Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.6, No.4, 2016

LEAF AREA DETERMINATION FOR MAIZE (*Zea mays L*), OKRA (*Abelmoschus esculentus L*) AND COWPEA (*Vigna unguiculata L*) CROPS USING LINEAR MEASUREMENTS

MUSA, UMAR TANKO and USMAN TAIWO HASSAN

Department of Crop Production, Kogi State University, P.M.B. 1008, Anyigba, Nigeria

ABSTRACT

The study was carried out within the green house of the faculty of Agriculture, Kogi State University (Latitude $7^{0}.6^{1}$N and Longitude $7^{0}.43^{1}$E) Anyigba in the Southern Guinea Savannah agro ecological zone of Nigeria, during 2015 cropping season. The experiment was laid using Randomized complete block design with a replicate. The treatment consisted of Maize, okra and cowpea. The result reveals K-coefficients for determination of leaf area to be 0.75, 0.62 and 0.75 for Maize, Okra and Cowpea respectively. The use of multiple regression equation did not improve the prediction over linear measurement. A simple and multiple regression analysis was also carried out in other to increase precision in determined leaf area in the three crops or treatments which are; maize ($Y=-1106.704 + 0.509x_1$, $Y= -1106.704 + 0.509x_1 + 135.239x_2$), Okra ($Y=-3.616 + 0.604x_1$, $Y=-3.616 + 0.604x + 0.882x_2$) and Cowpea ($Y=-8.155 + 0.925x_1$,$Y=-8.155 + 0.925x_1 - 0.009x_2$).e the data on leaf area and leaf number value of all the three crops were fitted into linear regression analysis separately as well as combined data, it did not show any significant difference or improvement over the use of linear measurement.

Key words: k-coefficient, linear measurements, simple and multiple regression of maize, okra and cowpea.

1. INTRODUCTION

Estimation of leaf area is an essential component of plant growth analysis and evapo-transpirational studies. Leaf area is important for crop light interception and therefore has a large influence on growth (Boote et al., 1988), transpiration (Enoch and Hurd, 1979) and growth rate (Leith et al., 1986). 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 as it allows determination of leaf area index, which is important for light interception, radiation use efficiency, plant growth, etc. However, measurement of leaf area of all the leaves of any single plant is not only time consuming but also involves a large amount of labour. But, one cannot do away without measuring leaf area because estimation of leaf area is an essential part of plant growth analysis. Although many methods are available for leaf area measurements, the use of leaf area as a variable in plant growth analysis and physiological studies is limited owing to the time consuming and laborious methods involved in its measurement and though sophisticated electronic instruments provide accurate and fast leaf area measurement, is expensive especially in developing countries. Hence the need to develop economically cheaper and technically easier but sound method is needed for leaf area measurement (Korva and Forbes, 1997). Direct methods of determination/determining leaf area through tracing, shadow graph etc. to measure the leaf area of leaves attached to shoot is time consuming, tedious, also in some experiments time is insufficient to make such measurement (Manivel and Weaver, 1974). The non-destructive methods reduce some of the experimental variability associated to destructive sampling procedures (Nesmith, 1992). The use of regression equation to estimate leaf area is a nondestructive, simple, quick, accurate, reliable and not expensive method. The usual procedure of this method involves measuring length, breadth and areas of sample of leaves and then calculating the several possible regression coefficient or leaf factors, to estimate areas of sub sequent sample (Wierma and Bailey, 1975). The non-destructive methods based on linear measurement are quicker and easier to be executed and present good precision for the study of plant growth in several crops (Robbins and Pharr, 1987). Therefore, a rapid and nondestructive method for measuring leaf area is required by the crop management specialist. Mathematical relationships between length, breadth and area of crops can serve as basis for direct leaf area estimation. Although, several prediction models are available to estimate leaf area for numerous crops. Montgomery (1911) first suggested that leaf area of a plant can be calculated from linear measurement of leaves using a general relationship:- A = b x length x max width, Where b is a coefficient. The simplest but most cumbersome methods for determination of leaf area in crops is tracing on graph sheet. Although high correlation between leaf area and fresh weight or dry weight have been observed (Watson, 1937) the use of leaf dry weight methods in leaf area estimation is destructive. It may however be used when foliage growth is profuse. Using the dry weight methods leaf area is determined as the product of the area per unit dry weight of leaves and total dry weight of leaves. (Ramanajam and Indiru, 1978). Therefore, the present study was carried out to determine leaf area for Maize, Okra and Cowpea Using: Linear measurements, Graph methods and linear regression models; to determine K-coefficients for correcting errors inherent in leaf area determination using linear measurements; Comparison of K-coefficients from the three crops using standard error

