects of management practices and environmental conditions on biomass and grain yield of soybean (Jones *et al.*, 2003). Agriculture is one of the most important sectors of the Iranian economy, as it is the major land user and provides employment for the majority of the population. In agriculture use of existing resources, e.g., land, water, fertilizers, pesticides for increasing the production and its efficiently (Monteith, 1981; Overman and Scholtz, 2002). The prediction of crop yield have direct impact on national and international economies and play an important role in the food management (Hayes and Decker, 1996). In other hand, factors like pests, diseases and human activities can cause local variations in predicted crop yield. This is a serious limitation to any forecasting method including this (Prasad *et al.*, 2006).

For measurements of grain yield and biomass production need to deduce various parameters such as evapotranspiration , soil type, light, carbon dioxide, temperature, water and the rate of growth and development (Monteith, 1981) and crop-weather relations (van Keulen, 1987) are increasingly used to predict crop yield. The model can be optimized with growing historical data for better prediction. A simple and robust crop model for soybean was developed by Sinclair and Ludlow, 1986) using a phenomenological and physiological framework. Crop modeling has been generalized and used to examine yield potential and production risks in cowpea, black-gram (Sinclair *et al.*, 1987) and peanut (Hammer *et al.*, 1995). Simulation of the behavior of the crops in land use planning in response to different policy instruments is very important (Soltani *et al.*, 1999).

Therefore calibration of CROPGRO model in different region such as Karaj for decision making in different management scenario is very important.
The aim of this study is evaluate of CROPGRO model for simulation of the reaction plant, soil and environment on grain yield and biomass (with different socio-economic and biophysical conditions) to different policy instruments in order to support agricultural planning at regional levels.

Materials and Methods

The experiment was conducted in Karaj area, Iran (35°43′N, 50°49′E, altitude 1174 MSL). The means annual precipitation and annual temperature were recorded 168 mm, 23 °C, respectively.

Manure requirements were determined in based on soil analysis (Table 1) in 30 centimeter of the soil depth. The experiment was arranged as split plot based on randomized complete block design with four replications. The main plot treatments consist of four sowing dates (19th, 30th May and 10th, 20th June) and sub plot treatments consist of two soybean cultivars namely; Williams, Zan (type III). Sowing depth and plant density was considered 3 cm and 25 plants per square meter, respectively for all the cultivars. Each plot designed six rows of 6m long and inter-row spacing of 0.5 m. The seeds cultivated in each sowing date with 10-day-intervals. These were consisted of ammonium phosphate (150 kg/ha) per plant and urea (150 kg/ha) at three stages, before seeding, R1 stage (Fehr and Shibles, 1980) and pod setting stage with equal ratio. Weeds was controlled using manually. In each plot, 20 days after planting (DAP), in 30 cm line plants were sampled at ground level randomly and measured total dry matter (kg/ha) and at 70 DAP 3 times sampled with 10-day-intervals till maturity and then calculated grain yield (kg/ha). Measured data biomass and grain yield located in file special and was summoned for CROPGRO-soybean.

Weather data

Weather important data comprise of maximum and minimum (Celsius) temperature, sunny hours and rain (mm) in based on daily was take in meteorology institute (Jones *et al.*, 2003).

Soil data

For suitable simulation using model we measured some of important soil characteristics in three different of soil layers (0-20), (20-40), (40-60) (Table 1).

Field management data

Some of important characters of field management comprise of plot dimension, seed rate, plant density, kind of treatment (scenario), summon of weather data, chemical and physical soil, plant genetic coefficient, management of irrigation and manure and etc. At the end, after preparing of model requirement data, plant, soil ,atmosphere as result model can be predicted processes of growth and development in based on daily. With summon of measured field data in model, points of predicted and measured located in one curve. Model can be calculate precision of fitted and showed some of statistic parameter for model evaluation.

