Scan Sick & Healthy Leaf – A SOFTWARE APPLICATION FOR THE DETERMINATION OF THE DEGREE OF THE LEAVES ATTACK

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Abstract. *Destructive and non-destructive methods have been used over time to determine the foliar surface of plants. The foliar surface at apple is specific to the various biotypes grown and varies with environmental and technological factors. The active photosynthetic surface is often affected by diseases and pests. The present study had the purpose an IT application for determining the sick and healthy foliar surface, Scan Sick&Healty Leaf, developed in the Processing program, with code lines written in Java programming language. A logical scheme edited in VISIO outlined the work steps. Based on the application, this determinate the total, healthy and sick foliar surface affected by the diseases and pests attack at apple leaves (Dysaphis ssp. and Venturia inaequalis). In the case of leaves attacked by gallmite, the total leaf surface varied between 13.57 - 32.74 ± 1.82 cm^2, healthy area between 4.77 - 25.53 ± 1.98 cm^2 and the attack area between 7.21 - 16.03 ± 0.83 cm^2 with a percentage weight between 22.01 - 66.94 ± 4.59%. In cases of Venturia inaequalis attack, the total foliar surface of the studied leaves oscillated between 11.31 - 39.92 ± 3.34 cm^2, the healthy leaf area ranged from 8.81 - 39.28 ± 3.44 cm^2 and the attack area was between 0.64 - 5.72 ± 0.64 cm^2 in absolute values, respectively between 1.61 - 38.09 ± 3.64% in percentages values. The ANOVA test revealed the existence of variance in the experimental data group, under statistical safety, F > F crit, p<<0.001. Analyzing the mean values shown in table 3 for the healthy surface (12.656 cm^2) compared to that attacked by the gallmite (11.49 cm^2), a ratio of 1.10: 1 was found. And under the same conditions of healthy surface area analysis (20.96 cm^2) against the Venturia inaequalis attack (3.164 cm^2), a ratio of 6.62: 1 was recorded.*

Keywords: *attacked leaves, leaf area, IT application, plant diseases, plant pests, Processing program*

INTRODUCTION

The leaves have an important and multiple roles in plant life for the interception of sunlight and the development of physiological processes such as sweating, breathing, photosynthesis, floral induction, and so on (LAMBERS et al., 1998; SARLIKIOTI et al., 2011).

The foliar apple surface is specific to the various biotypes cultivated and varies with environmental and technological conditions (GONZALEZ-MELER et al., 2004; HÜVE et al., 2012). A series of studies have highlighted the variation of foliar parameters and indices relative to fertilization (JIVAN and SALA, 2014; HE et al., 2015), water regime (XU and ZHOU, 2008), climatic factors (PINCEBOURDE and WOODS, 2012; LI et al., 2015), the management system of the plantation (SIMON et al., 2006).

Also, the photosynthetic foliar surface may be affected by the attack of pathogens, diseases and pests, which diminishes the foliar surface at the individual leaf level and extrapolated at plant level and cultivated surface (REYNOLDS et al., 2016; PANDEY et al., 2017). In the case of *Malus domestica*, a number of pathogens present a potential attack on the foliar level with a representative diminution of the active foliar surface and the qualitative and quantitative degradation of production (SIMON et al., 2010, DAMOS et al., 2015, PEISLEY et al. al., 2016). As a result of the importance of the plant foliage surface and its associated indices, a number of methods and techniques have been used to determine the foliar surface by destructive or non-destructive methods. Some foliar surface studies were based on the dimensional elements of the leaves (length - L and width - W) and some correction factors or surface constants (K_A) in order to optimize the foliar surface (NAUTIYAL et al., 1990; LITSCHMANN et al. SALA et al., 2015). Other non-destructive methods are based on leaf scanning, computerized or imaging models (EASLON and BLOOM, 2014, KAUR et al., 2014, KUMAR et al., 2017). Non-destructive methods have the advantage of the foliar study in dynamics, in a large number of experimental variants.

