

THE INFLUENCE OF DIFFERENT SOWING DISTANCES OF SOYBEAN UPON BACTERIAL BLIGHT

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Abstract

This paper aims to quantify the attack of *Pseudomonas syringe* pv *glycinea* in ecological conditions in Transylvania but also in different cultural conditions. Thus, observations were made regarding the frequency of attack of these bacteria in three soybean varieties, sown at different distances (25, 12.5, 50 cm). The attack of the bacterium was influenced by the soybean sowing distance. The attack frequency of this pathogen was between 9 and 25%. The lowest value of the attack was recorded in the Caro variety in the case of the 12.5 cm between rows.

Key words: soybean, pathogen, sowing distance *Pseudomonas syringe* pv *glycinea*.

INTRODUCTION

Soybean is one of the most important crop plants in Romania (Cărăbeţ et al., 2010) with cultivated areas that grow from year to year. Soybean production is influenced by climatic factors (Ionescu et al., 2016) but for high yields it is recommended to cultivate new varieties and/ or adapted to the production area (Haş, 2006) and due to nitrogen fixation capacity it can be a viable alternative to improve the soil fertility (Buah et al., 2017). Soybean production is expected to grow in the future, mainly because of the potential of this plant to improve the diet of the human population. (Hartman et al., 2011).

A limiting factor of the production is represented by the specific pathogens of soybean plants. From these, the most important in the Transylvanian region are: *Peronospora manshurica*, *Sclerotinia sclerotiorum*, Soybean Mosaic Virus and *Pseudomonas syringe* pv *glycinea*. For the control of the pathogens there are fungicides applicable to soil or vegetation (Reznikov et al., 2016), but there are other alternative methods to prevent their occurrence. It is already known that plant density influences the incidence of plant pathogens (Janzen, 1970; Connell, 1971; Bagchi et al.,

2014). This paper aims to study the behavior of soybean plants sown at different distances between rows.

MATERIALS AND METHODS

In order to determine the incidence of the pathogen *Pseudomonas syringe* pv *glycinea* under different ecological conditions were studied three soybean cultivations: Felix, Onix and Caro, these being some of the most cultivated varieties in Transylvania. Those three varieties are owned by Agricultural Research and Development Station (ARDS) Turda and shows similar characteristics. The main difference between the three varieties refers to their height (Figure 1).

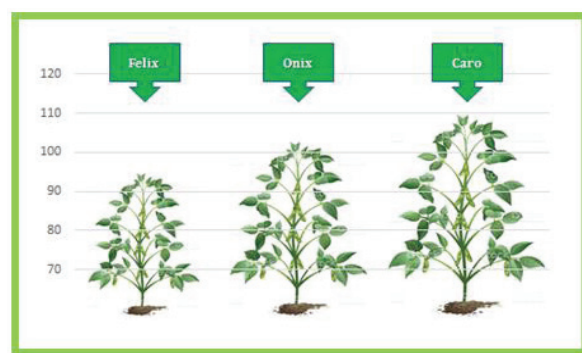


Figure 1. Comparison of varieties tested according to their height

These three cultivars were sown at different distances between rows while maintaining a density of 50 plants/ square meter (Figure 2).

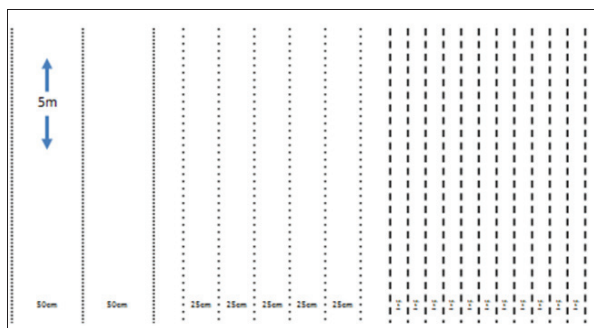


Figure 2. Rows distribution in experiment

Thus, three variants were sown:

- 50 cm distance between rows and 4 cm plant spacing;
- 25 cm distance between rows and 8 cm plant spacing;
- 12.5 cm distance between rows and 16.7 cm plant spacing.

