Nina Araslanova, Tatiana Antonova*, Ekaterina Lepeshko, Tatiana Usatenko, Svetlana Saukova, Maria Iwebor and Yulya Pitinova

New races of rust pathogen on sunflower in Russia

https://doi.org/10.1515/helia-2021-0007
Received April 8, 2021; accepted May 19, 2021; published online July 19, 2021

Abstract: Over the past two decades, there was observed a widespread of rust on sunflower in some regions of Russia. The identification of the racial structure of *Puccinia helianthi* populations in Russia has not been done since the early 80s of the last century. At that time, races 100 and 300 were identified. In our recent study, in addition to these races, new biotypes: 700, 710, 722, 772 were identified for the first time. The purpose of this study is to determine the racial identity of 160 *P. helianthi* isolates collected from 2018 to 2020 in the Rostov, Saratov, and Krasnodar regions. We used eight standard differentiating lines of sunflower: SM-90, SM 29, R-386, HAR-1, HAR-2, HAR-3, HAR-4, HAR-5. Sunflower variety VNIIMK 8883 was used as a differentiator susceptible to all races of the pathogen. In addition to the six races mentioned above, we identified 11 more new races for the first time: 304, 351, 352, 364, 704, 736, 740, 741, 745, 760, 762. Race 700 prevailed among the isolates collected in the Rostov region in 2020; we also identified single specimens of races 760, 762. Thus, 17 races of *P. helianthi* were found on sunflower in three regions of the Russian Federation. Other races may be also present here, so further research is required.

Keywords: fungus; *Puccinia helianthi*; races; region; rust; sunflower.

Introduction

The rust pathogen is an obligate parasite of sunflower. As a result of its vital activity, the fungus dries up the leaves, which have a negative effect the

***Corresponding author: Tatiana Antonova**, V.S. Pustovoit All-Russian Research Institute of Oil Crops, Filatov str., 17, Krasnodar, 350038, Russia, E-mail: antonova-ts@mail.ru. https://orcid.org/0000-0001-8915-1136
Nina Araslanova, Ekaterina Lepeshko, Tatiana Usatenko, Svetlana Saukova, Maria Iwebor and Yulya Pitinova, V.S. Pustovoit All-Russian Research Institute of Oil Crops, Filatov str., 17, Krasnodar, 350038, Russia

productivity and quality of the seeds of the crop (Gulya 1990; Gulya and Maširević 1995; Sackston 1962; Yang et al. 1986). Yield losses can reach 60–80% depending on weather conditions and the stage of plant development (Markell et al. 2009; Sackston 1962). Rust is common in all countries cultivating sunflower, including Russia (Detsyna et al. 2018; Friskop et al. 2012; Gulya 1997; Qi et al. 2011; Sendall et al. 2006; Vypritskaya 2015).

The spread of the disease is directly related to the emergence of virulent races of the pathogen. The racial composition of *Puccinia helianthi* Schwein is not constant; sexual and asexual reproduction inherent in the pathogen, along with mutations, which leads to the rapid emergence of new virulent pathotypes (Friskop and Markell 2016; Jing et al. 2015). Our earlier studies showed that in three regions of the Russian Federation, the Saratov, Lipetsk, and Krasnodar regions, we found six races of the sunflower rust pathogen. Of these, four races, 700, 710, 722, and 772, are highly virulent and have been identified in the Russian Federation for the first time. We also found the old races 100 and 300 (Antonova et al. 2020). This situation could arise under the influence of a combination of factors, such as: a widespread decrease of the time of return of a crop to its former place against the background of an increase in its crop acreage, as well as global warming. The monitoring of the racial structure of a population of the rust pathogen is a necessary condition for successful breeding in Russian Federation of sunflower varieties and hybrids resistant to this pathogen.

The aim of the study: to determine the racial identity of 160 *P. helianthi* isolates collected on sunflower fields in the Krasnodar and Saratov regions in 2018–2020, and in the Rostov region in 2020.

