MODERN TRENDS IN THE DEVELOPMENT OF AGRICULTURAL PRODUCTION

PROBLEMS AND PERSPECTIVES

EDITED BY
S. STANKEVYCH,
O. MANDYCH

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Reviewers:

Mykola DOLYA, Ph.D., Prof., Head Department of Integrated Plant Protection and Quarantine of National University of Bioresources and Nature Management;

Oleksandr KUTS, Ph.D., leading of science collaboration, Director of the Institute of Vegetable Growing and melon growing of NAAS of Ukraine.

The monograph presented for review is a collection of the results of actual achievements of domestic agricultural scientists, obtained directly in real conditions. The authors are recognized experts in their fields, as well as young scientists and postgraduate students of Ukraine. Research is conceptually grouped into 5 sections: modern technologies in crop production and fodder production; economy of the agro-industrial complex; breeding and breeding in the 21th century; protection and quarantine of plants; agrochemistry and soil science. The monograph will be interesting for experts in plant breeding, economics, plant protection, selection, agrochemistry, soil science, scientific workers, teachers, graduate students and students of agricultural specialties of higher education institutions, and for all those who are interested in increasing the quantity and quality of agricultural products.

Keywords: modern technologies, crop production, fodder production, plant protection, quarantine, agrochemistry, soil science, economy of agro-industrial complex.

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TABLE OF CONTENTS

INTEGRATED PROTECTION OF ALFALFA AGAINST FUNGAL DISEASES IN THE EASTERN FOREST STEPPE OF UKRAINE

Volodymyr TURENKO
Doctor of Agricultural Sciences, Professor of the B.M. Litvinov Department of Zoology, Entomology, Phytopathology, Integrated protection and Quarantine of Plants, State Biotechnological University
Viktoriya HORIAINOVA
PhD of Agricultural Sciences, Associate Professor of the B.M. Litvinov Department of Zoology, Entomology, Phytopathology, Integrated protection and Quarantine of Plants, State Biotechnological University
Ljubov ZHUKOVA
PhD of Agricultural Sciences, Associate Professor of the B.M. Litvinov Department of Zoology, Entomology, Phytopathology, Integrated protection and Quarantine of Plants, State Biotechnological University

The results of studies on the spread, harmfulness, and biological characteristics of the pathogen of fungal diseases of alfalfa in the Eastern Forest Steppe of Ukraine are presented in the article. Monitoring of alfalfa diseases showed that the most harmful were brown spot (the pathogen is Pseudopeziza medicaginis (Lib Sace.)), downy mildew (the pathogen is Reronospora aestivalis Sya.), Ascochyta leaf spot (the pathogen is Ascochyta imperfecta Peck.) and yellow spot (the pathogen is Pseudopeziza Dyonesii Nann.). A reliable connection between the indicators of the maximum spread and development of the diseases and meteorological factors during the growing season of the crop has been established. The conducted screening as for the disease resistance of promising alfalfa varieties showed that the Vlasta and Unitra varieties are characterized by group resistance to fungal diseases. The high efficiency of using summer wide-row sowing in stabilizing the phytosanitary condition, which ensures a reduction in the spread of the main alfalfa diseases by 11,8–17,5% compared to regular sowing has been established. The necessity of early spring stubble combing out has been proven. It contributes to reducing the infection in the crops, the spread of the diseases during the alfalfa growing season by 1,2–2,4%, and their development by 1,6–2,8% compared to the control. The equations for predicting the maximum spread of alfalfa Ascochyta leaf spot Y_1*= 0,034x9,651 and its maximum development* Y_2*=0,025x+3,9 have been developed. The use of the short-term forecast data as for the development of the alfalfa diseases which we have developed,*

provides an opportunity for timely spraying of alfalfa in the phase of budding with 25% e.c. of Tilt at the rate 0,5 l/ha and zinc sulfate at the rate 0,02 kg/ha. At the same time, the spread of fungal diseases was reduced by 3,6%, the development of diseases – by 13% compared to the common technology of growing alfalfa.
Key words: *alfalfa, variety, pathogen, spread, development, harmfulness, protective measures.*

Problem setting

Alfalfa occupies a leading place among the perennial leguminous grasses in the world fodder production. It is a high-yielding, winter-hardy and drought-resistant perennial fodder crop, which is a source of complete amino acid protein and quarantine. The practical value of alfalfa is not limited only to fodder properties, but it performs the important economic and biological functions: it supplies the soil with nitrogen, improves the physical and chemical and biological properties of the soil, increases its fertility, and is a good preceding crop to many agricultural plants.

