ESTIMATION LEAF AREA MODEL AND GROWTH PERFORMANCE OF BUCKWHEAT UNDER IRAQI ENVIRONMENT CONDITIONS

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ABSTRACT

Three separate experiments were conducted during the growing season 2013. The first one was applied to estimate leaf area of buckwheat *Fagopyrum esculentum* Moench Var. Hruszowska via a simple model derived from triangle area. Leaf parameters; height (h) and the baseline (b) were combined as an equation of triangle area then adjusted. Two models were compared with the conventional method (Millimeter graph paper) using simple linear regression. Regression analysis showed that the two models could be used for determining leaf area of buckwheat. The model equation of (((1/2BC.AG)-(1/2EF.DG)).(1/2EF.DG) /(1/2BC.AG)-(1/2EF.DG)) gave the most accurate estimate (r2=0.989, with linear equation of 0.707x+0.596). The second experiment was conducted to determine the effect of sowing dates on growth performance of buckwheat. Results showed that the buckwheat seed sowing at 6th September was significantly improved number of leaves per plant11.83, inflorescences per plant19.33 and seeds per plant 47.67. As well as, plants were sown in this date were taken the lowest period from sowing to germinate. The third experiment was applied to evaluate growth response of buckwheat under two locations. Al-Fallujah location was the best one wherein the most growth parameters were increased compared with other location. As a result, the proposed linear equation could be replaced with the derived model equation above (x= calculated area, y= adjusted area) to estimate buckwheat leaf area. Furthermore, al - Fallujah location was fitted to establish buckwheat and this plant could be sown at Sept6. Thus, it could be recommended that multi-environment test it is very important to evaluate proposed leaf area model.

Key words*:* Buckwheat; Leaf area model; Sowing Date; Growth performance.

INTRODUCTION

Common buckwheat or scientifically called *Fagopyrum esculentum* Moench is a plant species from the group of alternative cereals belongs to the Polygonaceae family and becoming increasingly as an important grain crop which involved in the usage of humans and domestic animals nutrition. It is known as a common plant since old times in Asia and eaten as a traditional food (Cawoy *et al*., 2009; Koyama *et al*., 2013). Buckwheat classified as a pseudo-cereal; a short season crop. Productivity and cultivated areas of this crop have been increased in worldwide and beginning to compete with wheat due to its consumption as a healthy substitute for wheat flour especially for allergic patients, which improves their health via lowering serum cholesterol, stunting gallstones and tumors (Tomotake *et al*., 2000; Liu *et al*., 2001). Buckwheat seeds featuring by high protein content as compared with wheat seeds. Furthermore, buckwheat possesses of a proper content of Rutin; A phenolic compound found in many plants and contributed as an antibacterial (Cho, 2015). Determination of the optimum growing conditions definitely, planting location and sowing time considered the most important environmental factors involved to give the best vegetative growth resulting from optimization of solar radiation consumption and photosynthesis efficiency, which leads to improving the final yields quantitatively and qualitatively especially in widespread annual plants such as buckwheat (Sobhani *et al*., 2014). Guo *et al.* (2011) reported that the interaction between buckwheat varieties and environmental factors may contribute more to individual antioxidant properties and phenolics. As well as, Drazic *et al*. (2016) stated that the analysis of variance showed the existence of significant differences in the rutin content depends on the variation of buckwheat growing locations. On the other hand, the optimum sowing date also has a great potential by enhancing the growth traits and yield components in buckwheat especially which enhance the final yield, such as the crop growth rate (CGR), the weight of 1000 seeds and harvest index (Sobhani *et al*., 2012). In addition to this, Omidbaigi and Mastro (2004) mentioned that the buckwheat plants that sown at the early date improved the traits studied as compared with other tested sowing dates.

Leaf area index is an important variable scale for assessing the growth and vigor of vegetation under available environmental factors especially in small cereal crops. According to Pandey and Singh (2011) leaf area is the most responsive physiological trait that correlated with numerous agronomic and physiological processes. Also, the leaf area considered as an eligible variance studied in the most of the environmental and physiological investigations (Blanco and Folegatti, 2005). Bavec *et al*. (2002) stated that the best yield production should be given by determining separately for any production system which was planted in full season cropping possessed higher leaf area index, more flower clusters, and more developed seeds. Moreover, Odabas *et al.* (2009) found a strong relationship between actual and predicted growth parameters and leaf area. Based on this, plant scientists; breeders, geneticists, agronomists and physiologists were interested in creating an easy and precise estimation of leaf area such as Rouphael *et al*. (2007) which extracted linear equation had W2 (W= leaf width) that supplied the highest precisely estimation of sunflower crop which is (r2=0.98, MSE= 985). In another study on the sunflower's leaf area, Tsialtas and Maslaris (2008) found that the estimated LA (leaf area, cm^2) was exponentially related to L (Length, cm). The leaf dry mass also has been utilized to estimate leaf area like a study conducted in the leaf dry mass of buckwheat to estimate leaf area by using linear regression; it has been highly accurate at 99% (Kajfez and Oresnik, 1989).

