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Original Contribution

INFLUENCE OF THE VEGETATION PERIOD ON THE SPREAD OF ECONOMICALLY IMPORTANT VIRAL DISEASES IN BURLEY TOBACCO

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ABSTRACT
The present study explores the influence of the vegetation period of Burley tobacco on the spread of viruses such as TMW, PVY-Complex, CMV / PVY-Complex, TSWV and CMV. To establish this relation, a correlation analysis is applied and the proven effects are represented by linear regression models. In 2014, the number of days from replanting has a strong positive impact on the percentage of plants infected by PVY-Complex (0.985**) as well as by TMV (0.781*). For 2015, the very strong effect was only seen on CMV / PVY-Complex (0.976**). In 2016, the duration of the period had a positive effect on the spread of CMV / PVY-Complex (0.868*), CMV (0.904 **) and TSWV (0.966**). In 2017 there is a very strong positive correlation between PVY-Complex (0.885*), CMV (0.948**) and TSWV (0.955**) on one hand and the planting period on the other. As a result of the conducted study over the entire four-year period, it has been proven that during the first two years the increase in the vegetation period leads to an increase in the incidence of PVY complex. During the second half of the analyzed period, CMV and TSWV are proved to be affected by the length of the time from the replanting.

Keywords: viruses, correlation analysis, regression analysis

INTRODUCTION

Tobacco production is among the major branches of agriculture in Bulgaria. Tobacco is cultivated in more than 100 municipalities, and in a large part of them it is the main livelihood of the local population (1). Four varieties are cultivated in the country - Oriental tobacco - Basma and Caba Kulak and big-leaved tobacco– Flue-cured - Virginia and Air Cured-Burley, occupying an area of 9963 ha (2). Tobacco cultivation should take into account the complicated interactions between the genotype and agro-ecological conditions as well as the presence of different phytopathogens (3). Some of them are viral diseases and the damage to the crop is significant. One of the most common viruses causing serious economic losses is the genus Potyvirus. The three potyviruses PVY (Potatovirus Y), TEV (Tobacco etch virus) and TVMV (Tobacco vein mottling virus) often occur as a tobacco viral complex (4-6).

Another economically important virus is TMV (Tobacco mosaic virus) of the genus Tobamovirus. It is spread in all the countries where tobacco is grown. The illness it causes is called a simple tobacco mosaic virus. Until the 1980s, the disease was a serious problem for tobacco production (7). Kovachevski et al. (8) report a reduction in dry tobacco yields to 50% after TMV contamination. With the introduction of TMV-resistant varieties of tobacco, the economic importance of the virus decreases. CMV (Cucumber mosaic virus) is a virus also spread worldwide which causes considerable damage to tobacco production (9). In Africa it can be found in Zambia and Morocco (10). The disease it causes with tobacco is called cucumber mosaic virus.

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Tomato spotted wilt virus (TSWV) is a serious problem for tobacco production in many countries around the world. The disease is widespread in Central Europe, Balkans and Ukraine. The virus was first reported on tobacco in South Africa in 1906, (11). The losses caused by Tomato spotted wilt virus in different crops worldwide can range from 25 to 50% (12). In Bulgaria, the disease was first found in 1952 in Gotse Delchev and Sandanski tobacco regions, and in the first years of its occurrence it caused 30 to 50% losses, and in separate years, such as 1956, 1969, 1977, 1983 and 1984. The viral disease covers up to 70% of the areas with oriental tobacco and 80-100% with large-sized tobaccos (8, 13). Signs of tobacco diseases vary greatly, but there are signs that can hardly be mixed with other viral diseases. Depending on the age of the plants and the external conditions, the length of the incubation period also varies. The more advanced is the phase when the plant develops the infection, the longer the incubation period. In hot weather and lack of moisture, the disease manifestation is delayed and the incubation period is greatly prolonged. (7).

The aim of the present study is to show the influence of the period from the replanting of Burley tobacco on the spread of economically important viral diseases in this tobacco group in the region of Plovdiv.

