Comparative evaluation of diseases affection of winter and spring false flax (Camelina sativa (L.) Crantz) in the Krasnodar region

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Abstract. We carried out the phytosanitary monitoring of winter and spring false flax (Camelina sativa (L.) Crantz) in the central zone of the Krasnodar region to comparatively evaluate the diseases affection for effective breeding work to develop varieties resistant to the most common and dangerous crop diseases. We noted the same frequency of occurrence of Alternaria blight, Fusarium blight, Sclerotinia blight, bacterial blight and phytoplasma disease on both forms of false flax. We observed the differences between winter and spring false flax in affection by downy mildew, powdery mildew, and white rust. The most harmful of the frequent diseases were downy mildew on winter false flax, and Fusarium blight on spring false flax, so one of the directions in breeding work with false flax is to develop varieties resistant to the affection by these diseases.

1. Introduction
False flax (Camelina sativa (L.) Crantz.) is a promising oil crop due to its simple cultivation in different weather conditions and early maturity, which allows it to be grown in different soil and climatic conditions [1]. Oil of false flax seeds is more oxystable and environmentally safe than other vegetable oils. It is used for food purposes, medicines as well as biofuels and high-value chemical raw materials with increasing frequency [2-6]. The cake remaining after pressing the oil from false flax seeds is a valuable, easily digestible feed for farm animals with high content of protein (23.2-29.1 %) [7].

During the growing season of cultivation in different countries with different climatic conditions, false flax is affected by diseases of various etiologies: downy mildew, powdery mildew, Fusarium blight, Sclerotinia blight, Alternaria blight [8-11]. A specific complex of diseases affecting the crop is formed depending on the region of cultivation. Scientists are working on the development of false flax varieties that are resistant to diseases occurring in each particular region [12-14].

The climatic conditions of the central zone of the Krasnodar region are favorable for the cultivation of winter and spring false flax. The development of pathogen-resistant varieties can effectively decrease seed yield losses of these crops from diseases. For this purpose, it is necessary to determine which diseases are the most widespread and harmful for both winter and spring false flax.

The purpose of the research was a comparative evaluation of spring and winter false flax (Camelina sativa (L.) Crantz) disease affection in the central zone of the Krasnodar region for efficient breeding work to develop varieties resistant to the most common and dangerous diseases of the crop.
2. Materials and Methods
In 2011-2021, we carried out phytosanitary monitoring of diseases in sowings of winter (variety Karat) and spring false flax (variety Kristall) in the central zone of the Krasnodar region (Krasnodar) at all stages of vegetation, beginning with the seedling stage. We performed the last counting of disease infestation at the yellow-green pod stage. To carry out the counting in false flax sowings, we selected 20 plants on 10 equidistant plots along the field diagonal. We calculated the occurrence frequency of diseases as the ratio of affected plants to the total number of examined plots, in percentage:

- – no symptoms of affection;
- + – low (up to 10 % of plants are affected);
- ++ – medium (from 11 to 50 % of plants are affected);
- +++ – high (51 % or more plants are affected).

During the counting, we used visual point scales according to the affection degree of plant surface (from 0 to 4), characterizing disease development: from minimum to maximum.

We carried the phytoexamination of the affected parts of false flax plants in the laboratory according to established practices. The pathogens were identified using a Motic BA 300 microscope, at 400x magnification.

3. Results and Discussion
As a result of phytosanitary survey of winter and spring false flax under the conditions of 2011-2021, we established the affection of crops by the following diseases: В результате фитосанитарного обследования посевов озимого и ярового рыжика в условиях 2011-2021 гг. установлено поражение культур следующими болезнями:

- downy mildew (the pathogen is a fungus-like organism *Hyaloperonospora brassicae* (Gäum.) Göker, Voglmayr, Riethm., Weiss & Oberw.),
- powdery mildew (the pathogen is a fungus *Erysiphe communis* Grev. *f. brassicae* Hammar L.),
- white rust (the pathogen is a fungus *Albugo candida* (Pers.) Kuntze),
- Fusarium blight (the pathogens are fungi of *Fusarium* Link. genus),
- Alternaria blight (the pathogens are fungi of *Alternaria* Nees genus),
- Sclerotinia blight (the pathogen is a fungus *Sclerotinia sclerotiorum* (Lib.) de Bary),
- vascular Bacterial blight (the pathogens are bacteria of genera *Xanthomonas* Dows., *Pseudomonas* Migula),
- phytoplasma (the pathogens are Aster yellows phytoplasma) (Fig. 1).
Figure 1. Manifestation of diseases symptoms on winter and spring false flax (*Camelina sativa* (L.)): a – downy mildew; b – powdery mildew; c – white rust; d – Sclerotinia blight; e – phytoplasma; f – Fusarium blight; g – vascular bacterial blight; h – Alternaria blight.

The occurrence frequency of different diseases on winter and spring false flax was not always the same during the years of research (Table 1).

Annually, on winter and spring false flax, we detected Alternaria blight and bacterial blight with low frequency of occurrence and Fusarium blight – with the low and medium frequency of occurrence. Development of Alternaria blight and bacterial blight did not exceed 1 point, which did not affect plant development, Fusarium blight had from 1 to 4 points. False flax affection by Fusarium wilt with an intensity of 3–4 points led to a significant decrease in the number of pods and seeds in them, as well as to the complete drying of plants.

