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ORIGINAL ARTICLES

New Computer Program for Estimating Leaf Area of Several Vegetable Crops

[1]S.K. Sadik, [2]A.A. AL-Taweel, [2]N.S. Dhyeab

[1]College of Agriculture, University of Baghdad, Baghdad, Iraq.
[2]Integrated Pest Control Research Center, Ministry of Science and Technology, Baghdad, Iraq.

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ABSTRACT

Measurement or estimation of leaf area is essential for understanding crop responses to experimental treatments. The objective of this study was to introduce new program for personal computer for estimating leaf area. Therefore, five plant species were selected for this study, Potato(*solanum toberosum*.L), Cucumber (Cucumis sativus L , Cauliflower (*Brassica oleracea*),Cabbage (*Brassica campestris* L.) and Melon (*Cucumis metuliferus*). Results showed that no significant differences in the leaf area between the three methods (meter c1-202, weight method and new computer software), the leaf area estimated by applying multiple regression equation was more highest if compared with the other two methods because the leaves of vegetable crops which used in this study differ in shape. From these results we suggest to use the computer method for estimating leave area because it was accurate method and could be used at any time after the photo of leaf plant or scanner image of the leaf were taken.

Key words: program, measurement, leaf area, vegetable crops.

Introduction

The leaf area of any crop is a determinant factor in mechanisms such as radiation interception and water and energy exchange. Therefore, accurate measurements of Leave Area Index (LAI) are essential to understand the interaction between crop growth and environment (Blackman, 1919). Light interception is important for crop therefore has a large influence on growth (Boote, 1988), transpiration (Enoch, 1979) and growth rate (Leith, 1986). Leaf area is essential for energy transference and dry matter accumulation processes in crop canopies, leaf area estimated is very important in studies related to plant growth and it is the interaction between the plant and surrounding environmental (de Jesus, 2001). Leaf area index (LAI) is the ratio of total upper leaf surface of vegetation divided by the surface area of the land on.LAI is a dimensionless value typically ranging from 0-6. Thus influence by arrangement of leaf on stem (Alboudi, 2005). LAI is used to predict photosynthetic primary production and reference tool for crop growth as such, LAI plays an essential role in theoretical production ecology. LAI reflects the efficiency of fertilizer to increase the vegetative growth. this index is often used in reduction conversion efficiency models and in modeling photosynthesis response of the canopy to incident light (Al-Sahaf, 2004).

There are many methods available for measuring leaf area. a direct method require stripping and measuring the foliage of plant canopy sample.Montgomery (12) is a first suggested that leaf area of plant can be calculated from linear measurement of leaves using a general relationship A=b×I×W where b is a coefficient (Montgomery, 1911), moreover There are several reports which suggest calculation of leaf area from leaf dry weight data (Sharrett, 1985; Ma, 1992). Measurement of leaf area in vegetable crops like potato, cucumber, with various types of leaf area is difficult because there is much variation in number, size and shape of the leaves (Reddy, 1989).

Furthermore, measuring instruments are very expensive and often not available in developing countries (Daughtry, 1984), therefore attempts for measuring leaf area using personal computer and handy scanner first

Corresponding Author: Ayad A.AL-Taweel, PhD, Integrated Pest Control Research Center, Ministry of Science and Technology, Baghdad, Iraq.
E-mail: ayadaltaweel51@yahoo.com

was suggested by Flading and Ritter (1990) then a new software developed and namely compu Eye leaf and symptom area by (Baker, 2005), In this study we use the new software for measuring leaf area of five crop vegetable and several variety for each crop.

Materials and Methods

2-1 Collecting Leaf Sample:

Collecting leaves from the individual plant species should be randomly carried out and should have their foliage exposed to light.whole leaves including the petiole should collected. as most leaf traits were rather variable within plants, it was recommended that for each species two randomly sample were collected and kept into heavy plastic bags.