The experiment met the requirements of the experimental technique and was performed in three repetitions.

The experiment was conducted over the course of two years (2016 and 2017) at the same location, but not on the same field.

In order to determine the level of the bacterial attack, notes were made at two different dates 2, 17 August in 2016 and 31 July, 16 August 2017. Recorded data on bacterial attack as well as production data have been statistically interpreted using Duncan test and T test and presented in the following.

RESULTS AND DISCUSSIONS

The main objective of this paper was to determine the evolution and behavior of the main soybean pathogens under different technological conditions. These mainly referred to the sowing distance between rows. To achieve this, three soybeans were compared: Felix, Onix and Caro. Thus, in 2016, an experimental field was set up in Salaj County, where soy was sown in rare rows (50 cm), normal (25 cm) and in thick rows (12.5 cm).

The recorded data refer to the incidence (frequency) of the attack (IA %) of the pathogens, but also to the production recorded according to the parameter mentioned above.

The first observation was made on 02.08.2016 and after these observations, we obtained the data presented in Table 1.

Table 1. Influence of sowing distance on the incidence of bacterium *Pseudomonas syringe* pv. *glycinea* (02.08.2016)

Variant	IA%	Difference	Duncan test
25 cm	16.60 ^{mt}	0.00	B
50 cm	15.83 [˘]	-0.77	B
12.5 cm	7.69 ^{ooo}	-8.91	A
	LSD p 5%	0.74	
	LSD p 1%	1.14	DS – 0.74
	LSD p 0.1%	1.71	

By sowing at different distances, the conditions for the manifestation of the bacterium *Pseudomonas syringe* pv *glycinea* have been changed. Thus, it can be seen the plants sown at a distance of 12.5 cm exhibited a lower incidence of attack compared with the classical sowing distance of 25 cm. The difference is over 50% and is statistically very significant (Table 1). Although the incidence of the disease is lower than the control, also in the variant sown in rare rows, it does not show significant differences.

Data showing the behavior of the varieties on the attack of *Pseudomonas syringe* pv *glycinea* is presented in Table 2. It can be noticed that there are no significant differences between the three varieties, the incidence of the attack being about 13%.

Table 2. The behavior of soybean varieties on the attack of *Pseudomonas syringe* pv. *glycinea* (02.08.2016)

Cultivar	IA %	Difference	Duncan test
Felix	13.45 ^{mt}	0.00	A
Onix	13.50 [˘]	0.05	A
Caro	13.18 [˘]	-0.27	A
	LSD p5%	0.53	
	LSD p1%	0.71	DS – 0.53
	LSD p0.1%	0.96	

Analyzing the behavior of the varieties under differentiated sowing conditions (Figure 3) it can be observed that: the sowing distance of 12.5 cm, resulted in a very significant decrease of the incidence of attack for all three varieties. For the sowing distance of 50 cm the frequency of attack increased only for the Caro variety, the differences being insignificant compared to the parcel sown at 25 cm.

