Dynamics of Hybrid Sunflower Disease Resistance

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Abstract

Breeding for resistance to the main diseases is very important part of sunflower history in Russia. The list of most important diseases is changed depending on the region and time. Traditionally, sunflower breeders pay more attention to broomrape, downy mildew and Diaporthe stem canker in Krasnodar region. The aim of our study was to evaluate dynamics for resistance of sunflower lines and hybrids to the most important diseases in a breeding program of All-Russia Research Institute of Oil Crops (VNIIMK) in Krasnodar in order to correct it. Experiments were conducted at the Central Station of VNIIMK from 2000 till 2013. Released, prospective and experimental sunflower hybrids and lines of VNIIMK breeding were used as a material. Experimental design was randomized blocks with three replications. Field resistance was evaluated by specialists from the Immunology laboratory of VNIIMK. Results of new experimental sunflower hybrids evaluation for resistance to main diseases are shown. Increasing of some pathogens occurrence is noticed, which requires taking more attention to them in the resistance breeding program. These data can be used for breeding program improvement.

Keywords: sunflower; resistance; pathogen; breeding; hybrid; disease

Introduction

Sunflower is the main oil crop in Russia. Breeding for resistance (or at least tolerance) to diseases always considered to be the most important aim in sunflower breeding. The list of most important diseases is changed depending on the region and time. Traditionally, sunflower breeders pay more attention to broomrape, downy mildew and Diaporthe stem canker in Krasnodar region. Rust, being one of the most important sunflower diseases previously was practically vanished after releasing of resistant cultivars in 1960s. Similar situation was occurred with Diaporthe stem canker, which was seems to destroy all the sunflower acreages in the southern regions in Russia in 1997, but steadily decreased the pressure when susceptible varieties were steadily replaced with “stay green” hybrids. Meanwhile susceptible lines show its symptoms every year in the sunflower nurseries. Fusarium disease is one of the most important one for many crops. But for sunflower it was earlier considered to be of less importance or minor disease (Gulya *et al*., 1997). During last years, it became a serious problem for sunflower crop in Russia (Antonova *et al*., 2002). Special breeding program for resistance to *Fusarium sp*. started at VNIIMK in 2001 year using the laboratory test developed in VNIIMK (Gontcharov *et al*., 2006).

As it is perfectly known, success in resistance breeding leads to disequilibrium in the “host-parasite” system and stimulates parasite to evolve new races. Varying climatic environments favor different pathogens in different years. All this requires constant control of phytopathologic situation (Van der Plank, 1968).

The aim of our study was to evaluate dynamics for resistance of sunflower lines and hybrids to the most important diseases in a breeding program of All-Russia Research Institute of Oil Crops (VNIIMK) in Krasnodar in order to correct it.

Materials and methods

Experiments were conducted at the Central Station (Krasnodar) of All-Russia Research Institute of Oil Crops (VNIIMK) from 2000 till 2013. Krasnodar region is situated in the Southern part of Russia near the Black Sea. Climatic conditions are very favorable here for sunflower production. Sunflower usually covers about 0.4–0.5 million ha in this region.

Released, prospective and experimental sunflower hybrids of VNIIMK breeding were used as a material. The number of evaluated hybrids varied from 250 to 500 from year to year. Most of the entries were tested during one or two years only, only released hybrids (Kubanskiy 930, Jupiter, Triumph, Hermes and some others) were evaluated every year. VNIIMK elite lines were used for observation of field resistance to downy mildew also.

Experimental design was randomized blocks with three replications. Each replication had four rows with 25 plants in each row. Field resistance was evaluated by specialists from the Immunology laboratory of VNIIMK. For our purpose, we registered incidence (%) of each disease in two ways: quantity of entries (hybrids) with at least one plant infected by a particular disease and maximum percentage of attacked plants on the most infected plot for each disease. Disease severity was not analyzed in this study.

Results and discussion

Field resistance of tested sunflower hybrids showed substantial differences for majority of diseases during the period from 2000 to 2013. Results for the most important sunflower diseases are presented below.

Downy mildew (*Plasmopara halstedii* Berl. et de Tony)

Previously symptoms of this disease were not registered on VNIIMK sunflower hybrids in the trials. It was a result of traditional VNIIMK breeding methodology: all elite restorer lines should be resistant to downy mildew (race 330). Situation changed with appearance of new races for our region (mainly 730 and 770) (Ivebor, 2009). From 2010 infected plants were registered every year. About a half of all entries had at least one plant with downy mildew symptoms in the hybrid trial in 2012 (Tables 1–2). Interesting that number of infected plants among mother lines was significantly lower in comparison with restorer lines. Meanwhile mother lines (*cms*-lines and maintainers) have no major genes for downy mildew resistance and all restorer lines were resistant to the most predominant race 330. Probably horizontal or field resistance of mother lines appeared as a results of infected plants discarding during a breeding process. In case of restorer lines, such breeding was impossible because of major resistance gene effect. From 2004 breeding material is evaluated for resistance to the new races of downy mildew at VNIIMK and resistant lines were developed. But only one resistant to them sunflower hybrid (Legion) is released till now.