MATERIALS AND METHODS

The scientific experiment was conducted in the 2014-2017 period on the experimental field of the Institute of Tobacco and Tobacco Products - Markovo. The present work studies the impact of the period from replanting of the Burley Tobacco on its morbidity rate of economically important viral infections. The scientific experiment was conducted in the 2014-2017 period on the experimental field of the Institute of Tobacco and Tobacco Products - Markovo. The spread of the viruses: PVY-Complex (%), TMV (%), TSWV (%), CMV (%) is studied after different periods of time from the moment of replanting. The areas were investigated by routing method, and the prevalence of virosis was assessed on the basis of the characteristic symptoms of the disease. Measurements are made on the basis of the percentage of attacked plants. The distribution of the virus contamination is calculated according to the following formula: $P = (n.100)/ N$, where P is the distribution of the disease, N – the total number of plants, n – the number of sick plants (14).

A classic method of studying the interaction between individual indicators is the correlation analysis. It determines the correlation coefficients that give information on the degree and direction of impact of one or more indicators (independent variables, factors) on another indicator (dependent variable, result). A variable whose correlation coefficient is insignificant should be excluded from the analysis as it does not affect the corresponding dependent variable. In the present work the Pearson-Brave correlation coefficient is calculated. A linear regression analysis is applied for a fuller analysis of the relations between the different indicators. Through it the functional relation between the surveyed indicators was obtained. For the mathematical data processing, the MS Excel and IBM Statistics SPSS 24 (15-18) were applied.

RESULTS AND DISCUSSION

The carried out correlation analysis resulted in the calculation of the correlation coefficients presenting the degree and direction of influence of the vegetation period on the spread of a given viral disease expressed in days from the replanting **(Table 1)**. It was found that in 2014 the number of days after the replanting had a strong positive impact on the percentage of infected plants by PVY-Complex (0.985**) and by TMV (0.781*). For 2015, the very strong effect was only seen on CMV / PVY-Complex (0.976**). In 2016, the duration of the period had a positive effect on the spread of CMV / PVY-Complex (0.868*), CMV (0.904**) and TSWV (0.966**). There is a very strong, positive correlation between the viruses PVY-Complex (0.885*), CMV (0.948**) and TSWV (0.955**), on one hand, and the period of replanting, on the other hand, in 2017.

For regression analysis to be applied, the experimental data need to meet a number of conditions. In the present work, the data is random, the observations are independent, each dependent variable in the corresponding regression model has a distribution close to normal (established by P-P-Plot). The regression compiled models, their significance grades (at a significance level of less than 0.05), as well as the results of the respective F-test are given in **Table 1**.

Table 1. *Correlation coefficients and regression models presenting the influence of the period of replanting (x) on the spread of certain viral diseases (%) in Burley tobacco (y)*

Year	Name of the virus	Correlation coefficient	Regression model	F-test	Sign. of model (<0,05)
2014	PVY-Complex(%)	0,985**	y=0,181x-3,523	159,342	0,000
	TMV (%)	0,781*	y=0,005x-0,194	7,836	0,038
2015	CMV/PVY-Complex (%)	0,976**	y=0,452x-8,069	140,361	0,000
2016	CMV/PVY-Complex (%)	0,868*	y=0,009x-0,105	15,327	0,011
	CMV (%)	0,904**	y=0,056x-0,770	22,394	0,005
	TSWV (%)	0,966**	y=0,062x-1,083	69,624	0,000
2017	PVY – Complex (%)	0,885*	y=0,003x-0,113	14,482	0,019
	CMV (%)	0,948**	y=0,08x-2,237	35,602	0,004
	TSWV (%)	0,955**	y=0,429x-11,935	41,176	0,003

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

All relations, statistically proven by the correlation analysis, are modeled by linear regression equations. The positive sign in front of the independent variable in each model confirms the positive effect of the replanting period on the spread of the virus. The statistically unreliable relations between some viruses and the percentage of diseased plants cause them not to be listed in **Table 1**. In these, the period has no proven impact on the research problem and they cannot be the basis for future analyzes.