2. MATERIALS AND METHODS

2.1. Experimental Location

The experiment was conducted in green house located within in faculty of Agriculture Kogi State University Anyigba. (Latitude $7^0.6^1$N and Longitude $7^0.43^1$E) Kogi State. Falls within the southern guinea savannah zone of Nigeria.

2.2. Experimental Design and Treatments

The experiment was laid out in front of the glasshouse using Complete Randomized Designed (CRD) with 3 treatment and 7 repetition making 21 pots Three crops: - Maize (*Zea mays*), Okra (*Abelmoschus esculentus*) and Cowpea (*Vigna unguiculata*) were for the experiment, the seeds were obtained from Agriculture Development Programme (ADP) Anyigba, Kogi State University. Treatments consist of three crops. Each treatment was repeated seven times, giving a total of twenty one (21) pots. 20 -21 litre capacity, perforated bucket were half filled with top soil. This large buckets were used so as to allow for full growth of the crops.

2.3. Planting, Watering and weeding

5 seeds of the randomized crops was sowned per pot each at 2cm depth making a total 105 seeds (i.e. maize, okra and cowpea) and later thinned to 4 stand per pot. Watering was done every three (3) days to allow for luxuriant growth of the foliage. Hand pulling of some weeds were carried out anytime such plants were seen.

2.4. Data Collection

Seedlings emergence; This was determined by counting the number seedling that emerge 3-4 days after planting depending the sprouting days required for each crops.

Number of leaves per plant: This was determined by visual count of the leaves of the plant per pot.

Leaf Tracing Methods: The contour of a leaf will be drawn on graph paper and its area will be measured by counting the surface or dots within the leaf outline. One plant/pot and for every crop was harvested at 3, 6 and 9 weeks after planting. The leaves were carefully plucked and placed on a graph paper traced out. The total leaf area was therefore determined by counting the number of squares ($1cm^2$) that fell within the leaf surface. For incomplete square areas, estimates were made using “cut and fill” method as is done in land survey. (Kvet and Marshall, 1971). This is one of earliest method for determining leaf area and has been used extensively to calibrate all other methods.

Leaf Area (cm^2): This was calculated as the product of the total length and breadth at the broadest point of the longest leaf on the plant i.e. Leaf Area = lamina length x maximum width x k (where k is the coefficient to be derived)

Plant height (cm) at 3, 6, and 9 weeks after planting or sowing and at maturity: This was done by measuring the plant height of the 4plant at ground level to the tip of the highest leaves or epical leaves.

2.5. Statistical Analysis

All data collected were subjected to regression analysis using simple and multiple regression model. The standard error and coefficient of determination was also determine for each data and for each crop.

3. RESULTS

3.1. Linear Measurements and Graph Method

Determination of K-Coefficient Using Ratios of Linear Measurement to Graph Method

K-coefficient using the ratio of linear measurement to graph determination at 3, 6 and 9 weeks for maize, Okra and cowpea (Table 1, 2 and 3) respectively were carried out appropriately during the period of the experiment. K-coefficient for maize vary between 0.675-0.805. However, the average value obtained over the 3 sampling period was 0.75 (Table1, 2 and 3). Cowpea on the other hand has a k-coefficient that varies between 0.703-0.895 for all the period of sampling. The average k value obtained for the crop was 0.75, 0.75 and 0.76 for 3, 6 and 9 weeks sampling period respectively (Table 4, 5 and 6). Okra k-value varies between 0.58 to 0.81, with an average value of 0.66, 0.61 and 0.61 (Table 7, 8 and 9). Respectively for 3, 6 and 9 weeks

3.2. Coefficient determination of leaf area (k)

K-Value for Maize, Okra and Cowpea and Standard Error

K-values for maize okra and cowpea and it their standard error (SE)values are presented in table 4, the lowest k value of 0.62±0.01 was obtained for okra, 0.75±0.03 and 0.75±0.05 were recorded for maize and cowpea.