In the conditions of the deterioration of the agrocenoses phytosanitary state of Ukraine, the increase in energy prices, and in the productivity of fodder production, the development of alfalfa seed production based on resource-saving technologies is the most promising. The expansion of alfalfa acreage is held back by a large shortage of this crop seeds.

Analysis of the latest studies and publications

The diseases of fungal, viral and bacterial etiology have a negative effect on the alfalfa productivity. The impact of alfalfa diseases manifests itself in different ways. Some diseases lead to thinning out the grass and the loss of seedlings, while others appear on the leaves and stems in the form of mycoses. The intensity of their development depends on the seasonal dynamics, temperature regime, air humidity and the amount of precipitation as evidenced by numerous studies by the scientists (Biletskyi & Turenko, 2002; Turenko, 2004; Turenko & Mieshkova, 2005; Turenko & Mieshkova, 2006; Turenko & Choni, 2010; Turenko, 2018). The insufficient study of the biological features of the pathogens of this crop diseases and the imperfection of protection measures in the region determined the conduct of the research.

Setting objectives

The field and laboratory studies were conducted in accordance with the methods of the research (Nazarbekova, 1980) during 2015–2021 in the conditions of Kharkiv district, Kharkiv region. The route surveys were carried out according to the methods of the Plant Protection Institute modified by us. Five samples were taken to determine the spread of the disease; 10 stems were analyzed in each of them, and the degree of lesions were determined in two of them. The methods of microscopic analysis and pure cultures were used to establish the genus and species affiliation of the pathogens.

Presentation of the main research material

Our monitoring of the phytosanitary condition of alfalfa crops showed that in the Eastern Forest Steppe of Ukraine mycoses caused the significant harm. Their harmfulness manifested itself on the leaves and stems in the form of spots, necrosis, and plaques, which led to premature fall of the leaves. The losses of alfalfa leaves caused by these diseases amounted to 37,8–77,6 %, and the shortage of seed yield was 42,5–60,7 %.

During the years of the research the brown spot (the pathogen is *Pseudopeziza medicaginis* (Lib Sace.)) caused the considerable spread and harm. It developed throughout the growing season, affecting all vegetative organs of the crop in different years of use and harvesting. The disease developed especially on the crops of the first cutting of alfalfa in different cultivation years. The brown spots with a diameter of 0,2–2,6 mm appeared on the alfalfa leaves, which were unevenly distributed over the surface of the leaf laminae. 2–6 apothecia were formed in groups on one spot. As they became mature, they opened and acquired a saucer-like shape and size of 0,3–1,4 mm. The cylindrical-shaped asci with a size of 52,0–65,4 mcm were located in a tight circle in the sporocarp, each of them contained eight single-celled, oval ascospores with a size of 4–8 mcm. During the growing season of the crops, the pathogen was spread by ascospores. The optimum conditions for the development and spread of the disease were formed at an air temperature of 17,5–22,8 ^{o}C and an average daily air humidity of 76,8–87,4 %. It was established that under the influence of the disease, the loss of leaves was 5,7–11,6 % with a slight degree of the lesion, with an average – 14,8–27,3 %, and with a severe – 16,2–62,8 %. The seed yield losses were 28,8–34,6 %. The disease contributed to the drying and falling off the leaves, which led to a shortage in the yield, deterioration in the quality of green mass, hay and alfalfa seeds. At first, the pathogen of the disease affected the lower leaves, and then the middle and upper leaves. The pathogen developed in the marsupial stage until the end of the autumn vegetation, which contributed to the spread of the disease in the crops.

Necrotic spots are the beginning of the leaves lesion by the disease, small spots are the final stage of the development of the pathogen with mature ascospores, which are necessary for the spread of the disease. The development of the marsupial stage of the pathogen took place from the first decade of April to the second decade of November.

The spread of the disease accounted to 12,4–48,5 %, and the development of the disease was 8,7–24,6 %. The incubation period lasted 3–5 days, the development cycle – 26–30 days, and two generations of the pathogen were noted. The main source of infection is apothecia on the affected leaves and stems of alfalfa. Knowing the biological features of the pathogen disease development, it is possible to predict the intensity of the disease development in the next year, and, depending on the meteorological factors, the organogenesis of the crop and the cultivation technology, it is necessary to carry out protective measures efficiently and in a timely manner.