To study the trends and the dynamics of morbidity changes in Burley tobacco, graphical images were constructed **(Figures 1-4)**. The most sensitive in 2014 is the trend of increasing the incidence of PVY-Complex (97%) as a result of the change in period from the replanting observed throughout the whole studied period from 20th to the 110th day. More moderate is the increase in the percentage of plants diseased by TMV (61%). In both diseases, no wavy changes or dynamic peaks and drops in their spread were observed.

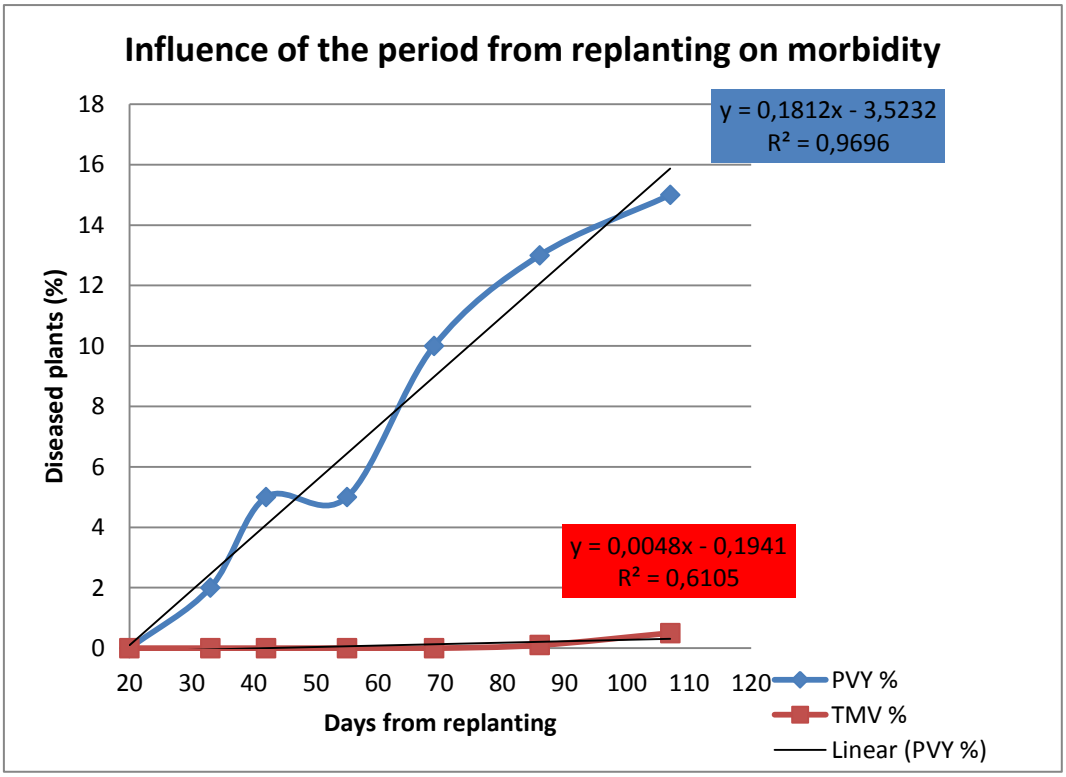

Figure 1. Influence of the period from replanting of Barley tobacco on the spread of PVY Complex and Tobacco Mosaic in 2014

In 2015, there was again a strong increase in the morbidity rate with the increase of the days from replanting (95%) **(Figure 2).**