2-2 Measuring Leaf Area by Meter c1-202:

Leaves area were calculated by using the leaf area meter c1-202.(American made) this procedure depended on placing leaf on the slide and cover it by layer of plastic paper and then scanner hand passed over the leaf, the area will be appeared by digital monitor (Fig 1).

Fig. 1: Meter c1-202.

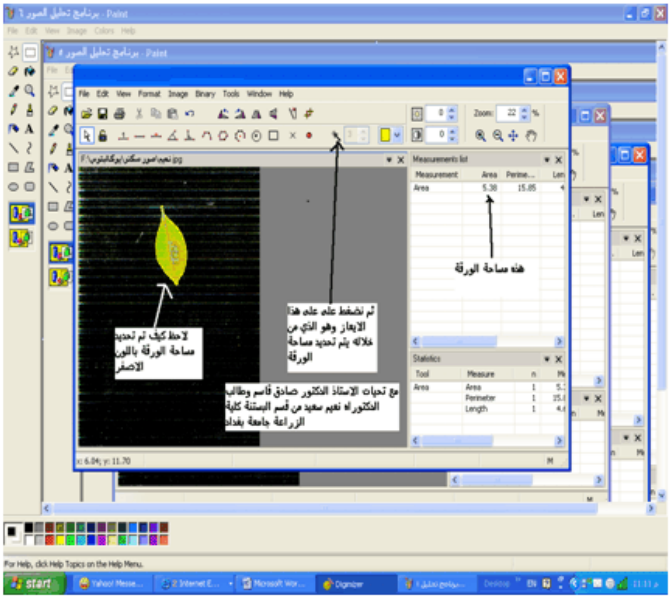

Fig. 2: Software computer.

2-3 Measuring Leaf Area by Multiple Regression Equation:

Leaf area was calculated by measuring width of the leaf and then applying any of the linear regression or multiple linear regression with two independent variable.

2-4 Measure Leaf Area by the Weight:

Each leaf was cut off from the plant and then divided into three sections, then area of each section calculated. Each section was put in individual paper bag and brought to the laboratory to measure leaf area and dry weight (de Jesus *et al*, 2001). To calculate true leaf dry weight, all leaf sections were dried in on oven with flow hot air (70ºC). The time to obtain a constant weight varied and depended upon crop leaves structure of the vegetable studies and could required about 96 hours, while leaflets required 48 hours. Dry weight was determined with an electronic balance.

2-5 Measuring Leaf Area by New Personal Computer Software and Scanner by:

This method depended upon imaging the leaf by digital camera or by scanner then this image was introduced to computer program which will provided the area (Fig2). The results could be saved and it look like a spreadsheet (but it is actually a.txt, or 'text' file, despite choosing.xls as a file extension.

2-6 Statistical Analysis:

The averages of leaves area calculated by using the three methods were compared by the least significant differences with CRD at a significant level of 0.05 using the Genstate program (2000).

3- Results:

The results illustrated a significant differences in the leaf area which estimated by different methods. Table (1) showed that the leaf area in the variety Innova 1400 recorded highest value in leaf area (210.1 cm^2) compared with variety Innova 1431 which recorded the lowest leaf area value (137.7 cm^2). Furthermore the leaf area that estimated by Regression equations method gave high value also (186.3 cm^2) in comparison with other methods that gave equal values, This results also showed no significant differences between LA Matter, Weight methods and New computer program methods.

Table 1: Leaf area measurement for several varieties of cucumber (*Cucumis sativus* L) crop by using diffrent methods.