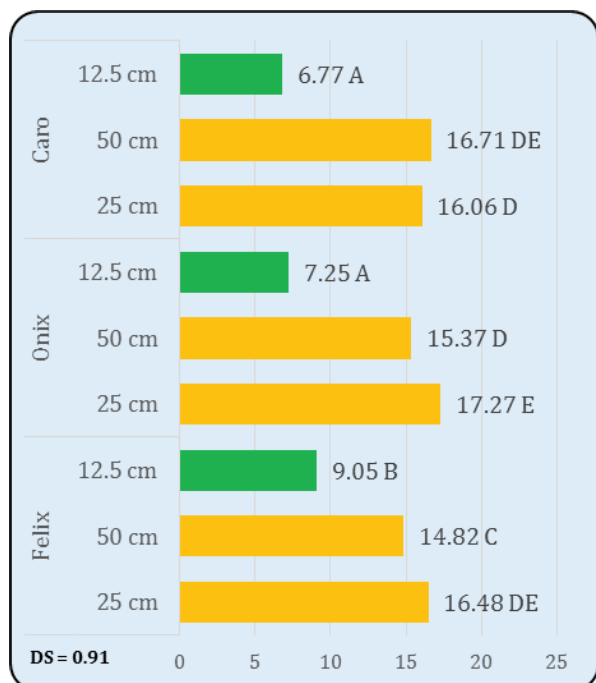


Figure 3. Influence of the sowing distance on the incidence of attack of the bacterial blight according to the monitored variety (02.08.2016)

In the case of the variant sown in thick rows (12.5 cm), the Onix and the Caro varieties are noticeable with the lowest levels of incidence, significantly differing from the Felix variety. The highest incidence of the attack was noted for the Onix variety, the plot sown at 25 cm.

Table 3. Influence of sowing distance on the incidence of attack of bacterium *Pseudomonas syringae* pv. *glycinea* (17.08.2016)

Variety	IA%	Difference	Duncan test
25 cm	22.59 ^{mt}	0.00	B
50 cm	24.08 ^{**}	1.49	C
12.5 cm	11.74 ^{ooo}	-10.85	A

LSD (p 5%) 1.00
LSD (p 1%) 1.45
LSD (p 0.1%) 2.18
DS - 1.00

Further analyzing the incidence of the *Pseudomonas syringae* pv. *glycinea*, it can be observed that: 2 weeks after the first observation on 17.08.2016, the frequency of the attack increased, due to climatic conditions (data not shown) favoring the manifestation of this pathogen.

On this date was noticed also the attack of the pseudofungus *Peronospora manshurica* (data not shown).

Table 4. The behavior of soybean varieties on the attack of *Pseudomonas syringae* pv. *glycinea* (17.08.2016)

Cultivar	IA %	Difference	Duncan test
Felix	19.43 ^{mt}	-0.04	A
Onix	19.62 ^ˆ	0.15	A
Caro	19.36 ^ˆ	-0.14	A

LSD (p 5%) 0.79
LSD (p 1%) 1.08
LSD (p 0.1%) 1.44
DS - 0.79

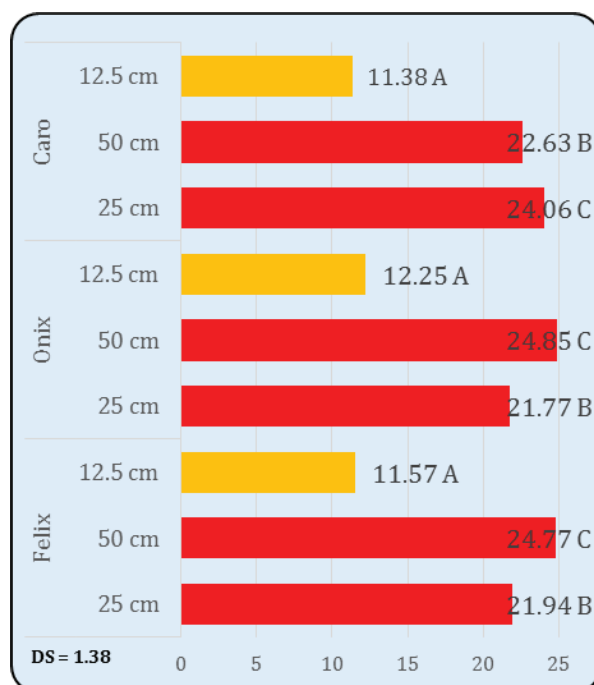


Figure 4. Influence of the sowing distance on the frequency of attack of the bacterial blight according to the monitored variety (17.08.2016)

As in the case of the first observation, the plants sown at 12.5 cm showed the lowest frequency of the attack; only 11.74% is the difference to the control (25 cm between the rows) being very significant. The data from the Table 3 shows that sowing plants in rare rows causes their sensitization to the bacterial blight. No significant difference has been recorded in the second observation between the three varieties; however, it can be seen that the frequency of the attack had increased in two weeks from the first observation with about six percentage points, reaching a maximum of 19.62% in the case of the Onix variety (Table 4).