Nowadays, the buckwheat crop began to attract a great interest in Iraq due to its promising nutritional value. Knowledge of buckwheat planting under Iraqi irrigated areas has not been established till now. Therefore, the aim of the present study was to design the appropriate model in order to find an attractive method to estimate leaf area in buckwheat and evaluate the growth performance of this crop in two locations and various sowing dates by obtaining the best growth location.

MATERIALS AND METHODS

Estimation For leaf area model: To create leaf area model to be usable for the estimation leaf area in buckwheat triangular leaves, an experiment was conducted separately by random selection of 20 plants (27 leaves of each plant) to establish a relationship between the leaf area parameters. The dimensions of each leaf of all selected plants were calculated according to the principles triangle shape wherein the buckwheat leaf is approximately similar to the triangle shape. The dimension (h) was measured from the lamina tip to the point of lamina-petiole intersection, while dimension (b); the triangle baseline distance, represented by the maximum distance perpendicular to the line of the point of lamina-petiole. The millimeter graph paper method was used to determine the leaf area, where the twenty-seventh leaves from each plant were projected. Then, the number of millimeters was counted and be fitted with equation of

A= 1/2b.h…………………………..……..1

Wherein A is the triangle area (cm^2),

b is the triangle baseline distance (cm).

h is the height of the triangle (cm).

This equation needs to adjust to being corresponding to leaf area using correlation and regression analysis, which the criterion of selecting the best-fitted curves was the high R2.

The used models are

Leaf area= total triangle area – small triangle area (cm^2)

=ABC area-DEF area……………………… (Fig.1)

=(1/2BC.AG)-(1/2EF.DG)……………….…………...…….2

$$\text{Leaf area} = \frac{\text{The filling leaf triangle area x non- filling small triangle area } (cm^2)}{\text{The filling leaf triangle area } (cm^2)}$$

$$\text{Leaf area} = \frac{((1/2BC.AG)-(1/2EF.DG)).(1/2EF.DG)}{(1/2BC.AG) - (1/2EF.DG)}$$

Figure 1. Proposed model of buckwheat leaf area measurement

Growth performance assay: Two field experiments were conducted during 2013 season using buckwheat Var. Hruszowska which obtained from the Lupnik station of crop research, Agricultural University of Szczecin, Szczecin, Poland. The first experiment conducted at Al-Ramadi-Iraq 33°25′11″N 43°18′45″E to evaluate the growth performance components of buckwheat crop under three sowing dates; 6th Sep, 14th Sept and 24th Sept. The soil type was loamy sand. The other experiment was conducted to evaluate the growth performance components of buckwheat crop under two locations; the first one was at Al-Ramadi (as mentioned above) and the other one was in Fallujah-Iraq 33°21′13″N 43°46′46″E. The soil type was loamy clay. The experiments in both locations were conducted on 24th September. The plot area in each experiment was 3x2m. The distance between rows was 30cm and between holes at the same row were 15cm. Three seeds were put in each hole and then, seedlings were thinned to one seedling/hole when the seedling height was 15cm high. Irrigation and fertilizer were applied as recommended (Inamullah *et al*, .2012). The traits; days from sowing to germination (DTG) and days from sowing to flowering (DTI) were recorded in time. While the other traits; the growth traits and yield components; plant height (cm), branches per plant, leaves per plant, inflorescences per plant, seeds per plant recorded when the buckwheat plants reached the maturity stage. Both experiments were conducted using a completely randomized block design (RCBD) and each experiment was replicated three times.

Statistical analysis: Data were subjected to one-way analysis of variance (ANOVA), using the SPSS software package version 22.0. Differences between means were compared using Fisher's least significant difference test (LSD: P ≤ 0.05). The leaf area model was fitted using standard regression and correlation methods.

RESULTS AND DISCUSSION

Leaf area models: In order to normalize the change in buckwheat leaf area statistically using each one of the equations above, the relationship between leaf areas estimated using the two models and leaf area measured by millimeter graph paper and combined in the linear regression analysis (Fig.2 and Fig.3). To derive the best fitting regression relationship between them, measured leaf area was applied by using millimeter graph paper. Consequently was plotted against green leaf area estimated using equation 1 (triangle principles) after adjusted to equation 3. Thus the model that described the relationship is summarized as:

Leaf area= 0.707x+0.596

Where R2=0.989 n=540

As can be seen from Figure.2, the model showed that R^2 is 0.989 with a slope of 0.596. From this statistical point, it could be concluded that 98.9% of the divergence in the estimated leaf area could result from the two dimensions as a triangular area. Where the millimeter graph paper was most effective to fit fills leaf area estimated via principles of triangle i.e. the (Equation 1).

