COMPUTER ASSISTED IMAGE ANALYSIS OF THE LESION'S EXTENSION IN THE FOLIAGE OF THE WINTER WHEAT PRODUCED BY FUNGAL PATHOGENS AND INSECT PESTS

ANALIZA DE IMAGINE A LEZIUNILOR FOLIARE ALE GRÂULUI PRODUSE DE CIUPERCI PATOGENE ŞI INSECTE

ALIN TEUŞDEA*, NICOLAE CSEP*

**University of Oradea, Faculty of Environmental Protection*,

Abstract : *Wheat fungal pathogens (Erisiphe graminis, Septoria tritici) as well as several insect pests induce foliar necroses; as a consequence, the reduction of the active assimilative foliar area is causing the diminution of the yield quantity and quality. This reduction is directly correlated with the affected area of the leaves. The exact estimation of the lesions extension is important for the characterization of the genetic resistance of wheat races and the efficiency of the foliar fungicides treatments. The computer program is based on the utilization of color filters for the determination of the ratio between total foliar area and the area of the necroses. The utilization of the computer assisted image analysis enhances the precision of these estimations and excludes the subjectivism of the specialist's visual assessment.*

Rezumat: *Ciupercile patogene ale grâuluii (Erisiphe graminis, Septoria tritici) ca de altfel şi unele insecte dăunătoare produc necroze ale frunzelor; în consecinţă reducerea suprafeţei active asimilante a frunzei duce la scăderea cantitativă şi calitativă a producţiei. Acestă scădere este direct proporţională cu suprafaţa frunzelor. Estimarea cât mai precisă a suprafeţelor leziunilor este importantă pentru caracterizarea rezistenţei genetice a tipurilor de grâu şi a eficienţei tratamentelor foliare cu fungicide. Softul are la bază utilizarea unor filtre de culoare pentru determinarea rapotului între suprafaţa totală a frunzei şi cea necrozată. Utilizarea analizei digitale de imagine măreşte precizia estimărilor şi exclude subiectivismul aparatului senzorial al specialistului*

Keywords: *computer assisted image analysis, wheat, foliar necrosis.*
Cuvinte cheie*: analiza digitală de imagine, grâu, necroză foliară.*

INTRODUCTION

The yield stability and the agronomic and economic efficiency of wheat cultivation depend on the influence of genotype, the level of applied technology, and the presence of an important number of diseases caused by the attack of parasitic fungi.

Testing of planting material for freedom from phytopathogenic fungi is an important [1-4], although not exclusive, method for control of foliar diseases of plants. Ideally, pathogen-free or pathogen-/disease-resistant planting material is desirable, but this situation is not always possible on a practical basis. For most bacterial pathogens, resistance is not available in cultivated hosts, and production of pathogen-free planting material requires strict tester schemes.

The yield stability and the agronomic and economic efficiency of wheat cultivation depend on the influence of genotype, the level of applied technology, and the presence of an important number of diseases caused by the attack of parasitic fungi.

Fungicidal treatment with systemic fungicides, according to regional advice at heading can contribute effectively to the limitation of losses [1-4].

The researches upon wheat genotype and antifungal products biological efficiency need measuring of the affected foliar surfaces. These measurements represent the attack intensity denoted with I (%).

Researchers use their experience to measure visually the percentage of affected foliar lesions. The subjectivity and lack of precision in these methods lead us to test a method that delivers a higher accuracy. Computer assisted image analysis uses high resolution image scanning of the leaves to discriminate foliar lesions surfaces with different colour parameters (table 1) from active photosynthetic surface of the leaves with other colour parameters.

This paper presents results of a preliminary research intended to test a new quantitative investigation method to study the winter wheat foliar lesions.

Table 1

The main winter wheat diseases in the Romanian Western Plain.

Symptomps expressed on:	**Disease common name**	**Causal agent**	**Economical importance**
Leaves	Barley Yellow Dwarf	*BYDV*	medium
Leaves	Powdery mildew	*Erysiphe graminisf.sp. tritici*	low
Leaves	leaf spot	*H. tritici-repentis*	medium
Leaves	leaf rust	*Puccinia recondita*	low
Leaves	stripe rust	*P. striiformis*	variable
Seed / head	head blight	*Fusarium spp.*	medium
Head	common bunt	*T. foetida, T. Caries*	variable
Lower stem	eyespot	*Pseudocercosporella herpotrichoides*	variable
Lower stem	sharp eyespot	*Rhizoctonia sp.*	low

Concerning the previously reasons was developed a computer program tested at Research and Development Center from Oradea in a antifungal treatment experiment.