From Figure 4 it can be seen that in the case of sowing at a distance of 12.5 cm, all three varieties registered significant decreases ranging between 9.5 and 12.6 percentage

points. Although at the first observation Felix and Onix varieties recorded lower frequency of attack than the control when they were sown at a distance of 50 cm between rows, the second notation shows that they behave differently, the incidence was 2-3% higher than the control. In the case of the variant sown in thick rows (12.5 cm) no significant differences are observed between the three varieties. For variants sown at 25 or 50 cm, the frequency of the attack exceeded 20%.

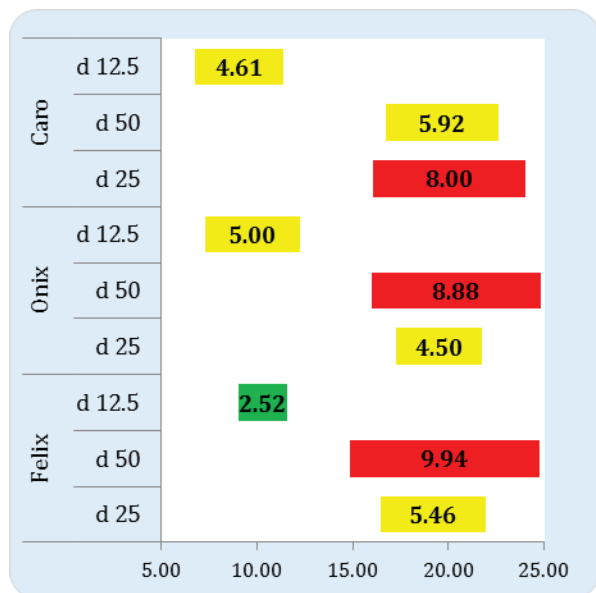


Figure 5. Evolution of attack frequency of the bacterial blight during 2016

The evolution of the pathogen between the two observations is shown in Figure 5. It can be noticed that the pathogen had a weak evolution only in the case of the Felix variety, which was in sow in thick rows, only 2.54%. For variants sowed in rare rows, the evolution was large, exceeding 8% for Felix and Onix varieties. Also, a great evolution is also noted for the Caro variety, sowing 25 cm between the rows. In 2017, the attack had a different evolution than in 2016. Thus, it is noted that the incidence of the attack at the first date of monitoring (31.07.2017) is higher than in 2016. In this case, sowing in thick rows leads to an incidence of attack much less than in the 25 and 50 cm variants. The attack of the *Pseudomonas syringe* pv *glycinea* bacteria is about twice as high in normal and rare-row variants (Table 5). Differences between the three variants are statistically covered.

Table 5. Influence of sowing distance on the incidence of attack of bacterium *Pseudomonas syringe* pv. *glycinea* (31.07.2017)

Variants	IA%	Difference	Duncan test
25 cm	18.80 ^{mt.}	0.00	C
50 cm	17.91 ^o	-0.89	B
12.5 cm	8.73 ^{ooo}	-10.07	A
	LSD (p 5%)	0.67	
	LSD (p 1%)	0.90	DS - 0.67
	LSD (p 0.1%)	1.17	

If in 2016 there were no significant differences between the three tested varieties, in 2017 the behavior of the varieties was different, and there were significant differences between them (Table 6). The most resistant was the Caro variety with a frequency of attack of 14.61%, being the only variety that had an attack of less than 15%.

The Duncan analysis shows that there are significant differences between the three varieties and, in comparison with the Felix variety, Caro variety presents distinctly significant differences. Compared to 2016, the frequency of attack was about 2% higher.