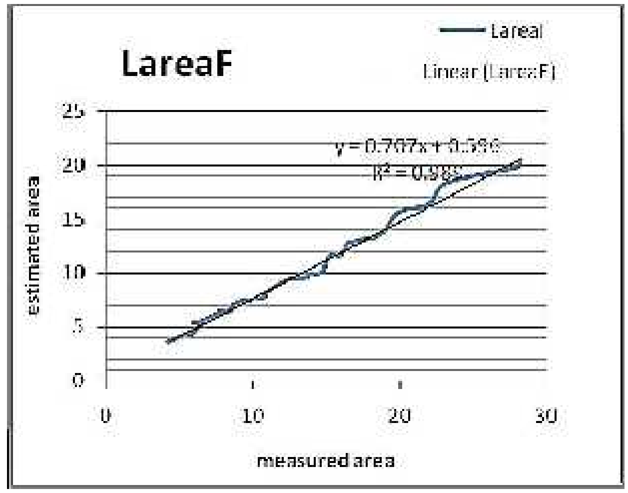


Figure2. The relationship between leaf areas measured with millimeter graph paper (x) and leaf area estimated with triangle dimensions (y), Larea F: Filling leaf area (Eq.3)

Fig.3 represents the total leaf area (Area T) accounted by the green filling leaf area plus a small triangle area that had not an extension of green leaf area. Thus, the relationship was fitted using linear regression analysis. So the results could summarize as:

Leaf area T = 0.913X+0.062

R2=0.979 n=540

The model above stated that R2 is equal to 0.979 plus to slope close to 0.062. That is mean that 97.9% of the variability in leaf area could be due to the two dimensions of leaf area estimated as triangle area which is less than the prior model with 1 percent, i.e. in spite that the model in equation 3 was adjusted using some parameters in equation2, the model from equation3 is better than from equation2 as using regression analysis because the equation3 used only green filling dimensions as millimeter graph paper used.

The analysis of regression showed that the two models had a large positive intercept of 0.707 and 0.913, respectively. However, the model extracted from Eq.3 had a shape coefficient (Slope of Eq.3) of 0.596 larger than of Eq.2. Where the selected parameters of the model that will be fitted such as height and baseline as in this study (dimensions of the leaf) are very necessary as least variables number that will be required to predict the leaf area. A large positive degree of correlation derived via using the two models revealed accounted evidence for this method of leaf area estimation (Fig.2 and Fig.3).

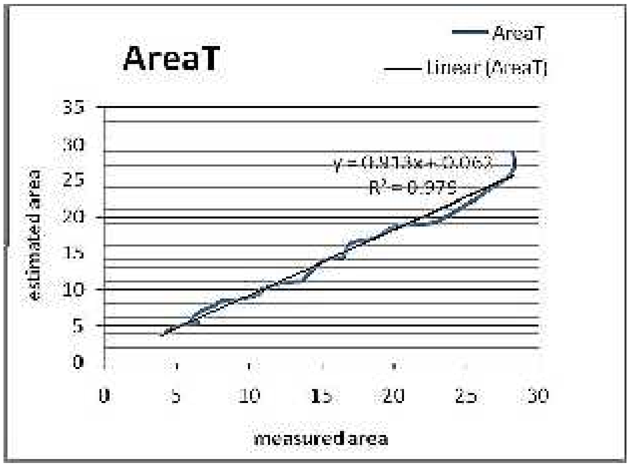


Figure 3. The relationship between leaf area measured with millimeter graph paper (x) and total leaf area estimated using triangle dimensions(y). Total leaf area (Eq.2).

