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Prediction Model of Leaf Area in Soybean (*Glycine max* L.)

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Abstract: Problem statement: Measure of leaf area by means of leaf area Meter is very expensive and difficult. Hence obtain of one simple model for calculate of leaf area in soybean (*Glycine Max* L.) is very necessary. **Approach:** In order to develop a suitable simple model for calculation of leaf area by means of leaf length and width, a Randomized Complete Block Design base donlit plot experiment with four replications was carried out in 2009 growing season at Karaj, Iran. Four soybean cultivars (Wiliams, Zane, L17 and M7) were used in the experiment. Totally, 1500 leaves for eight different times were measured in the experiment. Leaf width (W), length (W) and Leaf Area (LA) were measured. The actual leaf area of the plant was measured and regression model was fitted. **Results:** Pierson correlation showed that between actual leaf area relate to leaf width ($R^2 = 0.89$), L × W ($R^2 = 0.98$), W^2 ($R^2 = 0.9$), ln L×ln W ($R^2 = 0.9$), ln LW ($R^2 = 0.87$) and $(LW)^2$ ($R^2 = 0.93$) have been positive correlation. Also between L × W and actual leaf area in Zane cultivar have been equation y= 1.173 x + 0.984 ($R^2 = 0.92$), in Williams cultivar y= 1.147×+ 1.052 ($R^2 = 0.939$), in M7 cultivar y= 1.116 x + 1.824 ($R^2 = 0.962$) and in L17 cultivar y= 1.135 x + 0.865 ($R^2 = 0.976$). **Conclusion:** Developed model was calculated y= 3.46344 – 12.73172 ln LA + 0.827 LW + 9.47628 LL + 12.20208 ln LW + 0.05655 hWW + 0.00074436 h LW. Relation among L×W and actual leaf area in all of the cultivars y = 1.129×+ 1.344 ($R^2 = 0.965$). (h = half)

Key word: Soybean, leaf area, modeling, cultivars, long and width leaf

INTRODUCTION

Soybean (*Glycine max* L.) cultivated mainly for its seed, which is used as edible oil and for protein source of humans and animals. It is an important oilseed crop with 19-22% oil and 36-40% protein content.

The average of soybean grain yield in Iran is 2.4 ton per hectare comparison to 2277 ton/ha in the world.

Leaf area production is essential for energy transference and dry matter accumulation processes in crop canopies. It is also useful in the analysis of canopy architecture. Leaf area and its changes during plant growth also is an essential for plant growth analysis and evapotranspiration studies (Enoch and Hurd, 1979), chlorophyll contents studies under stress condition (Paknejad *et al*., 2009) and therefore has a large influence on growth (Boote *et al*., 1988; Arias *et al*., 1989; Bhatt and Chanda, 2003), transpiration and growth rate (Leith *et al*, 1986; Necdet *et al*., 2005).

Determination of leaf area index through the plant cycle is important, because this traits has positive correlations with grain yield. Measurement of leaf area divided to non-destructive and destructive ways. The Non-destructive way is very simple but need to expensive instrument. Usually in destructive way almost used by means of leaf area meter. This instrument is very expensive and very sensitive for calibration. Many researchers show that determinate mathematical model in between some of leaf measurement parameters, may be help to reduce of consume time and feasibility its.

Hence the need to develop economically cheaper and technically easier but sound method is needed for leaf area measurement (Korva and Forbes, 1997; Montgomery, 1911). Prediction equation leaf area in some of crops such as cotton, corn, wheat and cucumber conducted previously by researchers. Almost for makeup model of leaf area was used length, width parameters. Reported that Model y= - 201.2558 + 12.409 L + 13.359 W was best model for leafs with Length>16 cm in sugar beet.

Aim of this experiment was develop of linear regression models that can predict soybean leaf area by use of simple linear model and reduce of parameter number.