3.3. Simple and Multiple Regression

Prediction of leaf area of maize, okra and cowpea using multiple regression in Anyigba

Actual leaf area predicted for maize, okra and cowpea using simple and multiple regression respectively are presented in the table below (table 5). The coefficient of determination (R^2) for the 3 crops and for the prediction equation of the three (3) crops are 0.94, 0.999 and 0.896 respectively (Table 5).

Table 1: Determination of k-coefficients and leaf area of maize, okra and cowpea using graph and linear measurements ratios at 3weeks after sowing, Anyigba, Kogi State.

Pots/plots	No of leaves	LxB(cm^2)	Graph(cm^2)	Average LxB(cm^2)	Average Graph(cm^2)	Dry leaf weight(g)
1 maize	6	1109.74	800	184.96	133.33	2.693
2 okra	4	224.62	136	56.155	34	0.442
3 cowpea	11	325.34	241.5	29.54	21.95	0.468
4 okra	5	369.42	224	73.88	44.8	0.658
5 cowpea	11	233.94	172	21.27	15.64	0 .521
6 maize	4	607.43	410	151.86	102.5	1.365
7 cowpea	21	862.14	774.5	41.05	36.88	1.584
8 maize	8	1328.89	960.1	166.11	120	1.1374
9 okra	6	289.66	196	48.28	32.67	0.470
10cowpea	18	1088.88	768	60.48	42.67	2.284
11okra	6	426.29	346	71.05	57.67	0.660
12maize	7	1360.62	1069	170.08	133.63	3.61
13maize	6	481.69	357	80.28	59.50	0.962
14cowpea	13	576.47	418	44.34	31.15	1.234
15okra	6	422.54	286	70.42	47.67	0.619
16cowpea	14	613.56	454	43.83	32.43	1.171
17okra	6	747.47	485	124.58	80.83	0.826
18maize	6	578.97	454	96.50	75.67	1.270
19cowpea	14	566.14	398	40.44	28.43	1.011
20maize	7	1106.25	890	156.04	127.14	2.706
21okra	6	150.13	88.0	30.03	17.6	0.238

Table 2: Determination of k-coefficients and leaf area of maize, okra and cowpea using graph and linear measurements ratios at 6weeks after sowing, Anyigba, Kogi State.

Pots/plots	No of leaves	LxB(cm^2)	Graph(cm^2)	Average LxB(cm^2)	Average Graph(cm^2)	Dry leaf weight(g)
1 maize	9	6163.53	4443.22	684.84	493.69	14.957
2 okra	4	567.7	346.2	141.18	86.55	1.588
3 cowpea	77	5203.85	3862.45	67.57	50.16	7.485
4 okra	5	2233.68	1403.61	446.74	280.61	4.612
5 cowpea	37	1193.50	877.50	32.26	23.72	2.658
6 maize	12	6024.90	4066.66	502.08	338.89	13.539
7cowpea	83	7939.96	7132.83	95.66	85.94	14.588
8maize	12	20991.88	15166.27	1749.32	1263.86	17.967
9okra	6	737.95	465.2	122.99	77.53	1.976
10cowpea	84	6684.70	4714.93	79.58	56.13	14.022
11okra	6	2122.76	1221.2	353.79	203.53	5.023
12maize	12	9473.46	7443.02	789.46	620.25	25.135
13maize	11	4267.11	3162.53	387.92	287.50	8.522
14cowpea	83	6173.46	4476.39	74.38	53.93	13.215
15okra	6	1176.69	710.3	196.1	118.38	3.271
16cowpea	59	4422.24	3272.21	74.95	55.46	8.44
17okra	5	4011.2	2424.4	668.53	404.07	8.512
18maize	10	5257.10	4122.36	525.71	412.24	11.677
19cowpea	66	2876.06	2021.89	43.58	30.63	5.136
20maize	10	8124.76	6536.53	812.48	653.65	19.874
21okra	7	1797.09	1102.5	256.72	157.50	4.055

Table 2: Determination of k-coefficients and leaf area of maize, okra and cowpea using graph and linear measurements ratios at 9weeks after sowing, Anyigba, Kogi State.