In the case of disease and pest attack, the determination of the foliar surface is important in assessing the level of attack at the foliar level and the extrapolation at the plant level, respectively the culture. Also, on the basis of the affected foliar surface, the nature of the treatment and intervention for crop protection, the degree of the attack, the economic damage threshold, in relation to plant nutrition status etc. can be determined, and estimations can be made on the decrease in production (BOISSARD et al., 2008; HARTMAN et al., 2011; SALA, 2011; CERDA et al., 2017).

The present study aimed at assessing the degree of the attack on apple, produced by *Dysaphis* ssp. and *Venturia inaequalis*, based on an application made in the Processing program, and the code lines were written in Java, as a programming language.

MATERIAL AND METHOD

The purpose of the study was to evaluate the foliar surface attacked by galicolous lice and apple rasp by imaging analysis. The leaves of *Malus domestica* Borkh (*Rosaceae* Family, Generos cultivar) have been analyzed. This is a medium-to-high size tree with elliptical-ovate leaves and large spherical fruit, yellow-gold color with red-orange. The young leaves are tomentose, the mature ones become glabrous on the upper face. They have pinnate venation and slightly serrated margins.

Leaf collection and processing. The attacked leaves were randomly picked from the tree crown, on the two study cases, leaves attacked by *Dysaphis* ssp. and by *Venturia inaequalis*. The leaves were scanned in a 1: 1 ratio in the RGB color system.

The foliar surface recognition application was developed in the Processing, and the code lines were written in Java as a programming language. As a way of recognizing the leaf, the program reads pixel to pixel and counts all the pixels that represent the healthy color tone, respectively the diseased leaf at different leaf depletion rates (Figure 1).

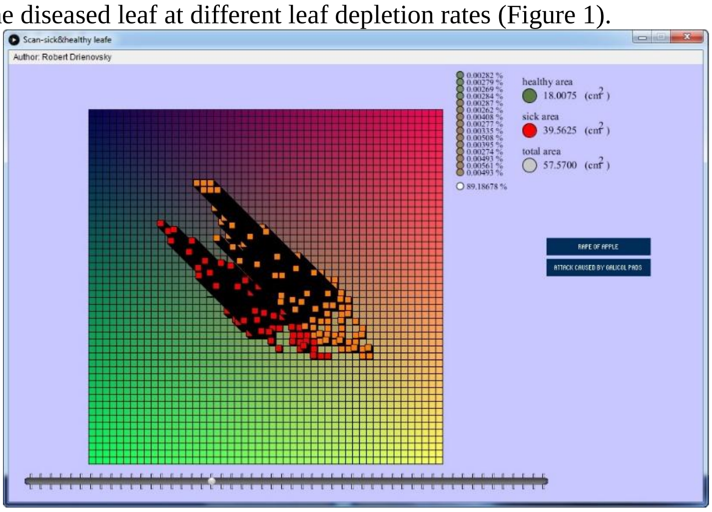
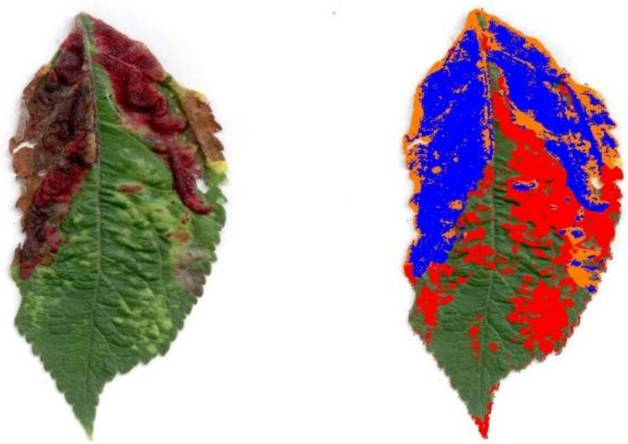


Fig. 1. 3D rendering in the Scan Sick&Healthy Leaf to evaluate the leaves attack in apple