Materials and methods

We collected the leaves affected by rust from the sunflower plants of different genotypes in the Krasnodar, Saratov, and Rostov regions and stored them in a refrigerator (+4–6 °C). The seeds of differentiating lines of sunflower resistance (SM 90, SM 29, R-386, HAR-1, HAR-2, HAR-3, HAR-4, HAR-5) and variety VNIIMK 8883, which was used as susceptible to all races of the pathogen, were sown in rows in flower boxes with a soil capacity of 6 kg. The boxes were placed in a climate chamber, where the plants were grown at a temperature of 23–25 °C in the daytime and 20 °C in the night-time with a 16 h photoperiod until the appearance of the second pair of true leaves. Watering was carried out daily. The samples of leaves affected by rust (with urediniua) were placed in a humidity chamber for 24 h to renew sporulation. Then the spores were washed off with a brush into distilled water. The amount of uredinio spores in the suspension was counted by using a Goryaev camera. Their optimal concentration for the affection of susceptible sunflower plants by 100% should be 100 … 110 thousand pieces in 1 ml of water (Slyusar 1981). The plants that formed the second pair of true leaves were sprayed with the prepared suspension and the boxes with them were placed in a humidity chamber at a temperature of 20–21 °C for 24 h. Then they were returned to their previous conditions until the appearance of affection signs on the leaves. The incubation period was nine days at 25 °C. After nine days, the affection degree of differentiators was analyzed and classified as R (resistant) or S (susceptible) according to their response. The infectious type 3 or more was classified as a susceptible reaction on a four-point scale proposed by E. E. Geshele (Geshele 1971) (Figure 1).

Figure 1: The sunflower affection by rust in the Krasnodar region in 2019 (orig).

Results

There were identified a total of 160 rust pathogen isolates collected during the period of 2018–2020 in the Krasnodar, Saratov, and Rostov regions. Each tested *P. helianthi* isolate affected the differentiators susceptible to it with a degree higher than 3–4 points (Figure 2).

Among the isolates of the Saratov region collected in 2018, five races were identified, of which race 304 was detected for the first time. Races 300 and 700 were prevalent. Race 736 with the highest virulence code was found in a single sample (Figure 3). In the sample of isolates of 2019, a total of seven races were identified, of which there were three new ones: 352, 364, and 710. Same as in the previous year, race 300 was prevalent, and race 736 was represented by one isolate. Races 700 and 300 dominated the sample of isolates of 2020. Two isolates represented race 100.

The isolates collected in 2018 in the Krasnodar region were identified as races 100 and 300, with the prevalence of the latter (Figure 4), while four races with the prevalence of race 300 as before represented the isolates of 2019. Races 100, 304, and 351 were represented by single isolates. Among these, race 351 was identified for the first time. Among the isolates collected in the Krasnodar region in 2020, race

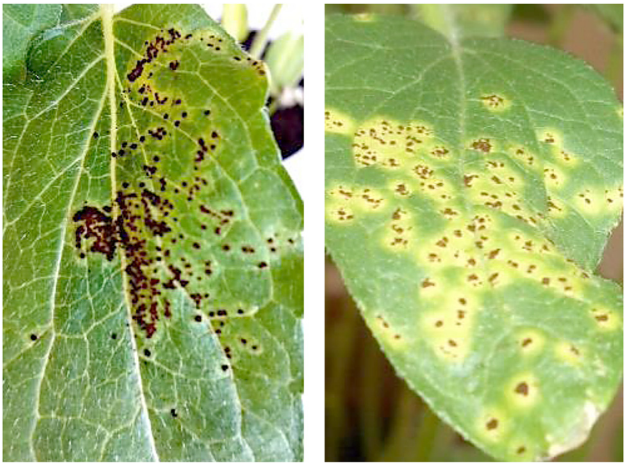

Figure 2: Uredopustules of *P. helianthi* isolate from the Rostovsky region with virulence code 700 on a leaves of differentiating line of sunflower resistance CM 90 (left) and CM 29 (right) (orig).

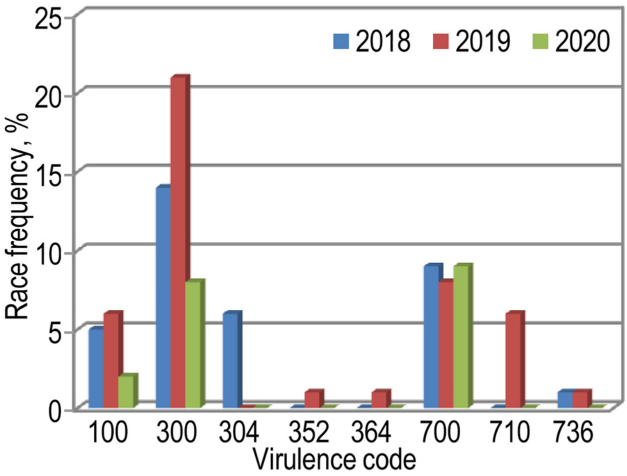

Figure 3: The distribution (%) of races of sunflower rust pathogen in isolate samples from the Saratov region, 2018–2020.

300 was also prevalent, but, for the first time in this region, there were identified races 700 and 704.