Table 6. The behavior of soybean varieties on the attack of *Pseudomonas syringe* pv. *glycinea* (31.07.2017)

Cultivar	IA %	Difference	Duncan test
Felix	15.67 ^{mt.}	0.00	C
Onix	15.17 ^r	-0.50	B
Caro	14.61 ^{oo}	-1.07	A
	LSD (p 5%)	0.61	
	LSD (p 1%)	0.88	DS - 0.47
	LSD (p 0.1%)	1.30	

Analyzing the behavior of the varieties under differentiated sowing conditions (Figure 6) it can be observed that: the sowing distance of 12.5 cm, resulted in a very significant decrease of the incidence of attack for all three varieties, as in 2016.

For Onix and Caro varieties, the incidence of attack on variants sown at 12.5 cm was below 10%, while for Felix it was 10.55%. While the Felix and Onix varieties have the highest frequency of attack, note the in normal sowing variants (25 cm), the Caro variety reacts negatively to sowing in rare rows (50 cm).

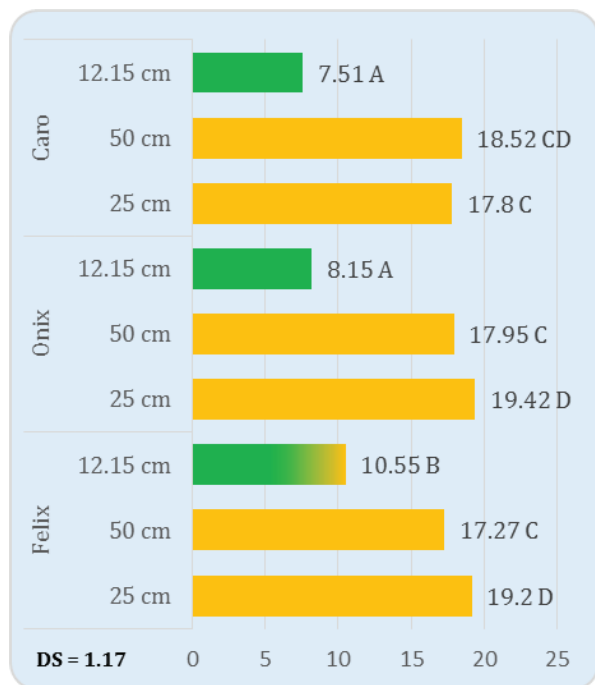


Figure 6. Influence of the sowing distance on the incidence of attack of the bacterial blight according to the monitored variety (31.07.2017)

The second date to observe the frequency of pathogen attack *Pseudomonas syringe* pv *glycinea* was 16 August. At this time we notice that the attack of this pathogen has not evolved as much as in 2016. This is probably due to drought-related climatic conditions (data not shown).

While, in the case of the variant sowed in thick rows, the evolution was not very significant (from 8.73 to 10.24), in the case of the rare rows variant, the increase was more significant, exceeding the value of the attack from the control variant. The difference between the control variant and the variants sown in thick rows is very significant (Table 7).

If on July 31, on the rare rows variants, the difference in attack was significantly lower, in August 16 the differences became distinctly positive, which could be explained by the more intimate contact between the plants on the rows.

From the analysis of Table 8 it can be noted that the Caro variety remains at the top of the most resistant varieties at the attack of the *Pseudomonas syringe* pv *glycinea*. There are no significant differences between Felix and Onix varieties.