Yellow spot. (The pathogen is *Pseudopeziza yonesii* Nann.) It appears on the leaves in the form of large fuzzy light-yellow spots stretched along the veins of the leaves. At first, the lower leaves were affected, then the disease gradually moved to the upper leaves. The disease became widespread from the end of the stalk forming phase and to the beginning of the alfalfa budding at an average daily air temperature of 19,8 … 23,7 ^{0}C, an average daily air humidity of 58–60 % and the amount of precipitation per decade of 18,6–45,3 mm. We have established that alfalfa lesions by the disease pathogen caused the shortage in the yield of green mass by 16 %, and 23 % stems with buds were affected. The first cutting of alfalfa in the flowering phase was affected by 12–17 %.

The first symptoms of the yellow spot appeared one – two weeks later than the brown spot. The long-term studies of the yellow spot dynamics development show that the affected leaves of alfalfa first appeared slowly, and then intensively. The maximum spread of *Pseudopeziza yonesii* Nann. accounted to 15,3–31,6 %, and the development of the disease was 6,7–16,3 %. The significant damage to the crops caused by the disease pathogen was noted in the flowering phase at the beginning of the bean formation. The intensive development of the disease was noted in May, and the maximum – in June. The growth rates of alfalfa yellow spot disease were different in different years. The intensive development of the disease was observed during the alternation of dry, hot weather (the average daily air temperature 25 ^{0}C, and relative humidity of the air 43 % of Selianinov Hydrothermal Coefficient = 0,6) and during the wet weather (the average daily temperature 16 ^{0}C, and the relative humidity of the air 70 % of Selianinov Hydrothermal Coefficient = 1,1).

A direct, reliable relationship has been established between the beginning of the intensive development of the yellow spot of alfalfa and its maximum development, which is expressed by the equation:

$$Y=110,4+0,5x$$

where Y is the period of maximum development of the disease,

x is the period of the beginning of its intensive development (r= 0,77)

We recommend using the revealed dependence to predict the maximum spread and development of the yellow spot.

The incubation period lasted from 4 to 14 days, and the pathogen development cycle lasted 14–26 days.

The conidia appeared in the pycnidia almost simultaneously with the first appearance of the yellow spot on the leaves surface. The greatest development of pycnidia was observed at the moment when the leaves began to die. During the drying of the leaves, the emergence of conidia was stopped. Our studies proved that the conidia did not affect the crops. At the end of June and the beginning of July, the formation of apothecia was noted in the phase of bean formation. This is the marsupial stage of the pathogen first generation. The second generation of the pathogen was formed as a result of lesions to the crops caused by the ascospores of the first generation, which developed on alfalfa of the first and previous years of use. According to our research, the apothecia were formed on the leaves that remained on the stems, as well as on the fallen ones that were in the soil. The process of maturation and ejection of ascospores developed slowly.

In the course of many years of the research, we have established that the alfalfa damage caused by the pathogen of yellow spot increased in the budding phase, and the formation of apothecia of the marsupial stage of the pathogen first generation took place in the phase of bean formation. The experimental data showed that the increase in the spread and development of the yellow spot occurred in the periods with more precipitation and high air humidity. Since moisture is necessary for the development of the pathogen, the latter did not develop during dry weather, and alfalfa infection was insignificant or absent at all. At the same time, the wet and cool weather during the long periods helped to increase the resistance of the crops. In wet weather the ascospores quickly died and the infection did not occur. In dry weather the ascospores were preserved for a long time, and the crop resistance reduced. The spots on the leaves became larger, and the affected leaves quickly dried up.

The main source of infection is the affected leaves and the remains of plants, on which the apothecia of the pathogen are stored, and from which the ascospores cause primary lesions to plants in the spring.

Ascochyta leaf spot (the pathogen is *Ascochyta imperfecta* Peck.) affected alfalfa in the growing phase. The first symptoms of the Ascochyta leaf spot were noted in the phase of stalk formation after a stable rise in the average daily air temperature of more than 10 ^{0}C. The spread of the Ascochyta leaf spot accounted to 7,6–17,2 %, and the development of the disease – 4,3–9,8 %.

