CLIMATE CHANGE AND ITS INFLUENCE ON OCCURRENCE OF YELLOW RUST IN SERBIA

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Abstract

There are challenges in monitoring the occurrence of rusts since population structure of wheat pathogens continuously change under selection pressures of agro-ecological conditions, resistant varieties and applied pesticides. Climate-change impacts on occurrence of yellow rust in Serbia were estimated in experiments involving efficacy testing for fungicides and breeding material resistance. The significant influence of climatic elements and varieties on disease index of yellow rust was confirmed and the most influencing were average temperatures in January ($P = 0.000$), variety ($P = 0.000$) and interaction between year and variety ($P = 0.000$). Furthermore, yield loss was significantly affected by the disease index of yellow rust ($P = 0.000$) and varieties ($P = 0.000$), but relationship of disease index and yield loss was not straightforward.

Introduction

The impact of climate change on wheat production has become a global issue and a cause of great concern within scientific community. The climate change affects many aspects of wheat farming systems including pest management and control. Population structure of wheat pathogens continuously change under selection pressures of agro-ecological conditions, resistant varieties and applied pesticides. As a result, breeding wheat for resistance to economically important diseases is a continuous and very challenging process. The occurrence of wheat rusts in Serbia was monitored for decades by experiments associated with resistance and fungicide efficacy testing. In 2014, warming winter and excessive rainfall in spring significantly affected population structure of rusts in Serbia resulting in

predominance of yellow rust caused by *Puccinia striiformis* f. sp. *tritici* over the leaf rust caused by *Puccinia triticina*. Thus, a great number of wheat producers suffered yield losses since the management of yellow rust and leaf rust is different regarding the time needed for fungicide application. Knowing that yield is a complex trait influenced by biotic and abiotic factors, the impact of changing climate elements on occurrence of wheat rusts and yield loss of different wheat varieties is examined in this study.

Materials and methods

The experiments were conducted in the locality Rimski Šančevi (Vojvodina, the northern province of Serbia). The influence of changing climate elements on occurrence of yellow rust was examined on three model varieties: common wheat NS 40S (*Triticum aestivum* spp. *aestivum*), club wheat Barbee (*Triticum aestivum* spp. *compactum*) and durum wheat Durumko (*Triticum turgidum* subsp. *durum*). Variety Barbee is known for increased susceptibility to wheat rusts while Durumko is usually used as susceptible check for leaf blotch diseases. Varity NS 40S is known for its tolerance on wheat rusts and released by the Institute of Field and Vegetable Crops, Novi Sad, Serbia. Field trials were set up in a randomized block design in four replicates with plot size of 10 m^2 under naturally occurring inoculum. The severity of rusts was estimated at the growth stage 71-73 BBCH (kernel watery; early milk) using modified Cobb's scale (Peterson et al., 1948). Disease index of yellow rust was calculated by taking into consideration rust incidence and severity. Yield was measured for each plot at 15% water content. The yield loss (%) was determined according to yield reducing effects in untreated plots compared to the yield of treated plots showing best control of wheat diseases. General Linear Model was used in order to investigate the influencing factors on occurrence of yellow rust and yield losses of wheat varieties. For all statistical analysis software Minitab 17 (trial version) was used.

Results and discussion

Until 2014 leaf rust was predominant rust pathogen in Serbia and well controlled. However, high temperatures in January and February together with above

average precipitation totals in March and April in 2014 favored occurrence of yellow rust over the leaf rust (Figure 1A). Using General Linear Model the significant influence of climatic elements on disease index of yellow rust was confirmed and the most influencing was average temperature in January (P = 0.000) together with the influence of variety (P = 0.000) and interaction between year and variety (P = 0.000). Different reaction of wheat varieties on disease pressure under favorable climatic conditions was shown using varieties with different levels of tolerance to rust pathogens. It was confirmed by Fisher's test at P = 0.05, when comparing paired means of disease index for yellow rust, that variety Barbee was significantly more susceptible than varieties NS 40S and Durumko (Figure 1B). It is important to point out that changing climate elements did not trigger change in genetic structure of existing rusts populations in the territory of Serbia, but enabled infection of winter wheat by races which were introduced in the country. Jevtić et al. (2017) reported that Warrior race, originated from the center of diverse (near-Himalayan region), predominated in wheat production area in Serbia in 2014.The Warrior race has been recognized as a serious threat for wheat prediction in many European countries since 2011 due to its higher aggressiveness and adaptation to higher temperatures than older populations of yellow rust (Hovmøller et al., 2016). As a consequence, many efforts were made in order to develop models for predicting occurrence of yellow rust and yield losses of wheat varieties (Coakley et al., 1988; Sharma-Poudyal and Chen, 2011).