Variety	leaf area measurement methods (cm^2)				Mean
	LA Matter	Regression equation	Weight methods	New computer program	
Innova 1407	153.58	180.6	160.54	143.54	159.6
Innova 1431	136.64	155.0	130.21	128.99	137.7
Innova 1405	177.69	254.0	180.55	177.24	197.4
Innova 1400	190.72	252.5	200.11	197.21	210.1
Apollo fuyu	132.34	162.3	166.25	131.35	148.1
Apollo brait	143.24	146.9	150.22	145.01	146.3
Apollo Jamila	168.97	184.9	180.77	173.83	177.1
P.S Amjad	153.10	154.6	165.88	159.74	158.3
Mean	157.0	186.3	166.8	157.1	

LSD = Program 6.99 LSD = Variety 9.89 LSD = Interaction 19.78

Data presented in table (2) showed significant differences in leaf area that calculated by different methods, values appeared approximately very similar especially in using New computer program and LA Matter methods, however of leaf area the maximum value (71.63 cm^2) found in regression equations method and minimum value (63.14 cm^2) found in the meter c1-202 method. So results in table (2) demonstrated that Vestri variety had the largest leaf area (84.72 cm^2) while Atria Variety had smallest leaf area (51.80 cm^2) than other varieties.

Moreover, the results in table (3) indicated a significant differences between all methods that used to estimate the leaf area for potato varieties, leaf area that calculated by Regression equations method showed highest value (56.26 cm^2), while leaf area which calculated by New computer program showed lowest value (39.57cm^2), on other hand, leaf area of Kuroda variety recorded highest value (76.86cm^2) while leaf area of Apollin variety was recorded the lowest value also (17.67 cm^2).

Table 2: Leaf area measurement for several varieties of cabbage crop (*Beassica campestris* L.) by using different methods.

Variety	leaf area measurement methods (cm²)				Mean
	LA Matter	Regression equation	Weight method	New computer program	
Atria	43.12	65.39	51.33	47.35	51.80
didane	64.10	75.40	70.56	65.34	68.85
Paltav	62.65	70.31	70.33	64.94	67.06
Vestri	88.16	86.33	83.44	80.94	84.72
Tobia	62.88	60.72	60.24	57.14	60.24
MEAN	64.18	71.63	67.18	63.14	

LSD = Program 0.31 LSD = Variety 0.34 LSD = Interaction 0.69

Table 3: Leaf area measurement for many variety of potato *Solanum toberosum.*L crop by using diffrent methods.

variety	leaf area measurement methods (cm²)				MEAN
	LA Matter	Regression equations	Weight methods	New computer program	
Rosetta	33.44	61.31	41.22	35.09	42.76
Bareen	69.42	92.76	62.47	59.05	70.92
pamela	22.13	32.81	22.55	20.88	24.59
Apollin	15.21	24.1	17.45	14.29	17.76
Yana	30.15	46.9	33.56	29.90	35.13
Daifla	47.94	54.60	50.87	45.48	49.72
Rosanna	48.65	65.07	51.1	45.26	52.52
Elbaso	62.95	95.38	65.36	61.09	71.19
Draga	32.18	52.47	40.54	34.23	39.85
Meadeleine	38.97	59.27	43.22	38.26	44.93
Arnova	45.99	61.38	44.74	42.05	48.54
Red Baron	20.20	28.9	25.58	21.49	24.04
Pravento	25.43	30.36	26.32	23.91	26.50
Alodin	21.61	31.90	24.25	21.86	24.90
Santa	17.04	27.58	22.35	18.17	21.28
Desiree	56.99	75.09	55.89	53.16	60.28
Rivera	48.90	60.20	45.75	44.12	49.74
Kuroda	71.12	85.25	78.58	72.51	76.86
Fontane	59.64	83.70	62.14	59.26	66.18
Agria	25.42	44.21	25.41	22.09	29.28
Arizona	16.96	23.93	22.12	18.61	20.40
Ambition	61.60	72.28	50.41	56.67	60.24
AR 97576	39.59	45.99	44.12	38.38	42.02
Avalon	68.49	74.99	70.14	64.24	69.46
Pekaro	44.76	75.96	55.14	49.15	56.25
Mean	40.99	56.26	43.25	39.57	

LSD = Program 0.97 LSD = Variety 2.43 LSD = Interaction 4.86

The data in table (4) also showed significant differences in leaf area between all methods that used in this study for cauliflower but leaf area that calculated by weight methods gave the highest value (47.10 cm^2) compared with leaf area that estimated by new program computer which recorded the lowest value(43.73 cm^2). The result showed that Cornetl variety had the largest leaf area (80.12 cm^2) compared with other variety especially Vinson variety which recorded the lowest value (12.77 cm^2).