Tab.
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Table 1:

Incidence of different diseases (attacked hybrids, %) inthe sunflower field trials during 2000–2012 years (Krasnodar)

Tab.
Table 2:

Maximum registered incidence of different diseases (infected plants per plot, %) in the sunflower field trials during 2000–2012 years (Krasnodar)

Broomrape (parasitic angiosperm *Orobanche cumana* Wallr.)

Field resistance evaluation to broomrape is not effective because crop rotation system used in VNIIMK protect the soil from contamination by *Orobanche* seeds. Only few broomrape plants could be found even in the restorer line nurseries, although they have no major genes for resistance to broomrape. Evaluation is made in the greenhouse and specially infected nursery only. Results were described in the previous report (Gontcharov, 2009).

Sclerotinia white rot (*Sclerotinia sclerotiorum* (Lib.) de Bary)

Head rot is very important disease but it is rather rare in Krasnodar region. Stalk form of the disease is more usual and show no obvious differences between genotypes. It was not registered in 2012. Frequency of damage is dependent on environmental conditions mainly. To breed for resistance to this pathogen, it is necessary to evaluate sunflower lines in other regions (more cold and humid) or to use an artificial inoculation.

Diaporthe stem canker (*Diaporthe helianthi* Munt.-Cvet.)

In the end of 1990s, it was the most important disease in Krasnodar region. Then its harmfulness was decreased greatly. But susceptible genotypes demonstrate symptoms of Diaporthe stem canker every year. That means infection is readily present in the field, so it is necessary to monitor the situation all the time, especially taking in the account new species of *Diaporthe* registered on sunflower in the USA and Australia.

Fusarium disease (*Fusarium* sp.)

Fusarium disease (*Fusarium* sp.) is registered on sunflower more and more often during the last time. Prominent results were achieved in breeding for resistance to it, but different forms and species of *Fusarium* which could attack sunflower make these efforts much more complicated (Gontcharov *et al.*, 2006). Individual selection in a segregated sunflower population based on the combination of artificial infection and field observation could improve situation with *Fusarium* resistance. Infected plants were discovered on every hybrid in the trial in 2012, and in one case 90% of plants on the plot were damaged. Severity was not very high but tendency is obvious.

Rust (*Puccinia helianthi* Schw.)

Rust, being one of the most important sunflower pathogen previously was practically vanished after releasing of resistant cultivars in 1960s. During a long time, rust was observed on foreign sunflower hybrids only (predominantly confectionary type or old samples from genetic collections). Now rust

could be found on the leaves of modern oil-type sunflower hybrids. In 2012, rust was registered on all hybrids in the trial, though in a very small extent (Table 1). It is possible that new races of rust appeared here.

Rhizopus head rot (*Rhizopus* sp.)

Rhizopus head rot (*Rhizopus* sp.) is quite common here, but usually from one to three damaged heads were registered per plot. Some genotypes are very susceptible to this pathogen and could be easily identified under field conditions and discarded. Such technique is quite appropriate till now. If new aggressive races will appear it would be necessary to start special breeding efforts. In 2012 about 20% of all entries were damaged, but only one hybrid was fully susceptible.

Bacterial blight

The frequency of bacterial diseases is increasing during the last years. More than 70% of all entries demonstrated symptoms of bacterial diseases in VNIIMK hybrid trials in 2012. Up to 82.2% of infected plants were registered as a maximum incidence per plot. Previously bacterial blight was not considered to be a problem and incidence was not calculated.

Other diseases

Other diseases such as charcoal rot (*Macrophomina phaseolina*), Verticillium wilt (*Verticillium dahliae*) and Alternaria (*Alternaria spp*.) showed no significant differences in harmfulness during the years. Contrary Phoma black stem (*Phoma macdonaldii*) became a little bit more noticeable and could become a problem in the future.

Conclusions

Sunflower hybrid trial showed substantial differences for field pathogen resistance depends on year. Analysis of field resistance allows us to discover some tendencies in dynamics of pathogen appearance during the period from 2000 to 2013. Fusarium disease became more common on sunflower from year to year, so as bacterial blight. It requires paying more attention to these pathogens in breeding programs. Rust was noticed on modern sunflower oil-type hybrids; previously it was registered on confectionary hybrids only. Possible new races appeared. New races of downy mildew forced to change sunflower hybrid breeding program. In general, sunflower field resistance monitoring gives valuable information for pathogens dynamics.

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