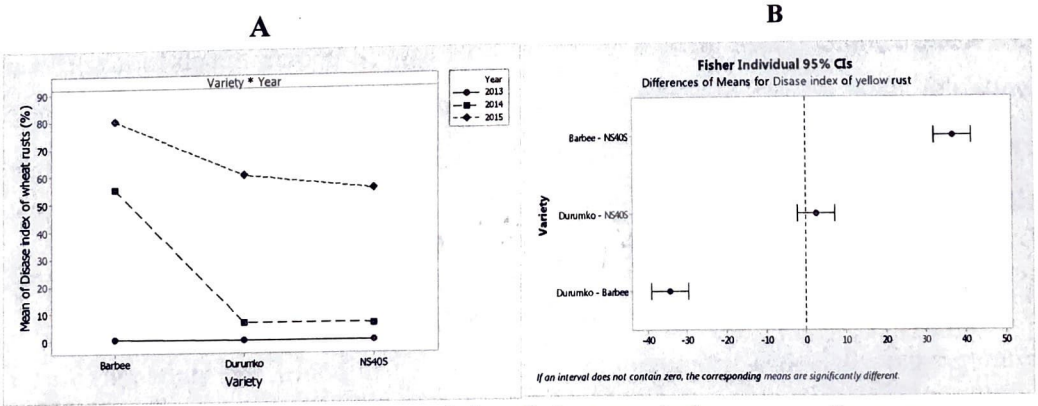

Figure 1. A) The mean of disease index of wheat rusts in three consecutive years; (B) The difference of means of disease index of yellow rust estimated by Fisher's test at P = 0.05.

The yield losses of three varieties were generally higher in 2014 than in 2015 although disease index of yellow rust was higher in 2015 (55–80%) comparing with disease index in 2014 (5–55%) (Figure 2A, 2B). Even though yield loss was significantly influenced by disease index of yellow rust (P = 0.000), the relationship between disease index and yield loss was not straightforward indicating that high scores of diseases index is not necessary related with high yield losses (Figure 2B). Knowing that the yield is a complex trait, yield loss of examined varieties could be attributed not only to significant influence of yellow rust but also to significant influence of the year (P = 0.003) and the varieties (P = 0.000).

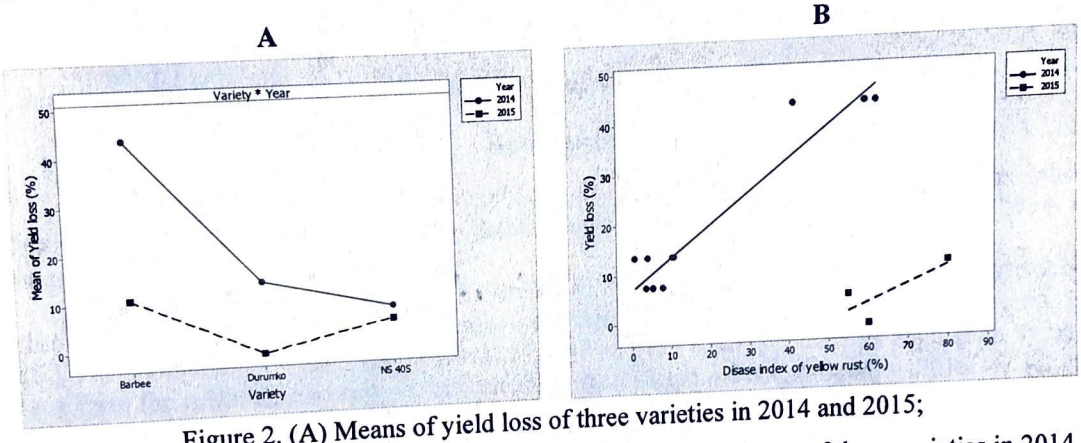

Figure 2. (A) Means of yield loss of three varieties in 2014 and 2015; (B) Regression of the disease index of yellow rust and yield loss of three varieties in 2014 and 2015.