Results

Biomass simulation

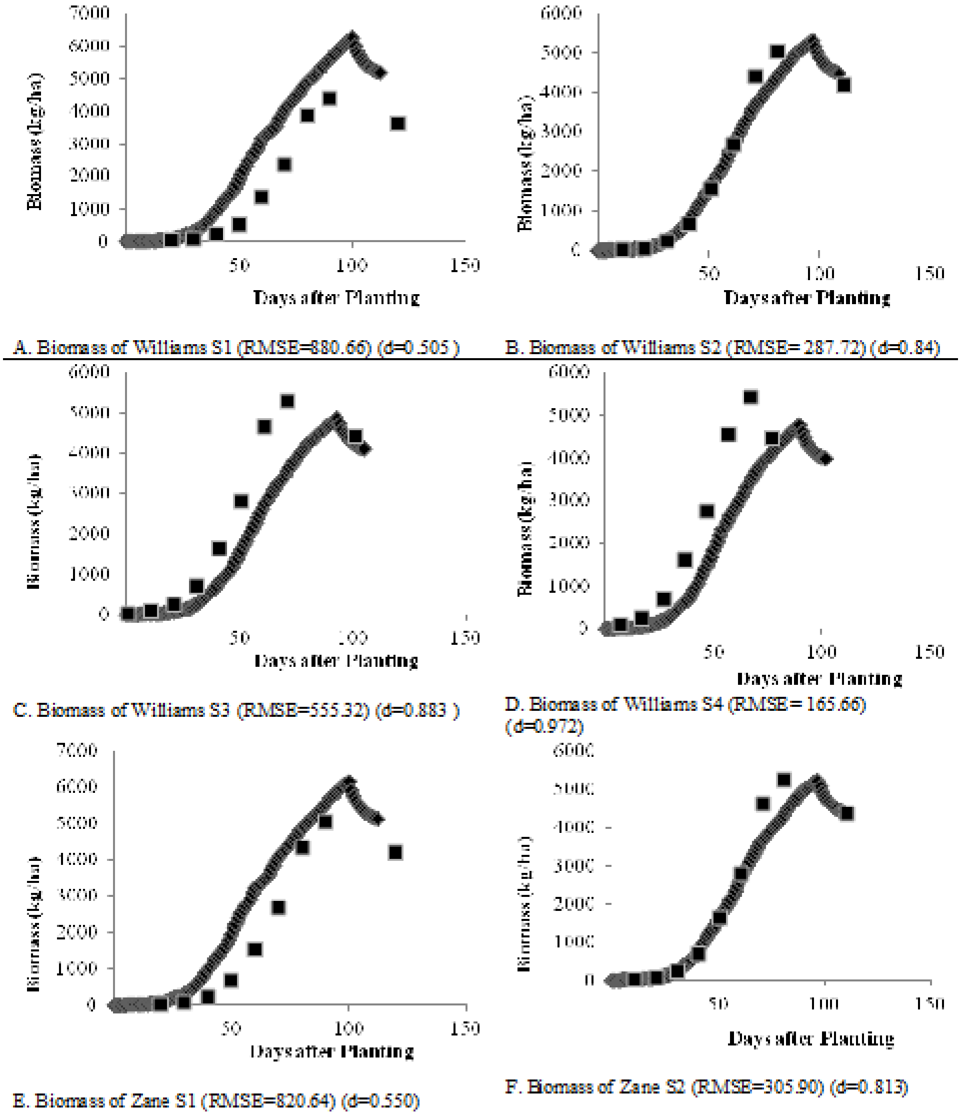
According to Fig 1. A process of biomass simulation, Williams cv. at May 30th sowing date (S2) have been lowest of root mean square error (RMSE=356.41) and highest of Wilmot coefficient (d=0.989). This result showed that Williams cv. S2 has highest of prediction precise. Variation dimension of RMSE and d obtained 1170.13-356.41 and 0.895-0.989, respectively. In Fig 1 some treatments such WS3, WS43, ZS3 and ZS4 indicated that model simulation was lower estimate comparison to measured data. Fig 3 A and B shown that in based on regression curve among observed and predicted (line 1:1) of biomass, R^2 coefficient was 0.988 and 0.985 for cultivars of Williams and Zane, respectively in all of the planting date. Therefore model can be presented suitable explain of biomass in different growth stage. In statistic viewpoint rate of correlation coefficient was significant (p<%1). Model description in fig 3 A, B indicated that in cv. Williams was more precise comparison to cv. Zane.

Table 1. Soil analysis in Karaj.

EC	PH	OC%	Total N%	P ppm	K ppm	Clay%	Silt %	Sand%	Texture	Specific weight	Soil layers
2.85	7.9	0.39	0.1	39	398	32	44	24	Clay loam	1.47	0-20
1.58	7.9	0..36	0.05	28	3380	28	42	30	Clay loam	1.91	20-40
1.32	7.9	0.30	0.04	28	360	25	44	31	Clay loam	2.06	40-60

Grain yield simulation

According to Fig 2 process of grain yield simulation, Zane cv. at June 20 th sowing date (S4) have been least of root mean square error (RMSE=169.02) and highest of Wilmot coefficient (d= 0.973). This result showed this treatment has highest of prediction precise. Variation dimension of RMSE and d obtained 169.02 -880.66 and 0.505 -0.973, respectively. According to fig 3 showed that (line 1:1) regression curve among observed and predicted of grain yield, variation of R^2 was 0.967-0.980 as result model could be presented suitable explain of grain yield in different growth stage in all of the planting date. In statistic viewpoint rate of correlation coefficient was significant (p<%1). Model description in fig 3 C, D indicated that in cv. Williams was more precise comparison to cv. Zane.