Pots/plots	No of leaves	LxB(cm^2)	Graph(cm^2)	Average LxB(cm^2)	Average Graph(cm^2)	Dry leaf weight(g)
1 maize	11	13442.98	9690.90	1222.09	880.99	32.622
2 okra	6	695.33	424.03	115.89	70.67	1.945
3 cowpea	118	5915.77	4390.86	50.13	37.21	8.509
4 okra	7	2737.37	1719.45	391.05	245.64	5.652
5 cowpea	45	1768.70	1300.40	39.30	28.90	3.939
6 maize	11	12206.89	8239.35	1109.72	749.03	27.431
7cowpea	146	9914.61	8906.75	67.91	61.01	18.216
8maize	13	48847.86	35291.73	3757.53	2714.75	41.809
9okra	8	1397.48	880.96	174.68	110.12	3.742
10cowpea	138	7869.37	5550.51	54.02	40.22	16.507
11okra	6	2916.42	1677.78	486.07	279.63	6.901
12maize	12	14243.92	11191.03	1186.99	932.59	37.792
13maize	11	11688.24	8662.63	1062.57	787.51	23.343
14cowpea	297	6977.43	5059.35	23.44	17.03	14.936
15okra	9	1443.97	871.64	160.04	96.85	4.014
16cowpea	120	6015.08	4450.82	50.13	37.09	11.48
17okra	8	4690.73	2835.11	586.34	354.39	9.954
18maize	11	12470.81	9778.99	1133.71	888.99	27.7
19cowpea	54	3766.99	2648.22	69.76	49.04	6.727
20maize	10	11368.29	9146.01	1136.83	914.60	27.808
21okra	9	4371.07	2681.62	485.67	297.95	9.863

Table4: K-value for Maize, Okra and Cowpea, weeks after harvesting in Kogi State University, Anyigba.

Crops	3weeks	6weeks	9weeks	Average	SE±
Maize	0.75	0.75	0.75	0.75	0.03
Okra	0.66	0.61	0.61	0.62	0.01
Cowpea	0.75	0.75	0.76	0.75	0.05

Table 5: the regression equation for calculating leaf area for each treatments (Maize, Okra and Cowpea)

Treatments	Regression equation (simple and multiple)	(R^2)
Maize	$Y=-1106.704 + 0.509x_1$ $Y= -1106.704 + 0.509x_1 + 135.239x_2$	0.940
Okra	$Y=-3.616 + 0.604x_1$ $Y=-3.616 + 0.604x + 0.882x_2$	0.999
Cowpea	$Y=-8.155 + 0.925x_1$ $Y=-8.155 + 0.925x_1 - 0.009x_2$	0.896

X_1= length x breath.

X_2= number of leaves

4. DISCUSSION

Linear measurement and graph method; K-coefficeint for determination of leaf area at 3, 6 and 9 weeks for maize, okra and cowpea were found to be 0.75, 0.62 and 0.75 respectively. K-value of 0.62±0.01 for okra, 0.75±0.03 for maize and 0.75±0.05 obtained for cowpea may point to the fact that value of 0.62±0.01 was more appropriate than the use of 0.75±0.03 for maize and 0.75±0.05 for cowpea, since lower se± values indicates higher precision. These coefficient agrees with works done in other crops such as jute (Chaudhari and Patra, 1972), cotton (Ashley et al 1963), Blackgram (Balakrishnan et al 1987), soybean (Wiersman and Bailey 1975). Frenchbean (Rat et al 1988), Pearl millet (Chanda et al, 1985), Sunflower (Chanda and Singh, 1975), Ramie (Sarkar and Maitra, 2001), Wheat (Chanda and Singh, 2003), etc. the realative change in the K-value obtained for all the crops with sampling period agreed with studies cariedout by Marshall (1968) who observed that k-values changes during plant growth and along with changes in the environmental conditions. Studies of Chanda et al (1995) support this conclusion.

In the present study also leaf area and leaf number value of all the three crops were fitted into a linear regression analysis separately as well as combine data. However, it did not show significant improvement over the use of linear measurement, this agrees with the works of (Bhatt and Chanda, 2003)

CONCLUSION

Leaf area production is essentially for energy transfer and dry matter accumulation process in crops. It is also useful in the analysis of canopy architecture as it allow leaf area index which is important for light interception, radiation use efficiency, plant growth etc.

However, measurement of leaf area of all the leaves of single plant is not only time consuming but also requires a large amount of labour. One cannot, however do away without measuring leaf area as estimation of leaf area is essentially for studies in plant growth analysis.