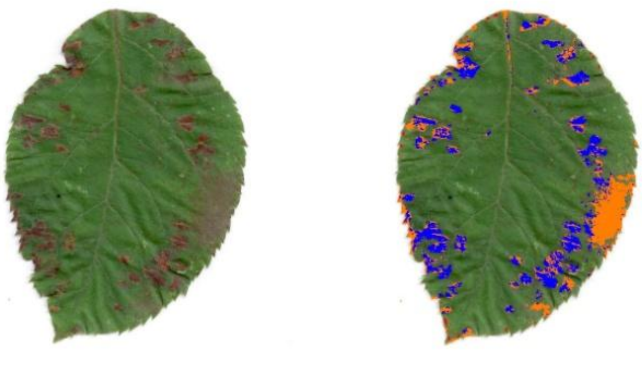
The recognition of the pathogen attack at the foliar level is based on computational equations that has delimited the healthy part of the diseased one, and the stage of attack that may be at an early stage (represented by red color), in a final phase, when the leaf is dry (represented by orange) or in intermediate stages (represented by blue and purple). As a result, the surface of the leaf entirely affected by the pathogen was represented by several colors such as red, blue, orange and purple, Figures 2 and 3.

The experimental data was analyzed by ANOVA test for variance assessment. Also, correlation analysis and coefficient of variation were evaluated (RUJESCU, 2015).



a) Original attack of *Dysaphis* ssp. b) Fals color to render the attack of *Dysaphis* ssp.

Fig. 2. Representation of apple leaves with *Dysaphis* ssp. attack, in original colors (a) and by fals color (b)



(a) Original *Venturia inaequalis* attack in apple (b) Fals color for *Venturia inaequalis* attack in apple

Fig. 3. Representation of apple leaves with *Venturia inaequalis* attack, in original colors (a) and by fals color (b)

RESULTS AND DISCUSSIONS

The overall, healthy and attacked foliar surface determination process was performed according to the logic scheme presented in Figure 4. From the imaging analysis of apple leaves with *Dysaphis* ssp. and *Venturia inaequalis* attack, the foliage's total leaf leaves and subsequently the attacked surface of each leaf, expressed in absolute and percentages. The experimental data is presented in Table 1. In the case of the leaves attacked by *Dysaphis* ssp., the total leaf surface varied between 13.57 - 32.74 ± 1.82 cm^2, healthy area between 4.77 – 25.53 ± 1.98 cm^2 and the surface attacked is between 7.21 – 16.03 ± 0.83 cm^2 with a percentage between 22.01 – 66.94 ± 4.59%. In cases of *Venturia inaequalis* attack, the total foliar surface of the studied leaves oscillated between 11.31 – 39.92 ± 3.34 cm^2, the healthy leaf area was between 8.81 – 39.28 ± 3.44 cm^2 and the attacked area was between 0.64 – 5.72 ± 0.64 cm^2 in absolute values, respectively between 1.61 – 38.09 ± 3.64% in procentage values.

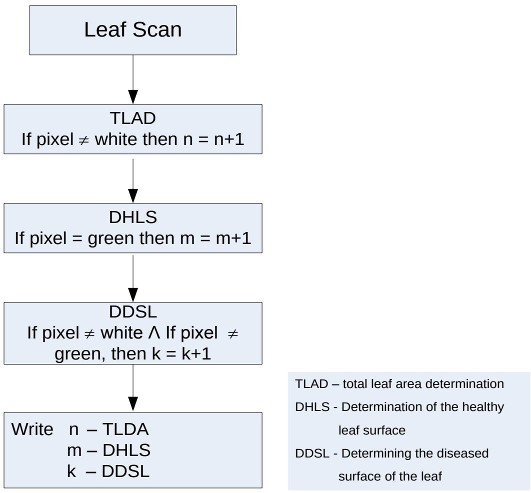


Figure 4. Logical scheme for determining foliar surfaces.

Table 1.