We observed signs of plant affection by Sclerotinia blight with low to medium occurrence frequency of disease (from 1 to 30 % of affected plants) on winter false flax every year of research, on spring false flax – in all years beginning from 2014, except for 2015-2016. The development of the disease on both forms of false flax ranged from 1 to 4.

| Disease              | Winter false flax |
|----------------------|-------------------|
| **Disease**          | **Research year** |
|                      | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  |
| downy mildew         |        |        |        |        |        |        |        |        |        |        |        |
| powdery mildew       |        |        |        |        |        |        |        |        |        |        |        |
| white rust           |        |        |        |        |        |        |        |        |        |        |        |
| Sclerotinia blight   |        |        |        |        |        |        |        |        |        |        |        |
| phytoplasma          |        |        |        |        |        |        |        |        |        |        |        |
| Fusarium blight      |        |        |        |        |        |        |        |        |        |        |        |
| vascular bacterial blight | |        |        |        |        |        |        |        |        |        |        |
| Alternaria blight    |        |        |        |        |        |        |        |        |        |        |        |
| Fusarium wilt        |        |        |        |        |        |        |        |        |        |        |        |

Table 1. The occurrence frequency of diseases on winter and spring false flax (*Camelina sativa* (L.) Crantz).
Downy mildew  
Powdery mildew  
White rust  
Sclerotinia blight  
Alternaria blight  
Fusarium blight  
Vascular bacterial blight  
Phytoplasma

| Disease          | Winter false flax | Spring false flax |
|------------------|-------------------|------------------|
| Downy mildew     | --                | + + + + + + + + + |
| Powdery mildew   | ++                | ++ ++ ++ ++ ++ ++ |
| White rust       | --                | -- -- ++ ++ ++ ++ |
| Sclerotinia blight | + + + + + ++ ++ ++ + + |
| Alternaria blight | + + + + + + + + + + |
| Fusarium blight  | ++ + ++ ++ ++ ++ ++ + + |
| Vascular bacterial blight | + + + + + + + + + + + + + + |
| Phytoplasma      | -- -- + -- + -- + -- + -- |

Annually, we detected plants of winter false flax affected by phytoplasma with a low occurrence frequency and decrease development not exceeding 1 point, in the case of spring false flax, phytoplasma was detected in some years, beginning in 2014.

Each year, we observed powdery mildew, one of the most harmful diseases, on winter false flax with a medium (11 to 45 % of affected plants) and on spring false flax with a low and medium (1 to 50 % of affected plants) occurrence frequency. The disease development in most cases was 1-3 points on winter false flax, while it did not exceed 2 points on spring false flax.

During our research, we first noted white rust on winter false flax in 2015, on spring false flax – in 2014. The occurrence frequency of disease on winter false flax was low, it was medium only in 2020 (the number of affected plants was 15-30 %). In contrast, the occurrence frequency of white rust varied from medium to high (15-60 % of affected plants) on spring false flax, and only in 2015 it was low, with the number of affected plants not exceeding 10 %. However, the disease symptoms varied on false flax. On winter false flax, we observed white pustules with pathogen spores on the stem and pods. Affection by the disease led to branch deformation and pod death. The disease development was 1-3 points. We noted symptoms of white rust on spring false flax only on leaves. The pathogen spores were located on their undersides, not infecting the stem and generative organs of the plants.

The manifestation of downy mildew also differed between the two forms of false flax. The height of winter false flax plants affected by the disease did not exceed 10-15 cm and the plants were completely covered by the pathogen coating, which subsequently led to their death. On spring false flax, we observed necroses caused by the pathogen only on the lower and middle leaves. The coating of the pathogen spores on the leaves’ underside quickly disappeared when the average temperature increased to 20.0-22.0 °C and relative humidity decreased to 56-58 %.

We observed downy mildew on winter false flax since 2015 with low occurrence frequency. In 2016 and 2017, the crop affection by disease reached 55-75 %. In the remaining research period, the occurrence frequency of downy mildew was low, but the disease development was maximal – 4 points. On spring false flax, we identified downy mildew annually with low to medium occurrence frequency. The disease development did not exceed 1 point, which was significantly lower compared to the winter form of crop.

4. Conclusions
In 2011-2021, under the conditions of the central zone of the Krasnodar region, the identified complex of diseases affected both winter and spring false flax. Alternaria blight, Fusarium blight, Sclerotinia
blight, bacterial blight, and phytoplasma had the same occurrence frequency on both forms of false flax. The number of false flax plants affected by Alternaria blight, bacterial blight, and phytoplasma did not exceed 10%, Fusarium blight and Sclerotinia blight had 5-30% of affected plants.

We established differences between winter and spring false flax for downy mildew, powdery mildew, and white rust. The occurrence frequency of downy mildew on winter false flax in 2016-2017 was high (55-75% of affected plants), on other years – low (up to 10% of affected plants). The occurrence frequency of disease on spring false flax ranged from low to medium (the number of affected plants did not exceed 30%). Annually, we observed powdery mildew on winter false flax with medium occurrence frequency, on spring false flax – with low and medium occurrence frequency (15-20 and 5-30% of affected plants, respectively). The occurrence frequency of white rust was low on winter false flax (5-10% of affected plants), while on spring false flax it ranged from medium to high (15-60% of affected plants).

The most harmful diseases among the frequently occurring were the following: downy mildew on winter false flax, Fusarium blight on spring false flax, so one of the directions in breeding work with winter and spring false flax is to develop varieties resistant to affection by these diseases.

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