Table 4: Leaf area measurement for many varieties of Cauliflower crop *Brassica oleracea* by use vary methods.

Variety	leaf area measurement methods (cm²)				Mean
	LA Matter	Regression equation	Weight method	New computer program	
Conero	55.74	65.62	62.21	59.71	60.82
Vinson	12.75	11.53	15.44	11.36	12.77
Feddah F1	29.13	33.26	33.25	28.68	31.08
Bromha	56.70	59.93	64.21	58.20	59.76
Kerdos	48.29	58.54	55.25	49.70	52.95
Preedom	50.69	56.84	55.12	53.30	53.99
Steady	42.06	52.62	50.14	47.10	47.98
Casper	42.42	39.99	40.14	39.74	40.57
Super white	39.76	39.85	40.14	39.33	39.77
Indam	43.32	45.67	44.25	42.10	43.84
Spacestar	32.44	38.92	40.12	36.59	37.02
Cornetl	84.03	69.85	84.65	81.96	80.12
Royal 05945691	38.85	35.85	40.45	34.20	37.34
Anahar	68.52	62.33	70.54	65.63	66.75
Solid show	22.95	25.50	25.23	23.04	24.18
chieftain	42.05	50.39	50.44	45.95	47.21

Table 4: Continue

Mariposa	45.82	55.20	46.21	43.32	47.64
Nome	15.62	17.39	18.42	15.43	16.72
Guardian	64.21	56.43	63.54	59.11	60.82
Royal 05976781	41.38	43.32	45.25	42.00	42.99
Megha	42.87	54.35	44.14	41.80	45.79
Mean	43.79	46.35	47.10	43.73	

LSD = Program 0.09 LSD = Variety 0.21 LSD = Interaction 0.42

Finally data in table (5) indicated similarity in leaf area between all methods except regression equation method which recorded the highest mean value (126.87cm^2), moreover, the varieties also differed between them in leaf area where variety Barcelona 425 recorded the highest value in leaf area (137.35 cm^2) and the variety Apollo AT2 recorded the lowest value (80.11 cm^2).

Table 5: Leaf area measurement for several varieties of melon crop (*Cusumis metuliferus*) by use vary methods.

Variety	leaf area measurement methods (cm²)				Mean
	LA Matter	Regression equation	Weight method	New computer program	
Kuk 9	76.56		77.45	74.49	84.29
Apollo AT2	82.54	66.69	86.54	84.67	80.11
Apollo AT1	91.85	137.48	100.21	97.40	106.74
PS Chazear	111.22	148.63	110.45	107.96	119.57
Najm	87.49	115.92	94.21	89.79	96.85
BFS 1000	110.38	135.29	118.22	112.21	119.03
MX 728	102.72	137.76	117.22	107.54	116.31
MX 727	83.82	108.17	90.36	83.96	91.58
Asiel	87.64	114.54	90.54	84.69	94.35
Barcelona 518	79.33	114.26	80.47	78.45	88.13
Barcelona 503	88.55	117.54	90.56	85.16	95.45
Barcelona 425	112.68	199.36	120.44	116.92	137.35
Barcelona 3005	84.88	143.48	92.21	87.03	101.90
Barcelona 3006	96.66	128.43	95.38	92.64	103.28
Mean	92.59	126.87	97.45	93.07	

LSD = Program 3.33 LSD = Variety 6.23 LSD = Interaction 12.45

Discussions:

From the above results (Tables 1-5) it can concluded that the new computer program method was the best way for estimating the leaf area because it depended on the technical analysis image that gave accurate results, on the contrary the regression equation method gave the highest leaf area because it was used only for plant that contain simple type of leaf. Furthermore the results of this study showed that the variety of vegetable crops varied in their leaf area, this variation can be reflected the yield because it related to photosynthesis process and thus effect on the amount of chemical compounds that transfer from leaf to the fruit and to the root.