Table 7. Influence of sowing distance on the incidence of attack of bacterium *Pseudomonas syringe* pv. *glycinea* (16.08.2017)

Variant	IA%	Difference	Duncan test
25 cm	20.10 ^{mt.}	0.00	B
50 cm	21.10 ^{**}	1.00	C
12.5 cm	10.24 ^{ooo}	-9.86	A
LSD (p 5%)		0.67	
LSD (p 1%)		0.90	DS - 0.67
LSD (p 0.1%)		1.17	

Table 8. The behavior of soybean varieties on the attack of *Pseudomonas syringe* pv. *glycinea* (16.08.2017)

Cultivar	IA %	Difference	Duncan test
Felix	17.68 ^{mt.}	0.00	B
Onix	17.28 ⁻	-0.40	B
Caro	16.48 ^{oo}	-1.20	A
LSD (p 5%)		0.61	
LSD (p 1%)		0.88	DS - 0.47
LSD (p 0.1%)		1.30	

From Figure 7 it can be seen that in the case of sowing at a distance of 12.5 cm, all three varieties registered significant incidence decreases ranging between 9.6 and 11.1 percentage.

In the year 2017, the values of the attack of over 20% were recorded in rare rows variants for the Felix and Onix varieties, but also in the variants normally sown for the Caro and Onix varieties.

The Onix variety presents the highest incidence of the attack, both variants sown in rare rows and normally exceeding 20%.

As for the evolution of the attack, it is easy to see that the values are much lower than in 2016 (Figure 8). Except for varieties rarely sown for Felix and Onix varieties, which show medium increase of attack, at the other variants, the increase from the first reading, are small.

Climatic conditions have significantly influenced the behavior of the bacterium *Pseudomonas syringe* pv *glycinea*. Year 2017 favored less the attack of this pathogen, especially in the first half of August. Data shown in Table 9 shows that there are significant differences between the two experimental years.

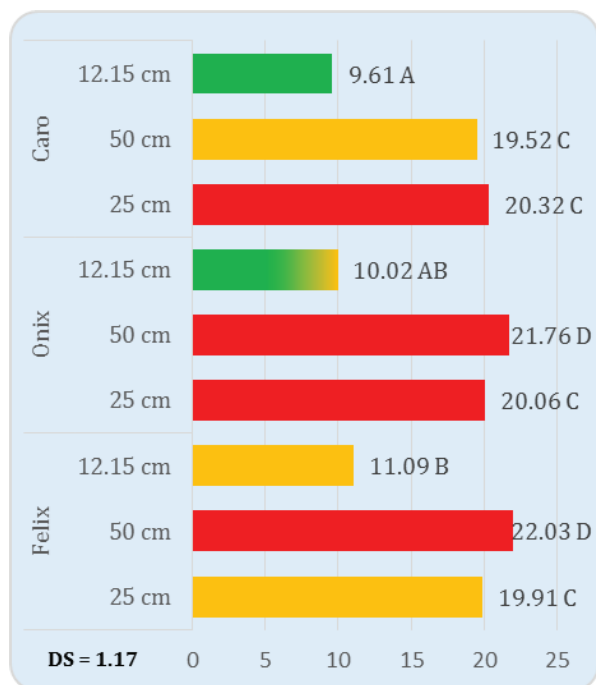


Figure 7. Influence of the sowing distance on the frequency of attack of the bacterial blight according to the monitored variety (16.08.2017)

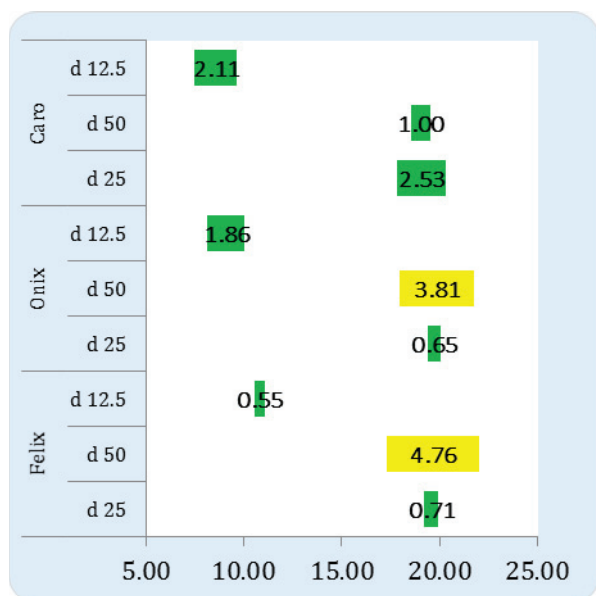


Figure 8. Evolution of the frequency of attack of the bacterial blight during 2017