MATERIAL AND METHODS

Computer assisted image analysis of winter wheat foliage lesions extension implies winter wheat leaves image scanning that produce digital images of leaves [5-10].

In our experiment the leaves were scanned with a Mustek 1200+ scanner which has a true optical resolution of 1200×600 dpi (dot per inch). The recommended optical resolution for leaves scanning is 400×400 dpi [11]. This resolution performs enough precision for surface analysis [10, 11]. In these conditions one pixel denotes *0.0635*mm×*0.0635*mm =*0,0040322* mm^2. The scanning procedure has colour (as hue), intensity and contrast parameters which must be tuned once and than kept the same over the entire experiment. Colour differentiation is done using colour filters (figure 1) which generates the following boolean colours [11]:

- black – foliar leaves lesions made by pathogen structures
- red – foliar leaves lesions with different intensity level for the fructifications made by pathogen structures
- blue – necrotic or chlorosis barrier made by host or pathogen toxins diffusion
- green – photosynthetic active surfaces.

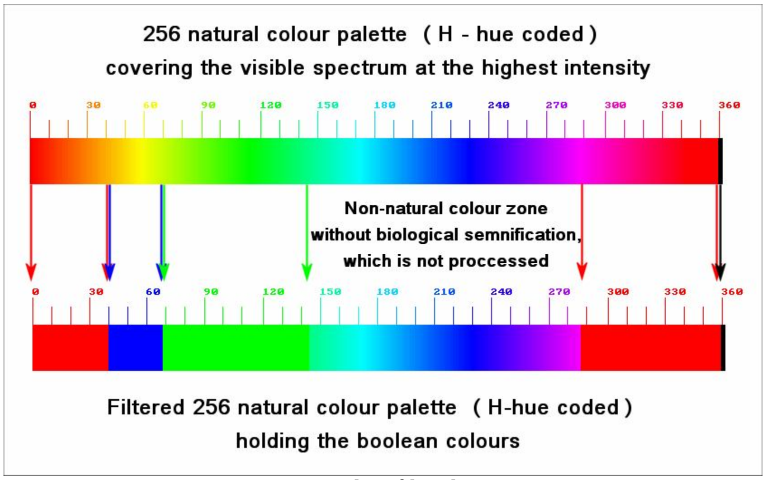
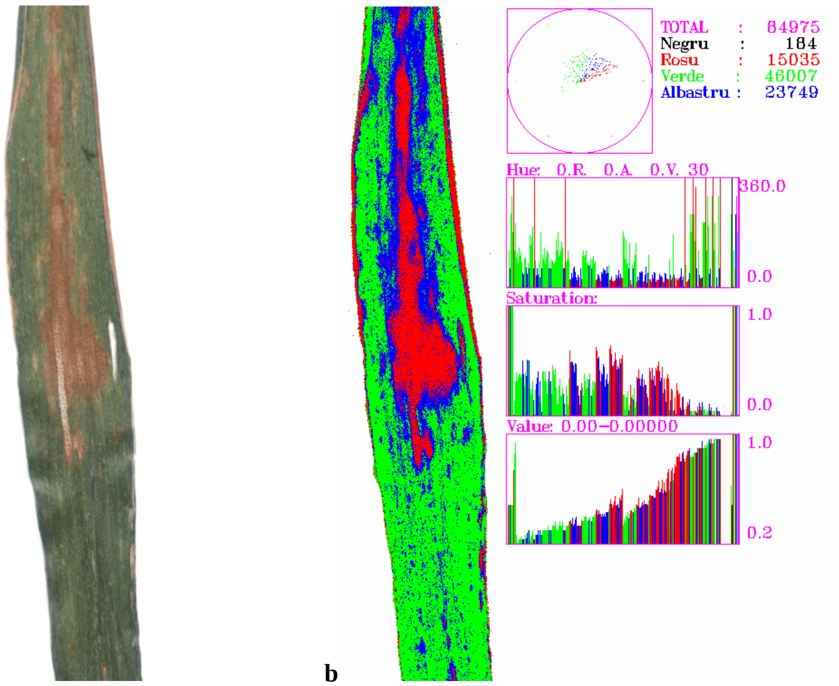


Figure 1. Colour filter diagram.



a b

Figure 2. a – Scanned winter wheat leave image; **b** – Colour filtered image with four boolean colours and the corresponding surfaces in pixels.