Data on the *Dysaphis* ssp and *Venturia inaequalis* attack on apple, Generos cultivar, determined with the Scan Sick&Healthy Leaf application

Case studied	Attack of the *Dysaphis* ssp.				Attack of the *Venturia inaequalis*			
	Total surface (cm^2)	Healthy surface (cm^2)	Sick surface (cm^2)	Attacked surface (%)	Total surface (cm^2)	Healthy surface (cm^2)	Sick surface (cm^2)	Attacked surface (%)
1	32.72	18.88	13.84	42.31	14.24	8.81	5.42	38.09
2	26.17	13.31	12.86	49.13	13.11	9.43	3.67	28.03
3	19.89	7.91	11.98	60.23	12.38	10.89	1.49	12.05
4	20.06	6.73	13.33	66.46	39.92	39.28	0.64	1.61
5	24.86	14.90	9.96	40.05	27.23	25.98	1.25	4.60
6	23.95	7.92	16.03	66.94	26.34	20.62	5.72	21.72
7	23.81	13.27	10.54	44.27	11.31	9.00	2.31	20.42
8	23.69	13.34	10.35	43.70	35.20	30.68	4.52	12.84
9	32.74	25.53	7.21	22.01	28.64	27.52	1.12	3.91
10	13.57	4.77	8.80	64.85	32.89	27.39	5.50	16.72
SE	1.82	1.98	0.83	4.59	3.34	3.43	0.64	3.61

The ANOVA test revealed the existence of variance in the experimental data group, under statistical safety, F > F crit, p<<0.001, table 2.

Table 2.

ANOVA test for experimental data

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	13597.37	7	1942.482	23.64956	2.39E-16	3.976777
Within Groups	5913.798	72	82.13608			
Total	19511.17	79				

Alpha = 0.001

The values obtained for the total, normal and attacked foliar surface have normal distributions, according to the graphs shown in Figures 5-7.

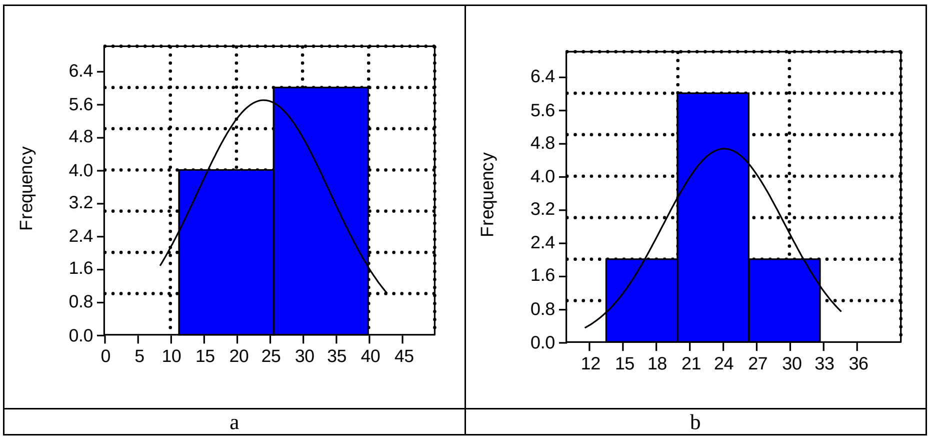


Fig. 5. Distribution of the experimental values for the total foliar surface at the apple in relation to the studied cases: a - attack of *Dysaphis* ssp.; b – *Venturia inaequalis* attack

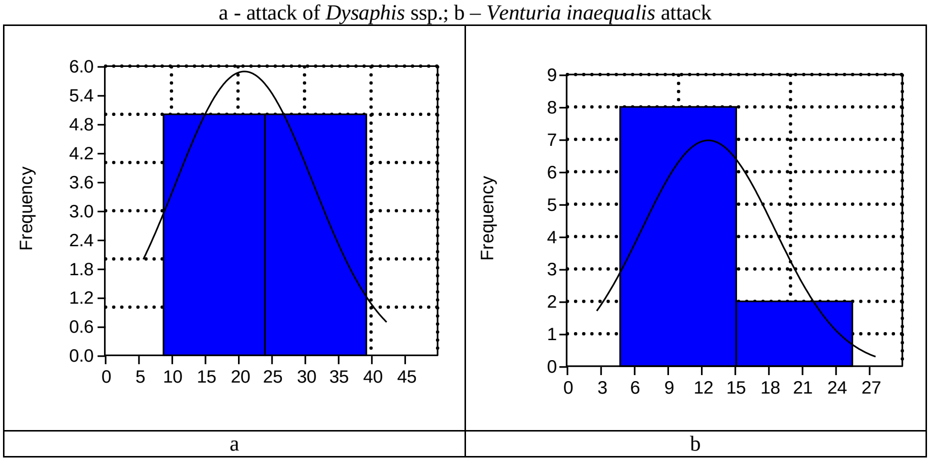


Fig. 6. Distribution of the experimental values for the normal foliar surface to apple in relation to the studied cases: a - attack of *Dysaphis* ssp.; b – *Venturia inaequalis* attack