In the Rostov region, a strong affection of sunflower by rust occurred in 2020. In the sample of pathogen isolates collected there during this period from different

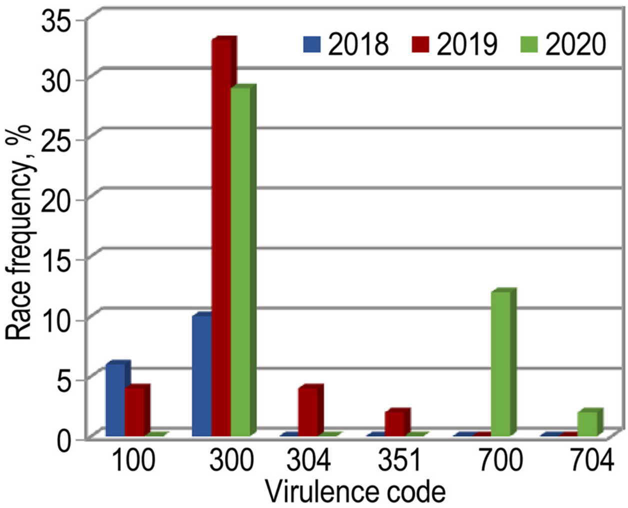

Figure 4: The distribution (%) of races of sunflower rust pathogen in isolate samples from the Krasnodar region, 2018–2020.

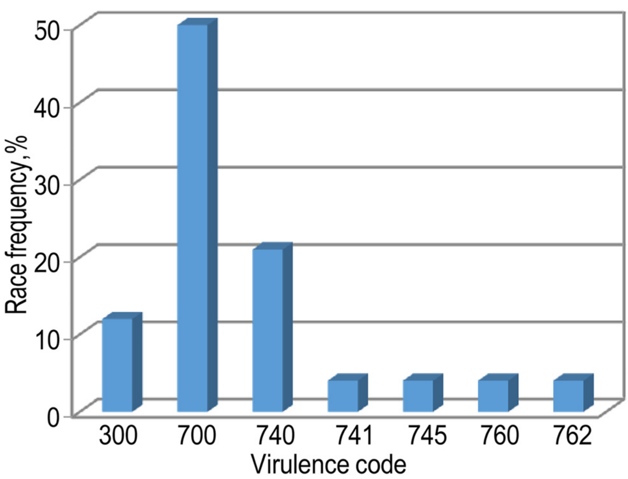

Figure 5: The distribution (%) of races of sunflower rust pathogen in isolate samples from the Rostov region in 2020.

sunflower genotypes, seven races were identified, among which race 700 was prevalent (Figure 5). For the first time in the Rostov region, there were identified races 740, 741, 745, 760, 762.

Table 1: The ratio of identified *P. helianthi* races among the isolates collected on sunflower in three regions of the Russian Federation in 2018–2020.

Region	Number of isolates, pcs.														
	Virulence code of isolate														
	100	**300**	**304**	**351**	**352**	**364**	**700**	**704**	**710**	**736**	**740**	**741**	**745**	**760**	**762**
2018															
Saratov	4	12	5	0	0	0	8	0	0	0	0	0	0	0	0
Krasnodar	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0
2019															
Saratov	5	18	0	0	1	1	7	0	5	1	0	0	0	0	0
Krasnodar	2	17	2	1	0	0	0	0	0	0	0	0	0	0	0
2020															
Saratov	2	7	0	0	0	0	8	0	0	0	0	0	0	0	0
Krasnodar	0	15	0	0	0	0	6	1	0	0	0	0	0	0	0
Rostov	0	3	0	0	0	0	12	0	0	0	5	1	1	1	1
Total number of isolates	16	77	7	1	1	1	41	1	5	1	5	1	1	1	1
The races ratio in the total sample of isolates, %	**10**	**48**	**4.4**	**0.6**	**0.6**	**0.6**	**26**	**0.6**	**3.1**	**0.6**	**3.1**	**0.6**	**0.6**	**0.6**	**0.6**

In the combined sample of isolates from the indicated regions of the Russian Federation for 2018–2020, race 300 was prevalent (48% of samples) (Table 1). Race 700 should also be noted (26%). The small number of specimens of other races presented in Table 1 requires further monitoring of the frequency of their occurrence.

Discussion

The virulence diversity of *P. helianthi* isolates from the studied regions may be related to the growing intensification of sunflower cultivation with the widespread use of foreign-bred hybrids as sowing material, as well as with changes in climatic conditions. The races ratio in the total sample size may depend, in particular, on the number of isolates and varietal diversity of host plants from which the affected leaves were collected. The problem requires an elaborate approach to further study the ratio of rust pathogen pathotypes in the regions of the Russian Federation. Regular monitoring of the racial structure of the rust pathogen populations is required, both in the indicated regions of sunflower cultivation, and in others.