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MATERIAL AND METHODS

Soybean (*Glycine max* L.) cultivars comprise of Williams, Zane, L17 and M7 (in type 3 with indeterminate growth condition) cultivated in four sowing date as experimental material. The research was conducted in Karaj, Iran (35° 45' N lat 50° 56' E long and 1313 m elevation), place on Alborz province in Iran. Sampling of leafs was conducted in different stage of vegetative and reproductive stage. Precipitation mean in Karaj is 240 mm and temperature mean is centigrade.

The experiment was split plot in base of Randomized Complete Block Design with four replication. After seeding, plant density considered equal to 25 plant m^{-2}. Four cultivars planted in four sowing date with 10 days interval comprise of 19 may, 30 may, 8 June and 21 June respectively. Leaf number sampled was four leaves each plot in 6 times with 10 days interval. A total 1500 leaves scanned by holding flat and copied on A4 paper then leaf area individual were measured by AOUTOCAD mathematical software one by one. The measurements parameters comprise of leaf Width (W) from tip to tip at the widest of the lamina and leaf length (L) from lamina tip to the connected place petiole to lamina. Multiple regression analysis was performed on the cultivars together and also each cultivar individually. Then we looking forward to by means of independent variables, comprise of length (L), Width (W), length width (W× L), length square × width (L^2×W), lnW, ln L, ln LW, ln L×ln W, half of L×W (h LW) and length×width square (L×W^2). The best predicted equation for the Leaf Area (LA) of soybean was determined by use of SAS software until was selected the best equation with high R^2 and also simplest model.

RESULTS

Results Pierson correlation (Table 1) showed that between actual leaf area relate to leaf width (R^2 = 0.89), L×W (R^2 = 0.98), W^2 (R^2 = 0.9), ln L×ln W (R^2 = 0.9), ln LW (R^2 = 0.87) and $(LW)^2$ (R^2 = 0.93) have been significant positive correlation (p<1%).

Fig .1.A. showed that between L×W and actual leaf area in Zane cultivar have been equation y = 1.173×+ 0.984 (R^2 = 0.92). Fig. 1.B. showed that between L×W and actual leaf area in Williams cultivar have been equation y = 1.147 x + 1.052 (R^2 = 0.939). Fig. 1.C. showed that between L×W and actual leaf area in M7 cultivar have been equation y = 1.116×+ 1.824 (R^2 = 0.962).

Fig. 1.D. showed that between L×W and actual leaf area in L17 cultivar have been equation y = 1.135×+ 0.865 (R^2 = 0.976).

Figure 2 shows all of the cultivars line located on the some line, therefore we can use equation Fig. 2 for all of the four cultivars. Because of the cultivars cultivated in four sowing date and also leaf