The present study, therefore, obtained k-coefficient for correcting leaf area measurement for maize, okra and cowpea as **0.75, 0.62** and **0.75** respectively. A simple and multiple regression equation for predicting leaf area for **maize ($Y=-1106.704 + 0.509x_1$, $Y= -1106.704 + 0.509x_1 + 135.239x_2$)**, **Okra ($Y=-3.616 + 0.604x_1$, $Y=-3.616 + 0.604x + 0.882x_2$)** and **Cowpea ($Y=-8.155 + 0.925x_1$, $Y=-8.155 + 0.925x_1 - 0.009x_2$)** were obtained respectively during the period of the work

Finally, it is hoped that further study in other crops will be embarked upon by this department so as to reduce the labor incurred in destructive measurement usually carried out during physiological and plant growth analysis studies.

REFERENCE

Ashley D. A., B. D. Doss, O. L. Bennett, (1963). A method for determining leaf area in cotton, Agron. J., 55, 584-585.

Balakrishnan K., K. M. Sundaran, N. Natara jaratnam, (1987). Leaf area estimation by non-destructive method in blackgram. India J. Agric. Sci., 57, 286-288.

Boote K. J. J. W Jones, G. Horgenboom, 1988 Research and management application of pnutgro crop growth model proc. Am. Peanut Res. Edu. Soc., 20, 57

Chaudari B. B and Patra A. P (1972) Note on rapid method of determining leaf area in tossal jute. India *Journal Agriculture Sci. 44, 1142-1143*.

Chanda S. V., A. K. Joshi, P.P. Vaishnav, Y. D. Singh, (1985). Leaf area determination in pearl millet using linear measurements – area and matter – area relationships. *Photosynthetica*, 19, 434-427.

Chanda S. V., Y. D. Singh, (1975). Estimation of leaf area in wheat using linear measurement area relationships. *Plant Breed. Seed Sci*., In Press.

Chanda S. V., Y. D. Singh, Chaudhuri B. B and P.P. Vaishnav (1995)Leaf area determination in pearl millet using linear measurements – area and matter – area relationships. *Photosynthetica*, 19, 434-427.

Enoch H. Z., R. G Hurd, (1979). The effect of elevated CO_2concatenation in the atmosphere in plant transpiration and water use efficiency: A study with potted carnation plants. Int. J. Biometer… 23, 343-351.

Leith J. H., J. P. Reynolds, H. H. Rogers, (1986). Estimation of Leaf Area of soybeans grown under elevated carbondoxide levels field crops Res., 13, 193-203

Korva J. T., G A Forbers, (1997). A simple and low cost method for leaves. Leaf Area measurement of detached leaves. *Exp. Ag., 33, 65-72*.

Manivel, L; Weaver, R. J Biometric correlation between leaf area and length measurement of ‘Grenache' grap leaves. *Hort. Science, v. 9 n.1, page 27-28. (1974)*

Marshal J. K., (1968). Method of Leaf Area measurement of large and small leaf samples. Photosynthentica, 2, 41

Montgeomery E. G., (1911), correlation studies in corn, Nebraska Agr. Exp. Sta. Annu. Repr. 24, 108-159.

Nesmith D. S (1992). Estimating summer squash leaf area non-dsetructively. *Hortscience*. 27, 77.

Ramanujam; T. and Indira P. (1978). Linear measurement and weight methods for estimation of leaf area in cassava and sweet potato. Journal of Root crops 4: 47-50

Robbins, S.N and Pharr, D.M. (1987). Leaf Area prediction models for cucumber from linear measurements. Hort. Science 22(6): 1264-1266.

Sarkar, M and Mitra B. C (2001). Studies on Ramie leaf area determination. Journal of Applied Polymer Sci. 67(6), 1093-1100.

Watson DJ. 1947. Comparative physiological studies on the growth of field crops: I. Variation in net assimilation rate and leaf area between species and varieties, and with and between years. *Annals of Botany. 11:41-76*

Wiersma J. V and Bailey, T. B (1975). Estimation of leaflet, trifoliate, and total leaf area of soybeans, *Agronomy Journal*, 67:26-30.

Bhatt M and Chanda S. V. (2003). Prediction of leaf area in *Phaseolus vulgaris by* non-ddestructive method. *India Journal, department of Bio. Sci. Saurashika University, Rajkot 360005.*