A. Biomass of Williams S1 (RMSE=880.66) (d=0.505)
B. Biomass of Williams S2 (RMSE= 287.72) (d=0.84)
C. Biomass of Williams S3 (RMSE=555.32) (d=0.883)
D. Biomass of Williams S4 (RMSE= 165.66) (d=0.972)
E. Biomass of Zane S1 (RMSE=820.64) (d=0.550)
F. Biomass of Zane S2 (RMSE=305.90) (d=0.813)

Fig. 1. Biomass simulation process comparison to obsereved data (points= obsereved and line= simulated).

Discussion

According to researchers reports many important factors caused increasing of different among measured versus simulated traits that including unequal in soil productivity, sowing depth unequal, plant standing unsuitable, weed competition (Sau *et al.*, 1999). Some time in crop management implement specially irrigation implement in based on turn caused that plant have not growth potential and increased simulation error rate. When model was predicted over estimate or lower estimate, indeed its reason can be inaccurate identification many important parameters for model, as limited condition appearance in filed but we described optimum condition for model (Jones *et al.*, 2003). Biomass predicting by model in WS2 better than

WS1 treatment, apparently. This result agree with Sau *et al.*, 1999. Indeed, identification condition for model in comparison to field condition had similar. Researchers should be applied model for predicting of parameters that model have high capability in parameter simulation. If weed control don't carry out well in each growth stage caused biomass decreasing and increasing of the different among measured and predicted traits. This problem reported by Soltani *et al.*, 1999. Using weather data near to the field experiment caused avoidance of error due to high weather variation. Reason of increasing in predicting error for grain yield due to harvest time, may be in grain filling stage was not suitable irrigation and plants encountered to drought stress condition. However while this case in the next years observed, we can obtain a corrected coefficient for decreasing of simulation error.