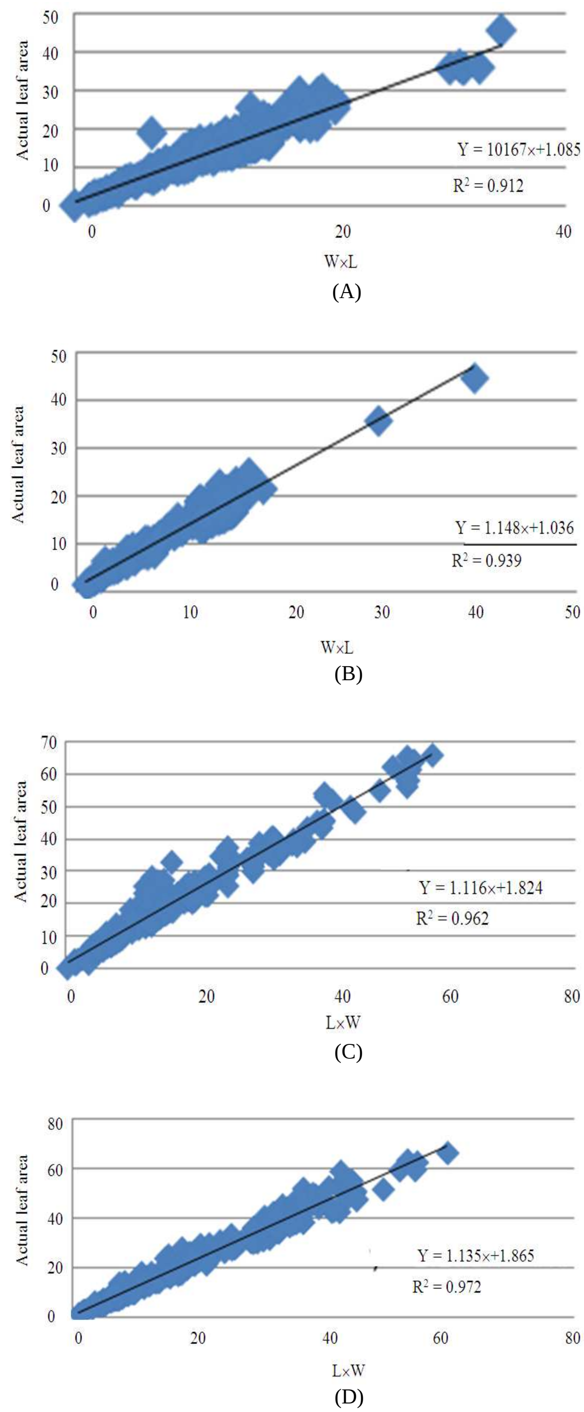

Fig. 1: (A) Relation regression between L×W and actual leaf in Zane cultivar (B) Relation regression between L×W and actual leaf in Williams cultivar (C) Relation regression between L×W and actual leaf in M7 cultivar (D) Relation regression between L×W and actual leaf in L17 cultivar

Table 1: Results of pierson correlation among Leaf area, Ln LA, Length, Width, LW, LL, WW, lnw, ln L ln W, ln LW, hLL, hWW, hpLW and ln L

	Leaf area	ln LA	Length	width	LW	LL	WW	LnW	lnL lnW	Ln LW	hLL	hWW	hpLW	LnL
Leaf area	1	0.80341**	-0.01705	0.89574**	0.98264**	-0.01867	0.9099 **	0.81822**	0.90512**	0.87569**	-0.01867	0.9099 **	0.93944**	0.63254**
Ln LA		1.0000	0.32889 **	0.78693 **	0.082911 **	0.32721 **	0.71453 **	0.83797**	0.95203**	0.92418**	0.32721**	0.71453*	0.66976**	0.91826**
Length			1.00000	-0.00832	-0.01748	1.00000 **	-0.00969	-0.00491	0.26360**	-0.01523	1 **	0.00969	-0.01298	0.50561 **
Width				1.00000	0.91638**	-0.00955	0.97617**	0.9586 **	0.89758 **	0.81916**	-0.2955	0.97617**	0.85808**	0.50552**
LW					1.00000	-0.01914	0.92371**	0.84509**	0.92960**	0.87501**	-0.01914	0.92371**	0.85808**	0.65228**
LL						1.00000	-0.01085	-0.00622	0.26198**	-0.01699	1**	-0.01085	-0.01433	0.50395**
WW							1.00000	0.88133	0.85733**	0.748553	-0.01085	1**	0.92247**	0.55339**
Lnw								1.00000	0.87884**	0.86789**	-0.00622	0.88133**	0.73126**	0.55339**
LnL lnW									1.00000	0.89666**	0.26198**	0.85733**	0.81446**	0.81538**
Ln LW										1.00000	0.89666**	0.74853**	0.71146**	0.78082**
hLL											1.00000	-0.01085	-0.01433	0.50395**
hWW												1.00000	0.92247**	0.45109**
hpLW													1.000000	0.49165**
LnL														1.00000