Growth performance

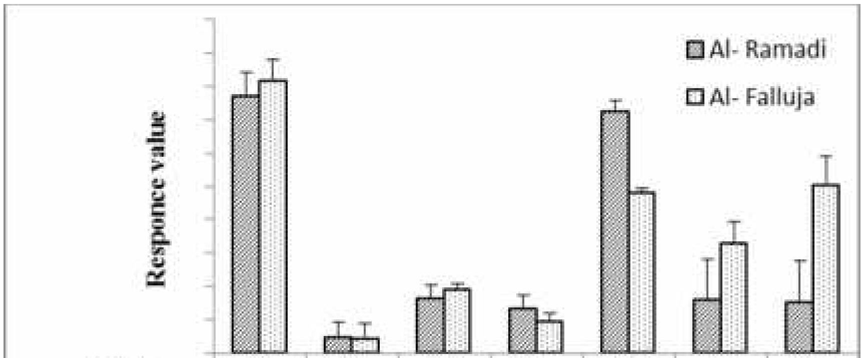
***Sowing dates*:** Results of statistical analysis (ANOVA, P≤ 0.05) presented in (Table 1) showed the growth performance of buckwheat presented by the studied traits under three sowing dates, 6th, 14th and 24th September. Although the plant height was increased when sown at the late sowing date; 24th September (38.67cm) as compared with the other applied dates, 6th September (35.67cm) and 14th September (34.33cm), there are no significant differences observed between all of them. Also, the various sowing dates did not record significant differences in terms of affecting the number of branches per plant and came in the same value (2.33 branch /plant). Regarding the other studied traits; the early sowing date; 6th September has achieved the best results and differed significantly as compared with the other studied dates in traits; the number of leaves per plant (11.83), inflorescences per plant (19.33) and seeds per plant (47.67). Furthermore, buckwheat plants under the early sowing date spent fewer days to germinate (3.00d) and fewer days to inflorescences (19.33d). Overall, the early sowing date is an effective date among other studied dates wherein buckwheat plants grow faster due to the optimum growing conditions defiantly, temperature and appropriate weather. The optimum growing conditions resulting in transmitting more nutrients and photosynthetic materials to the reproductive parts (Sobhani *et al.*, 2012). Our results came in the lane with results of Alekseyeva *et al.* (2001) who pointed out that the most appropriate sowing time for buckwheat when sown in irrigated rice area of Ukraine is the first half of July wherein the buckwheat grain yield plants which were sown during this period was (1.20 ton. hectare^{-1}) and significantly differed from the other studied dates which gave grain yield ranged from 0.80 to 0.87 ton. hectare^{-1}. Podolska (2016) also indicated that seeding time impacted on rutin content in buckwheat seeds which determined by growth and plant development. The results of the current study supported by earlier studies wherein determining the sowing time could be proposed as an optimal cropping system to increase grain yield and improving the quality (Japhet *et al*., 2009; Jung *et al*.,2016; Lukach and Hanson,2009).

***Growing location*:** Figure.4 showed the growth performance of buckwheat plants under two growing locations. There is a histogramatical difference between the two growing locations conducted. Wherein buckwheat plants demonstrated the best performance when sown at Al-Fallujah location as compared to plants that sown at Al-Ramadi in most studied traits which coming y the best means in traits; plant height (41cm), leaf per plant (9.5), inflorescence per plant (16.6) and seed per plant (25.2). Moreover, buckwheat plants were needed a little time to germinate (4.67d), as well as for releasing inflorescences (24.0 d).

In contrast to this, the plants grown under Al-Fallujah location recorded less value in term of the number of branches per plant (2.27), while the same trait recorded (2.33) at Al- Ramadi Location. The application of Multi-location trials is very important and necessary to detect the specific environment that will be suitable for the growth performance of buckwheat genotypes. From this particular point, the properties spatial variance of the two locations might contribute to trait variance. The findings of the current study in agreement with the study of (Podolska. 2016) which stated that the chemical composition of buckwheat nuts is mostly influenced by weather conditions during the growing period.

Table 1. Buckwheat growth response under various sowing dates at al- Ramadi location.

Sowing dates	Traits						
	Plant Height	**Branch/ plant**	**Leaf/ plant**	**DTG**	**DTI**	**Inflourence /plant**	**Seed /plant**
6th September	35.67	2.33	11.83	3.00	19.33	19.33	47.67
14th September	34.33	2.33	6.67	4.00	19.67	7.67	12.33
24th September	38.67	2.33	8.20	6.69	36.33	8.00	7.67
LSD 0.05	n.s.	n.s.	2.65	0.76	2.00	1.85	5.76



Traits	Ph	Bp	Lp	DTG	DTI	Ip	Sp
Al- Ramadi	38.67	2.33	8.20	6.69	36.33	8.00	7.67
Al- Falluja	41.00	2.27	9.50	4.67	24.00	16.60	25.20

Figure 4. Response value of buckwheat studied traits under two growth locations

Ph: Plant height (cm), Bp: Branch/plant, Lp: Leaf /plant, DTG: days from sowing to germination, DTI: days from sowing to flowering, Ip; inflorescence/plant, Sp: Seed/plant.

Conclusions: The present study revealed that the proposed mathematical models could be usable for determining leaf area of buckwheat. As well as, suitable location and sowing time considered the most important and effective factors to develop buckwheat production by identifying the best environmental factors. Further studies to detect additional climate conditions under irrigated Iraqi areas is required to evaluate the proposed leaf area model and develop the production of this promising crop.

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