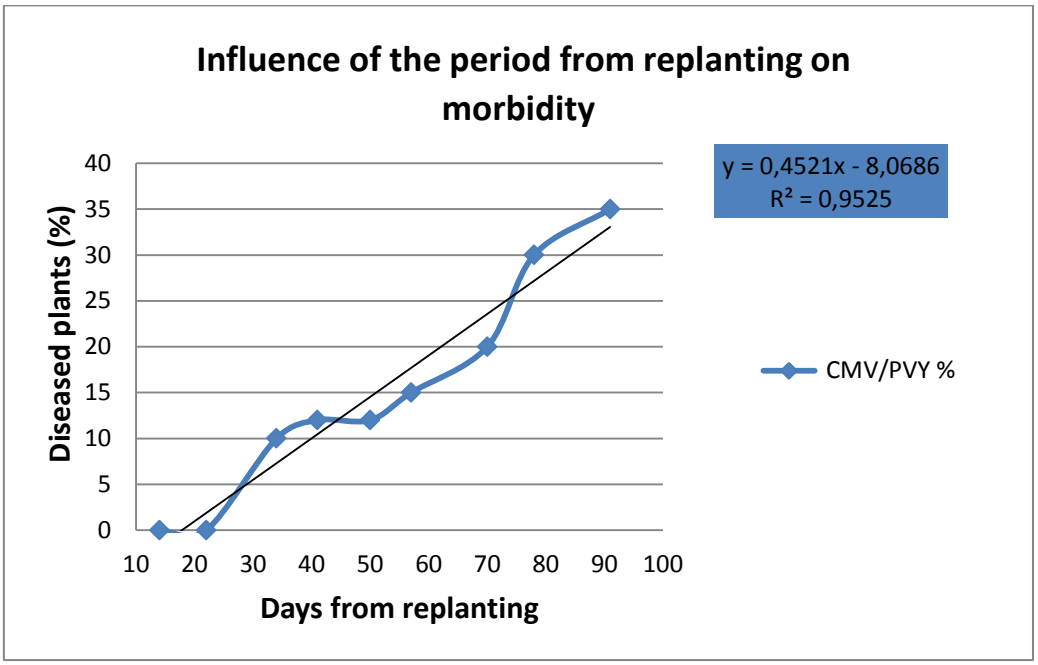

Figure 2. Influence of the period from replanting of Barley tobacco on the spread of mixed infection of PVY complex and cucumber mosaic in 2015

It is clear from the graph in **Figure 3** that in case of plants diseased from TSWV (93%) and CMV (82%) in 2016, the period between 20 and 60 days from replanting has a strong positive effect. Relative stability is then observed. In PVY-Complex (75%), there is an insignificant increase after day 30, but there was no evidence of changes in disease progression.

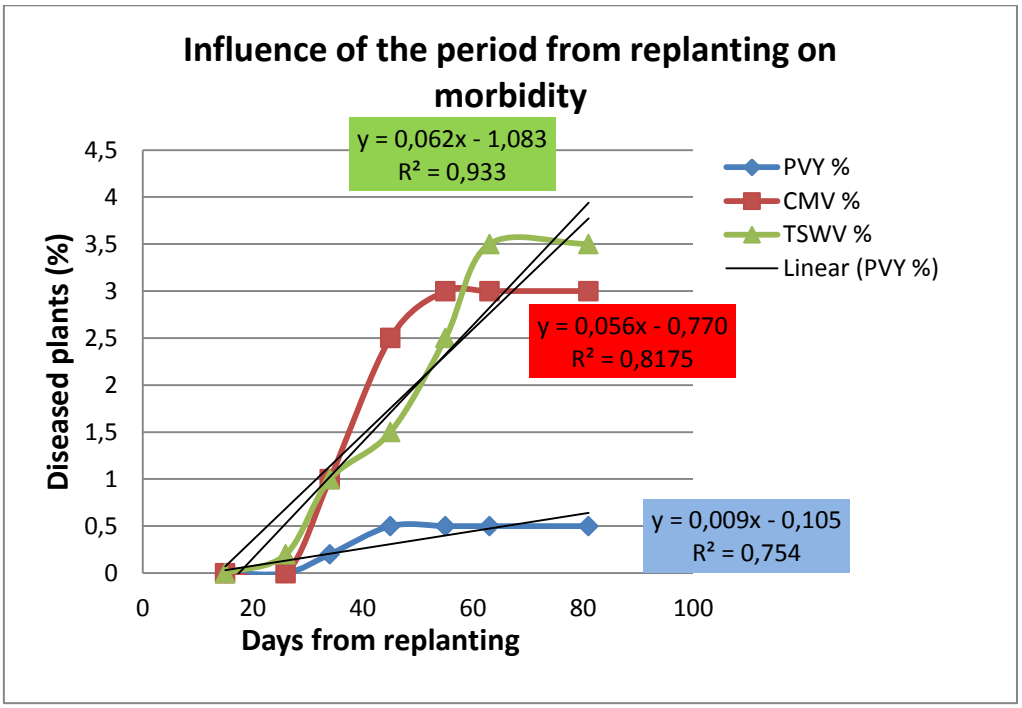

Figure 3. Influence of the period from replanting of Barley tobacco on the spread of PVY complex, cucumber mosaic virus and Tomato spotted wilt virus in 2016

In 2017, the proven influence of the change in the period from replanting over the percentage of diseased plants from TSWW is proved most significantly (91%), and it is most sensitive in 50-80 days. No strong dynamic changes were observed for other viral diseases **(Figure 4)**.