Boolean colours are invoked in informational classification of boolean tests methods. Boolean colour is an artificial colour which denotes leaves surfaces with certain initial colour parameters filtered (i.e. chosen) by user.

The colour filter implies a RGB colour space to HSV colour Space transformation. In the RGB colour space the colours are coded in R-red, G-green and B-blue levels – this colour space is ordinary used for image broadcasting; in the HSV colour space the colours are coded in H-hue, S-saturation and V-value – this colour space is used for image digital processing [6]. In HSV colour space the colours can be represented in 3D polar coordinates in which the H-hue parameter denotes the "colour" with values between [6]. The actual colour filter works only in a 2D colour space with H and S parameters which are introduced as intervals for each boolean colours.

In the colour filtered image (figure 2) for each boolean colour can be calculated the corresponding surface by counting the pixels and multiplying with the pixel surface in mm^2.

The computer program is written in Borland Pascal v7.0 in protected mode and it takes just 10 seconds to display the filtering results of the designated surfaces (in pixels).

RESULTS

The experiment consists in image scanning of 25 leaves/replication×4 replications (a total of 100 leaves). Figure 3 presents the graphical representation of total foliar surface affected by pathogens computed with the previously mentioned computer program. The *F1* to *F6* are the indexes of the leaves from winter wheat treated with different antifungal products (denominations are confidential); the *FM* is the index of the untreated control winter wheat leaves.

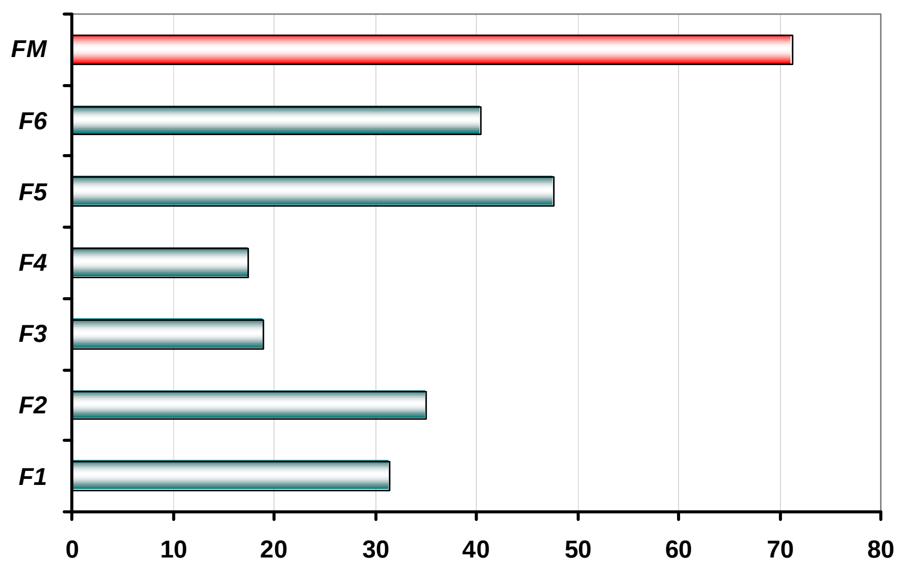


Figure 3. Total foliar surface affected by foliar pathogens determined by computer assisted image analysis (%).

Statistical processing results of data from figure 3 are presented in table 2 with the corresponding fungicide concentration in solution and the pathogen's mortality rate.

Table 2.

The variation of affected fungal surface after different fungal treatments

Nr.	Antifungal treatment	% of affected foliar surface	Difference %	Significance of difference
1	***F1***	31,45	37,05	* * *
2	***F2***	35,00	33,50	* * *
3	***F3***	18,93	49,57	* * *
4	***F4***	17,41	51,09	* * *
5	***F5***	47,74	20,76	*
6	***F6***	40,51	27,99	* *
7	***FM untreated (control)***	71.33	-	-

LSD 5%	11,0 %
LSD 1%	20,9 %
LSD 0,1%	28,4 %

DISCUSSIONS AND CONCLUSIONS

A computer assisted image analysis program was developed based on colour filters which permit a high colour resolution in order to quantify such surfaces as lesions containing fungal structures and chlorotic or necrotic barriers developed by host as response to pathogen invasion.

A mean lesion area of 71.33% of total foliar area was determined on several foliar samples collected from winter wheat control leaves and a mean of 31.84% of total foliar area was determined on several foliar samples collected from winter wheat antifungal treated leaves.

Statistical significance differences were obtained at all foliar treated variants. Fungicide combinations were developed in experiments of several research projects.

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