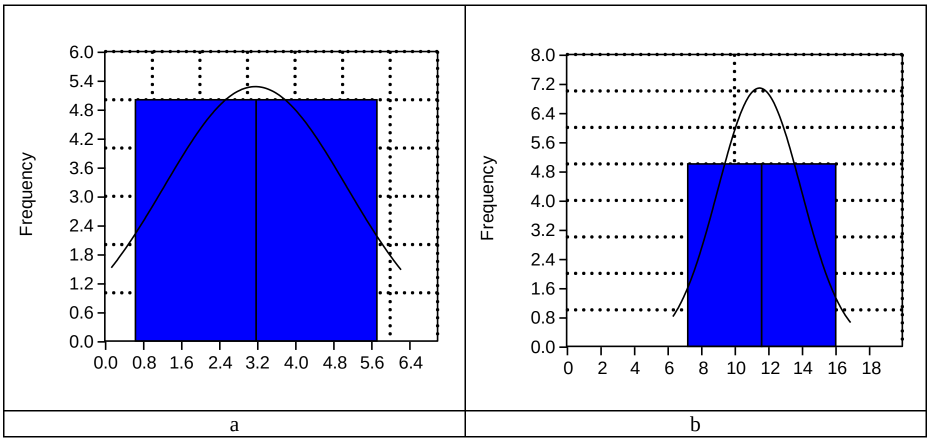


Fig.7. Distribution of the experimental values for the apple leaf attack surface in relation to the studied cases: a - attack of *Dysaphis* ssp.; b – *Venturia inaequalis* attack

Analyzing the mean values, shown in Table 3, for the healthy surface (12.656 cm^2) in relation to that attacked by *Dysaphis* ssp. (11.49 cm^2) a ratio of 1.10: 1 was found. Under the same conditions of healthy surface analysis at (20.96 cm^2) a ratio of 6.62: 1 was recorded from the *Venturia inaequalis* surface (3.164 cm^2). This shows that in the case of the present study, *Dysaphis* ssp. attack significantly reduced the healthy foliar surface compared to the *Venturia inaequalis* attack. Hence, the need for intervention to combat *Dysaphis* ssp. is much needed compared to intervention to combat *Venturia inaequalis* attack, the degree of attack being much higher in pests compared to that given by diseases. The graphical distribution of the total area, healthy and attacked in the two studied cases is shown in Figures 6 and 7.

Table 3.

Complex statistical analysis of the data on the foliar surface of the apple, Generos cultivar, attacked by *Dysaphis* ssp. and *Venturia inaequalis*

Statistical parameters	Attack of the *Dysaphis* ssp.				Attack of the *Venturia inaequalis*			
	Total surface (cm^2)	Healthy surface (cm^2)	Sick surface (cm^2)	Attacked surface (%)	Total surface (cm^2)	Healthy surface (cm^2)	Sick surface (cm^2)	Attacked surface (%)
Min	13.57	4.77	7.21	22.01	11.31	8.81	0.64	1.61
Max	32.74	25.53	16.03	66.94	39.92	39.28	5.72	38.09
Mean	24.15	12.66	11.49	49.99	24.13	20.96	3.16	16.00
Std. error	1.8227	1.9806	0.8282	4.5922	3.3418	3.4396	0.6405	3.6427
Variance	33.223	39.227	6.859	210.881	111.679	118.312	4.102	132.694
Stand. Dev	5.764	6.263	2.619	14.521	10.568	10.877	2.025	11.519
Median	23.88	13.29	11.26	46.7	26.785	23.3	2.99	14.78
Coeff. Var	23.8708	49.4878	22.7941	29.0464	43.8026	51.8946	64.0118	72.0002