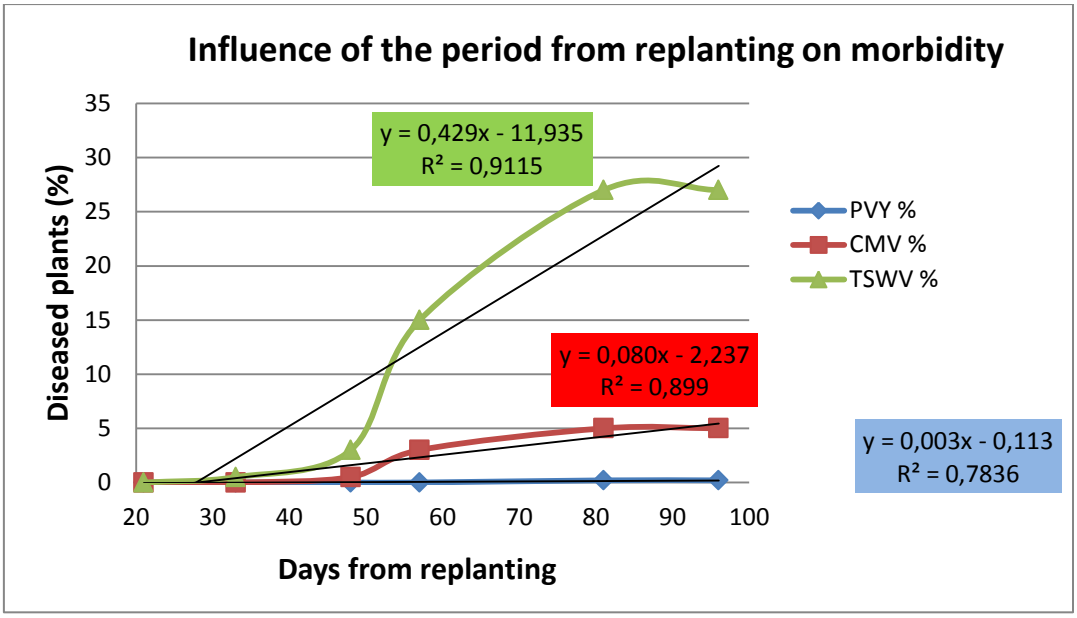

Figure 4. Influence of the period from replanting of Barley tobacco on the morbidity in 2017

CONCLUSION

In 2014 and 2015, no wavy changes or dynamic peaks and drops in the incidence of the reported viral diseases were observed. In 2016, there was strong dynamic in the development of the Tomato spotted wilt virus and the Cucumber mosaic virus, in the period from the 20th to the 60th day from replanting. In 2017, the influence of the change in the period from replanting over the percentage of diseased plants from TSWW is proved to be the strongest and it is most sensitive in 50-80 days. The conducted study over the entire four-year period it has proven that during the first two years the increase in the vegetation period leads to an increase in the incidence of PVY complex. During the second half of the analyzed period, only CMV and TSWV are proved to be affected by the length of the time from the replanting. The spread of diseases such as sipanitsa, tomato spotted wilt virus and cucumber mosaic virus in Burley tobacco is influenced by many factors mainly climatic, which are combined in different ways during the separate years. The climatic conditions directly or indirectly affect the vectors of viral diseases, which determine also their development. As a result of this study, the strong, positive influence of the period from replanting over the morbidity of the plant was proven. The spread of viral diseases according to the period from replanting for different years is different. The compiled regression models provide an opportunity to predict the morbidity rate of Burley Tobacco under conditions identical to those in the study.

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