On other hand it can calculated the length and width of the leaf using this program too and such results can be saved in any hard or CD Ram or flash memory, also using this program to calculate leaf area without cutting the leaves, which can be carried out by digital camera, when the image of the leaf was taken ruler should be used, such informations needed for calibration operation in future.In addition, it is possible to use this program to calculate the area of any large leave such as banana plant leaves which can not estimated by classical methods.

References

Alboudi, A., 2005. Morpho-physiology differences for many kind of (Medicage Spp.) in syri. Biological Sciences Series, 27(2).

Abdulaziz, R., A. Al-Harbi, H. Tageldin, H. Nasroun and K.Z. Al-Mugbil, 2002. The effect of Windbreaks on Micro-climate and the Growth and Yield of Summer Squash (2) The Effect of Windbreaks on growth and yield of Summer Squash *Cucurbita pepo* L. King Saud University ; accepted for publication.

Al-Sahaf, F.H., I.M. Al-Barazengi and S.M. Al-Dulaimy, 2004. Application of regression equation for tomato leaf measurement.journal of Agricultre Science, 35(3): 47-50.

Baker, E.M., 2005. A new software for measuring leaf area and area damaged by Tetranycgus urtic.Journal of applied Entomology, 129: 173-175.

Blackman, V.H., 1919 The compound interest law and plant growth. Ann. Bot., 33: 353-360.

Boote, K.J., J.W. Jones, G. Hoogenboom, 1988. Research and management application of the nutgro crop growth model. Proc. Am. Peanut Res. Edu. Soc., 20: 57.

Daughtry, G.S.T. and S.E. Hollinger, 1984. Costs of measuring leaf area index of corn. Agron. J., 76: 836-841.

Durfene, E., B. Dubos, H. Rey, P. Quence and B. Saugier, 1993. Changes in Eva transpiration from oil plam satand (*Elaeis guinensis*) exposed to seasonal soil water deficits. Actaecologia, 48(3): 105-120.

Enoch, H.Z., R.G. Hurd, 1979. The effect of elevated CO2 concatenation in the atmosphere on plant transpiration and water use efficiency: A study with potted carnation plants. Int. J. Biometer, 23: 343-351.

Fladung, I. and S. Ritter, 1990. Plant leaf area Measurements by personal computer.journal of agronomy and crop science, 166: 69-70.

Matthew, E., O.'Neal, A. Douglas, S. Landis and I. Rufus, 2002. An Inexpensive, Accurate Method for Measuring Leaf area and defoliation Through Digital Image Analysis. J. Econ. Entomol., 95(6): 1190-1194.

Montgomery, E.G., 1911. Correlation studies in corn. Nebraska Agr. Exp. Sta. Annu, Rep., 24: 108-159.

Leith, J.H., J.P. Reynolds and H.H. Rogers, 1986. Estimation of leaf area of soybeans grown under elevated carbon dioxide levels. Field Crops Res., 13: 193-203.

Reddy, V.R., B. Acock, D.N. Baker and M. Acock, 1989. Seasonal leaf area-leaf weight relationships in the cotton canopy. Agron. J., 81: 1-4.

de Jesus, W.C., J.F. do Vale, R.R. Coelho and L.C. Costa, 2001. Comparison of Two methods for estimating Leaf Area Index on Common Bean. Agronomy Journal, 93: 989-991.

Watson, D.J. and M.A.Watson, 1935. Comparative physiological studies on the growth of yield crops.111. Effect of infection with beet yellow. Annals of Applied Biology, 40(1): 1-37.

Sharrett, B.S., D.G. Baker, 1985. Alfalfa leaf area as a function of dry. Crop Sci., 26: 1040-1042.

Ma, L., F.P. Gardner, A. Selamat, 1992. Estimation of leaf area from leaf and total mass measurements in peanut. Crop Sci., 32: 467-471.