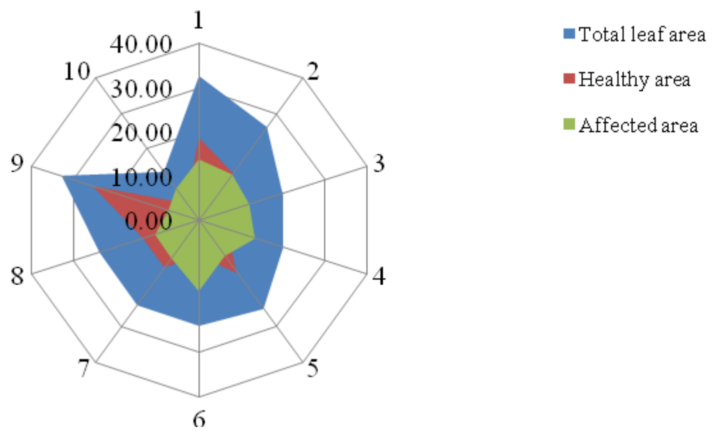


Fig. 6. The distribution of the surface area attacked by the *Dysaphis* ssp. in relation to the normal and total surface of apple leaves, the Generos cultivar

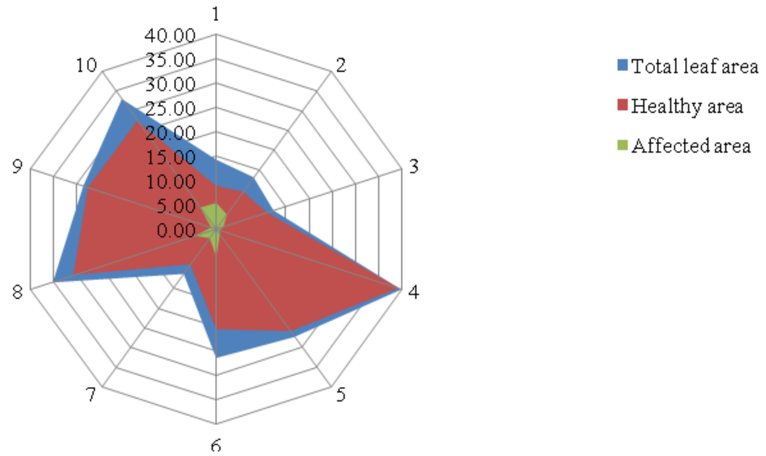


Fig. 7. The weight distribution of the surface attacked by *Venturia inaequalis* in relation to the normal and total surface of apple leaves, Generos cultivar

Assessing the attack of diseases and pests on different crop plants is necessary to replicate the pathogen or pests, the degree of attack, the level of damage caused and the recommended treatments (POIATTI et al., 2009; de SOUZA et al., 2016). Some studies have tracked the impact of pathogens and pests on the degree of natural or induced resistance of plants (DANGL and JONES, 2001; TREUTTER, 2006; de LANGE et al., 2014).

Determination of the attacked foliar surface has been the subject of many studies, imaging and IT technologies, with increased interest (PUJARI et al., 2015; DEY et al., 2016; SINGH and MISRA, 2017; XU et al., 2017). Such methods are increasingly promoted because they are fast, highly accurate and highly effective in diagnosing disease and pest attack.

The present study has introduced a simple and sufficiently precise method for assessing the foliar surface attack by *Dysaphis* ssp. and *Venturia inaequalis* at apple to determine the degree of attack without identifying at this stage of application the pathogen or pest, these details being known by classic methods.

CONCLUSIONS

The IT application made in the Processing program, with Java-language code lines, has made it easier to determine the total foliar surface, the healthy surface, and the one affected by diseases and pests, in a state-of-the-art condition.

It can be used for evaluations of plant protection in horticultural species, can be developed as a distinct PC application or can be customized and developed for mobile apps (smartphones, tablets) on Android or IOS.

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