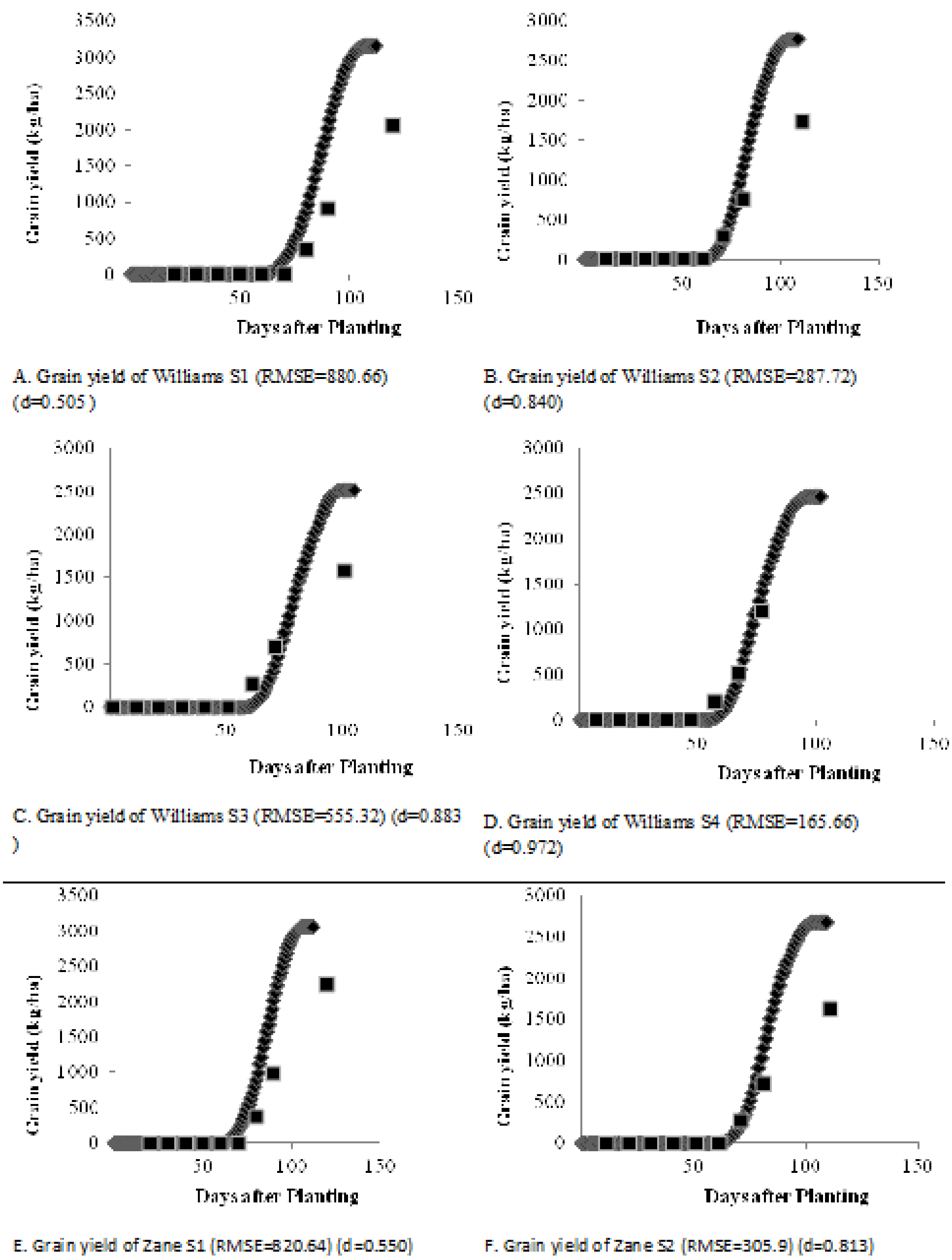


Fig. 2. Grain yield simulation process comparison to obsereved data (points= obsereved and line= simulated).

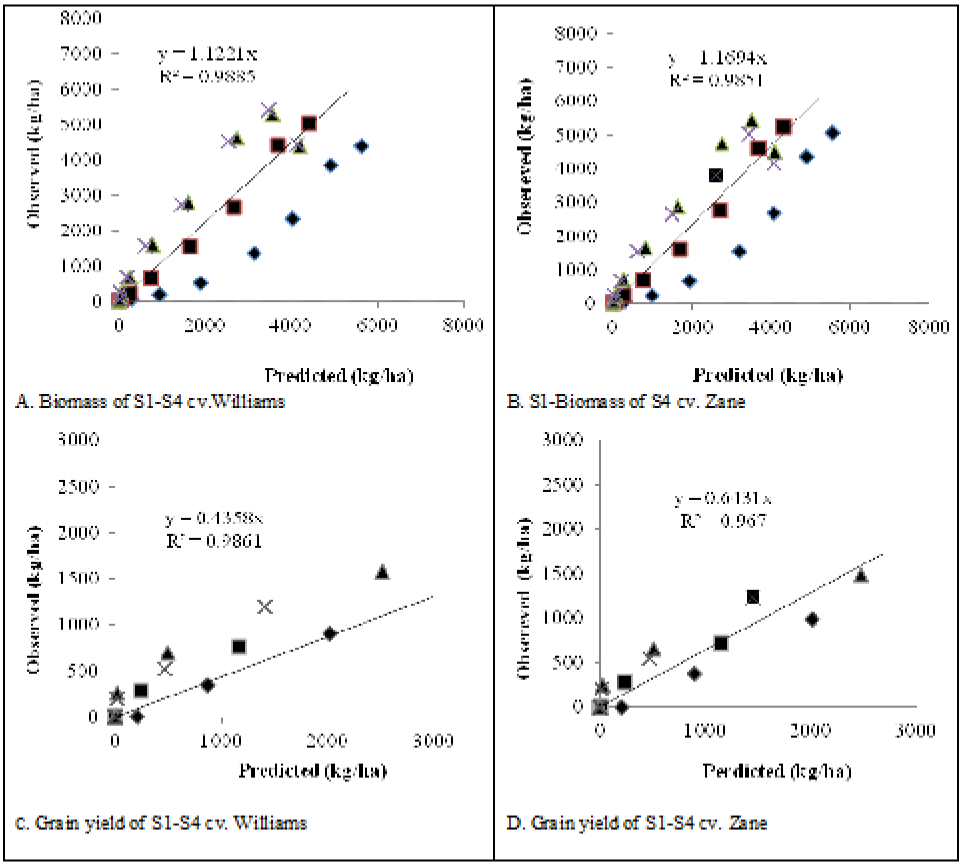


Fig .3. Regression curve of observed versus predicted of biomass and grain yield (1:1 line) for different of cultivars and planting date.

Conclusion

Generally for both two cultivars of Williams and Zane, predicting process of biomass the more precise comparison to grain yield. Generally according to regression curve (1:1 line) for all of planting date, R^2 for both cultivars was significant ($p<1\%$). Model predicting relating to delaying of planting date in grain yield showed decreasing that was similar to its actual (Field data).

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