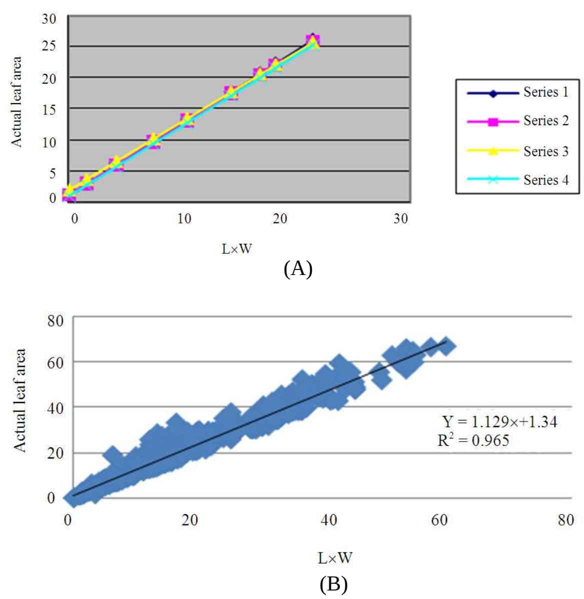

Fig. 2: (A) shows that among L×W and actual leaf area in all of the cultivars have been equation y = 1.129 + 1.344 (R^2 = 0.965) (B) shows that among L×W and actual leaf area in all of the cultivars have been equation y = 1.129 + 1.344 (R^2 = 0.965)

sampling conducted in different growth stage therefore in this experiment have been variation environmental effects. Therefore equation obtained in Fig. 2 is very important and applied.

Among of the cultivars, L17 cv have been highest R^2 = 0.976 and Zane cv have been lowest R^2 = 0.92.

Stepwise ways showed that in the first stage with import LW to model (R^2 = 0.96) then with import Ln LW, hL×W, ln LA, LL and hWW to the model, rate of R^2 increased to 0.99. Therefore developed model was calculated y = 3.46344-12.73172 ln LA+0.827 LW+9.47628 LL+12.20208 ln LW+0.05655 hWW+0.00074436 h LW.

Many researchers reported that leaf area can be estimated by linear measurement such as leaf width and leaf length in the some of plants such as: cucumbers (*Cucumis sativa* L.) (Robbins and Pharr, 1987) French bean (*Phaseolus vulgaris* L.) (Rai *et al*., 1990) and Broad bean (*Vicia faba* L.) (Odabas *et al*., 2009) and also found that were close relationship between leaf area value, leaf length and leaf width for these plants (R^2 = 0.76-0.99 for cucumber, R^2 = 0.89-0.93 for French bean, R^2 = 0.95-0.98 and R^2 = 0.99 for Broad bean).

DISCUSSION

In all of cultivars between L×W and actual leaf area have been equation y = 1.173×+ 0.984 (R^2 = 0.92), y = 1.147 x + 1.052 (R^2 = 0.939), y = 1.135×+ 0.865 (R^2 = 0.976), y = 1.116×+ 1.824 (R^2 = 0.962) for Zane, Williams, M7 and L17 respectively.

Among L×W and actual leaf area in all of the cultivars have been equation y = 1.129 + 1.344 (R^2 = 0.965). We proposed that using of equation y = 1.129 + 1.344 (R^2 = 0.965) for all of cultivars because this equation is the more applicatory. Perhaps reason of the decreasing of the correlation coefficient in Williams and Zane cultivars was correlated to higher variation in leaf shape under environmental condition variety. If we measured leaf area in each of growth stage and then obtain one equation for each stage, as result would increase in correlation coefficient rate.

CONCLUSION

The highest regression correlation between L×W and actual leaf area was belong to M7 and L17 to rate

R^2 =0.96, R^2=0.97, respectively. Also the lowest regression correlation was between L×W and actual leaf area belong to Williams and Zane to rate R^2= 0.93, R^2=0.92, respectively. We proposed that using of equation y = 1.129 + 1.344 (R^2 = 0.965) for all of cultivars is the more applicatory.

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