Župunski et al. (2016) reported positive moderate correlation (Pearson's r = 0.397) between yield loss of 17 commercial varieties and disease index of yellow rust examined in locality Rimski Šančevi, Serbia in 2014. In that experiment, coefficient of determination R^2 was 16% indicating a great dispersion of data. It was reported that regression models which take into account only disease index of yellow rust had low possibility of predicting future yield losses. As a consequence, more factors influencing yield loss should be taken into consideration for constructing yield loss prediction models.

Conclusions

This study confirmed that rising winter temperatures, especially temperatures in January, significantly affected changes in population structure of wheat rusts

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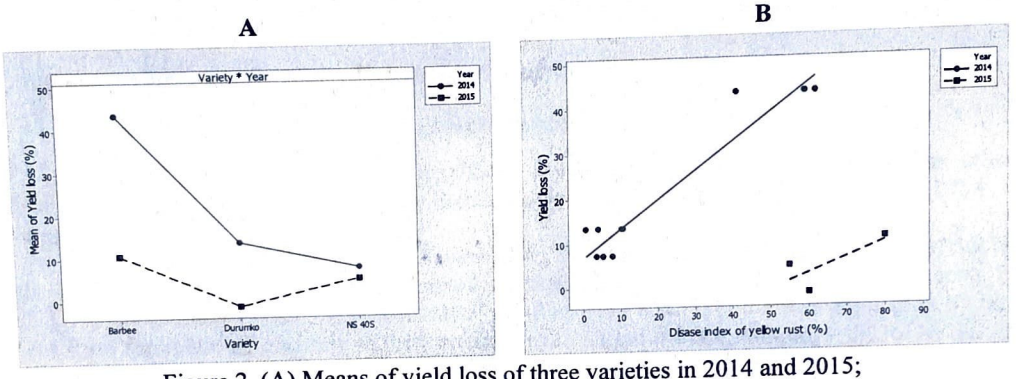

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Conclusions

This study confirmed that rising winter temperatures, especially temperatures in January, significantly affected changes in population structure of wheat rusts

favoring occurrence of yellow rust in Serbia. Wheat yield losses were significantly affected not only by disease index of yellow rust but also by varieties and abiotic factors, emphasizing the need to include both biotic and abiotic factors for constructing yield loss prediction models. This study also confirmed that global warming together with the changes in population structure of wheat rusts are serious threats, and many efforts should be made in order to ensure sustainable wheat production in the future.

Acknowledgements

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References

Coakley S. M., Line R. F., McDaniel L. R. Predicting striperust severity on winter wheat using an improved method for analyzing meteorological and rust data // Phytopathology. 1988. № 78. pp. 543–550.

Hovmøller M. S., Walter S., Bayles R. A., Hubbard A., Flath K., Sommerfeldt N., Leconte M., Czembor P., Rodriguez-Algaba J., Thach T., Hansen J. G., Lassen P., Justesen A. F., Ali S., de Vallavieille-Pope C. Replacement of the European wheat yellow rust population by new races from the centre of diversity in thenear-Himalayan region // Plant Pathology. 2016. № 65. pp. 402–411.

Jevtić R., Župunski V., Lalošević M., Župunski Lj. Predicting potential winter wheat yield losses caused by multiple disease systems and climatic conditions // Crop Protection. 2017. № 99. pp. 17–25.

Peterson R. F., Campbell A. B., Hannah A. E. A diagrammatic scale for estimating rust intensity on leaves and stems of cereal // Canadian Journal of Research. 1948. № 26. pp. 496–500.

Sharma-Poudyal D., Chen X. M. Models for predicting potential yield loss of wheat caused by stripe rust in the U.S. Pacific Northwest // Phytopathology. 2011. № 101. pp. 544–554.

Župunski V., Jevtić R., Lalošević M. The occurence of yellow rust of winter wheat in relation to year. XV Simposium on plant protection, Zlatibor, Book of abstracts. 2016. pp. 9–90 (In Serbian).

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