The average of the two experimental years (Table 10) shows that thick sowing of the soybean may result in very significant decreases in the incidence of the bacterial blight attack. Sowing the soybean in thick rows can lead to half the attack, which can be explained by the more uniform distribution of the nutrition space and implicitly the distances between the plants. These elements must be confirmed by future research.

Table 9. The influence of climatic conditions on the attack of *Pseudomonas syringe* pv. *glycinea*

Cultivar	IA %	Difference	Duncan test
Media	18.31 ^{mt.}	0.00	
2016	19.47 ^{***}	1.16	B
2107	17.15 ^{ooo}	-1.16	A
	LSD (p 5%)	0.28	
	LSD (p 1%)	0.40	DS - 0.35
	LSD (p 0.1%)	0.58	

Table 10. Influence of sowing distance on the incidence of attack of bacterium *Pseudomonas syringe* pv. *glycinea* (2016-2017)

Variant	IA%	Difference	Duncan test
25 cm	21.34 ^{mt.}	0.00	B
50 cm	22.59 ^{***}	1.25	C
12.5 cm	10.99 ^{ooo}	-10.35	A
	LSD (p 5%)	0.47	
	LSD (p 1%)	0.63	DS - 0.77
	LSD (p 0.1%)	0.81	

Table 11. The behavior of soybean varieties on the attack of *Pseudomonas syringe* pv. *glycinea* (2016-2017)

Cultivar	IA %	Difference	Duncan test
Felix	18.55 ^{mt.}	0.00	B
Onix	18.45 ⁻	-0.10	B
Caro	17.92 ^o	-0.63	A
	LSD (p 5%)	0.47	
	LSD (p 1%)	0.65	DS - 0.44
	LSD (p 0.1%)	0.88	

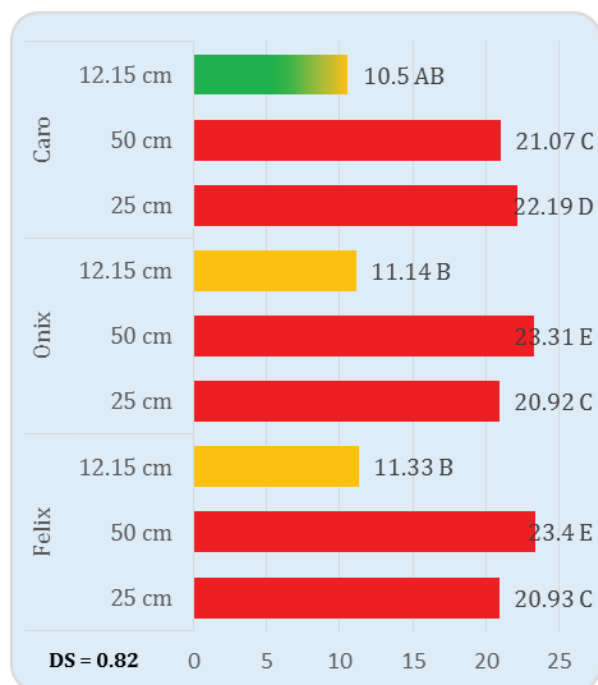


Figure 9. Influence of the sowing distance on the frequency of attack of the bacterial blight according to the monitored variety (2016-2017)

On rare sown variants the attack increased. Although the difference between these variants and those sown normally is only 1.25%, it is statistically covered.

The behavior of varieties tested in the two experimental years was very similar regarding the differences between them.