Conclusions

Thus, among the total studied sample of isolates of sunflower rust pathogen, collected in three regions of the Russian Federation in 2018–2020, we identified 17 races, races 300 (48%) and 700 (26%) prevailed. For the first time, there were identified 11 new pathotypes with the code numbers: 304, 351, 352, 364, 704, 736, 740, 741, 745, 760, 762.

Acknowledgment: The authors express gratitude to fellow scientists from the United States: T. Gulya, S. Markell, R. Harveson, M. Gilley, and A. Friskop for the support and for the provided seeds of differentiator lines of sunflower resistance to rust.
Author contributions: All the authors have accepted responsibility for the entire content of this submitted manuscript and approved submission.
Research funding: None declared.
Conflict of interest statement: The authors declare no conflicts of interest regarding this article.

References

Antonova, T.S., Araslanova, N.M., Iwebor, M.V., Saukova, S.L., and Pitinova, Y.V. (2020). New races of *Puccinia helianthi* Schwein – sunflower rust pathogen in the Russian Federation. Vestn. Russ. Agric. Sci. 2020(5): 23–26.

Detsyna, A.A., Tereshchenko, G.A., and Illarionova, I.V. (2018). The occurrence of rust on sunflower varieties in the conditions of the Krasnodar region//Oil crops. Sci. Tech. Bull. VNIIMK 2018: 101–106.

Friskop, A.J. and Markell, S.G. (2016). Rust: 23–25. In: Harveson, R.M., Markell, S.G., Block, C.C., and Gulya, T.J. (Eds.), *Compendium of sunflower Diseases and pests*. The American Phytopathological Society, St. Paul., Minnesota, U.S.A.

Friskop, A., Gulya, T., Jordahl, J., Ramsett, M., Harveson, R., Acevedo, M., Harveson, R., and Markel, S. (2012). Determination of *Puccinia helianthi* races in the Unites States Northern Great Plains. In: *Proceedings of the 18th international sunflower conference*. International Sunflower Association, Mardel plata & Balcarce, Argentina, pp. 214–218.

Geshele, E.E. (1971). The infectious process and rust pathogenesis. In: *The book Methodological guideline for phytopathological evaluation of cereals*. N/A, Odessa, pp. 50–55.

Gulya, T.J. (1990). The sunflower rust situation in 1989. In: *Proc. Sunflower research workshop*. National Sunflower Association, Bismarck, ND, p. 106.

Gulya, T.J. (1997). Sunflower rust races in the United States in 1996. Phytopathology 87: S36.

Gulya, T.J. and Maširević, S. (1995). *Proposed methodologies for inoculation with Puccinia helianthi and for disease assessment*. The FAO European Research Network on Sunflower, Bucharest, Romania, pp. 31–48.

Jing, L., Xu, X., Jing, J., Li, L., and Navi, S. (2015). Determination of physiological races and evaluation of sunflower for resistance to *Puccinia helianthi* Schw. J. Phytopathol. 163: 507–515.

Markell, S., Gulya, T., McKay, K., Hutter, M., Hollingsworth, C., Ulstad, V., Koch, R., and Knudsvig, A. (2009). Widespread occurrence of the aecial stage of sunflower rust caused by *Puccinia helianthi* in North Dakota and Minnesota in 2008. Plant Dis. 93: 668–669.

Qi, L., Gulya, T., Seiler, G., Hulke, B., and Vick, B. (2011). Identification of resistance to new virulent races of rust in sunflowers and validation of DNA markers in the gene pool. Phytopathology 101: 241–249.

Sackston, W. (1962). Studies on sunflower rust. III. Occurrence, distribution, and significance of races of *Puccinia helianthi* Schw. Can. J. Bot. 40: 1449–1458.

Sendall, B., Kong, G., Goulter, K., Aitken, E., Thompson, S., Mitchell, J., Kochman, J., Lawson, W., Shatte, T., and Gulya, T. (2006). Diversity in the sunflower: *Puccinia helianthi* pathosystem in Australia. Australas. Plant Pathol. 35: 657–670.

Slyusar, E.L. (1981). The races of sunflower rust. Plant Prot. (11): 42.

Vypritskaya, A.A. (2015). *Mycobiota of sunflower in the Tambov region: monography*. Print-Service, Tambov, p. 143.

Yang, S.M., Antonelli, E.E., Luciano, H., and Lucinai, N.D. (1986). Argentine and Australian sunflower rust differentials to four North American cultures of *Puccinia helianthi* from North Dacota. Plant Dis. 70: 883–886.