However, it can be seen from the statistical analysis that the Caro variety shows significant differences from the other two tested varieties. In this case, the frequency of the *Pseudomonas syringae* pv *glycinea* attack had the lowest value of 17.92 (Table 11).

From the analysis of the graph in Figure 9 it can state that there are significant differences between the variants sown in thick rows compared to the other two experimental variants. On average over the two experimental

years, the incidence of the attack ranged between 10.5 and 11.4 for variants sown in rows and between 20.9 and 23.4 for variants sowed in normal and rare rows.

Analyzing the production data of the three varieties (Figure 10) it can be seen that the different sowing distance influences their production. The lowest yields (under 2000 kg/ha) are recorded for variants sown in rare rows. This is due in particular to the high incidence of pathogens in these plots.

For all the tested varieties in the plots sown in thick rows the yields exceed 3000 kg/ha.

Also, the graphic shows the relationship between production and the level of attack of the bacterial blight. It is noted that there is an inversely proportional relationship between these two parameters.

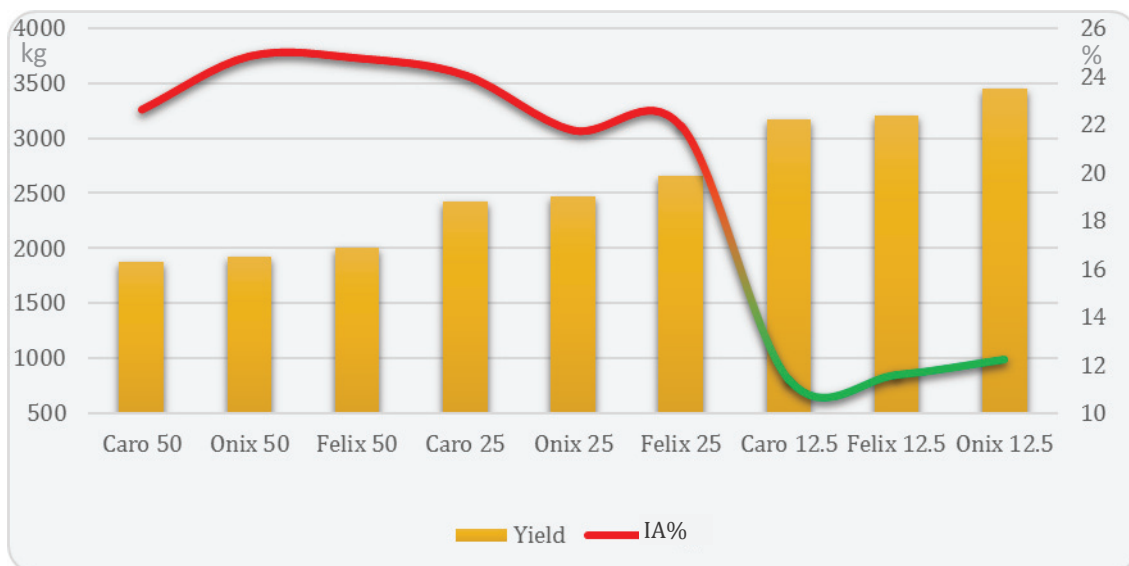


Figure 10. Relationship between production and the frequency of attack

CONCLUSIONS

The sowing distance influences the level of attack of the bacterium *Pseudomonas syringae* pv *glycinea*.

Under the climatic conditions of 2016, bacterial blight showed an incidence of the attack (frequency) which range between 11 to 25%.

In 2017 attack frequency range 9 to 23%, about 2% lower than in the previous year.

Seeding in thick rows (12.5 cm) led to a significant decrease in the attack of this disease.

Climatic conditions have significantly influenced the pathogen attack. The drought in the

first half of August practically stopped its evolution.

The soybean variety with the best bacterial attack behavior in the two experimental years turned out to be Caro

It can also be concluded that there is an inversely relationship between the level of attack and production. The production in variants sown at 12.5 cm between rows exceeded 3 tons per hectare.

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