We have noted that when the average daily air temperature was over 20 ^{0}C, the spread and development of the disease was decreasing and the recession in the development of the Ascochyta leaf spot was noted in the phase of bean formation. With a strong degree of the crop affection the leaves fell down, which led to a decrease in the assimilation surface of the plants, reduced seed yield by 10–15 % and deteriorated the quality of green mass and hay. In the affected beans a thin, darkened seed coat was formed, which contained a fungal infection.

During the alfalfa vegetation, the pathogen was spread by pycnospores. The incubation period of the disease lasted 4–5 days. The cool rainy weather contributed to the spread of the disease. The pathogen produced several generations of conidial sporulation.

The equation $Y_1 = 0{,}034x + 9{,}651$ for predicting the maximum spread of the Ascochyta leaf spot and the equation $Y_2 = 0{,}025x + 3{,}9$ for predicting its maximum growth were developed.

Y_1 and Y_2 are the equations for predicting the maximum spread of the disease.

X is the sum of positive temperatures during the period of stable temperature change by 10 ^{0}C.

The source of infection is the mycelium in the affected plants and seeds and the pathogen pycnidia on the affected remains. At the end of the growing season, when the air temperature lowers, the pycnidia were formed and remained for the winter.

Downy mildew (the pathogen is *Peronospora aestivalis* Sya.) mainly affected the young leaves of the apical shoots of alfalfa of the first cutting in the phase of growing up. On the alfalfa crops downy mildew was noted in the third decade of April at an average daily air temperature of 14 ^{0}C, relative air humidity of 58 %, and the amount of precipitation of 14 mm per decade.

The spread of the disease was 5,5 %, and its development – 3,6 %. The first symptoms of the affected alfalfa leaves caused by downy mildew appeared earlier than other fungal diseases. The manifestation of the disease was noted in the phase of stalk formation after a stable rise in the average daily air temperature of more than +10 ^{0}C and at the Selianinov Hydrothermal Coefficient of 0,8–1,8. Later, with the rise in the average daily air temperature from 28 ... 30 ^{0}C and a decrease in the average daily air humidity to 45–50 %, the development of the disease reduced. The spread and intensity of the downy mildew development were s ignificantly influenced by the pathogens of fungal etiology. We have established that for the germination of the pathogen conidia, water is necessary not only for moistening the conidia shells, but also for their swelling. During a prolonged drought, the conidiophores were not formed, and the mycelium temporarily stopped its development. The correlation coefficient between the spread and development of downy mildew was 0,92 and it is reliable when $R < 0{,}01$. Depending on the meteorological conditions of the year and the degree of the infection, the disease caused a shortage in the green mass of the crop up to 10–12 %, and in the alfalfa seeds – up to 3–4 %. At the same time, the assimilation surface of plants decreased, which negatively affected the vital activity of the alfalfa plants and worsened the fruiting. A gray plaque with a purple tint appeared on the underside of the leaves. The microscopic analysis of the spots, carried out by us, confirmed that in these places the tissue of the leaf is permeated with a colorless single-celled mycelium, the lateral suckers of which penetrated into the plant cells and extracted juice from them, which caused the death of the cells. The gray plaque is the mycelium branches that came out in bundles of 2–4 pieces from the stomata on the lower surface of the leaves. The conidiophores were dichotomously branched 4–7 times and were 170–410 × 4–8 mcm long. Their terminal branches are located at an angle and had one pale yellow-brown elliptical conidia at the pointed ends. Conidia are the asexual summer stage of the pathogen development. They were easily separated from the conidiophores, carried by air flows, rain or insects to healthy alfalfa leaves and quickly germinated in the presence of droplet-liquid moisture. Young hyphae penetrated into the plant tissues, where they formed a new mycelium. Under favorable conditions a large number of conidia were formed on dichotomously ramified conidiophores. Due to the fact that many conidia were formed, and the incubation period of the disease lasted 3–8 days, a new plaque appeared after 6–14 days, and the spread and development of the disease increased rapidly. During a prolonged drought, the conidiophores were not formed, and the mycelium, which was inside the plant tissues, temporarily stopped to develop. The germ hyphae penetrated the alfalfa tissues through the stomata, less often – through the cuticle gap. The pathogen was stored on the affected leaf during winter in the stage of oospores or mycelium. The oospores are spherical, dark-brown with a thick, smooth or uneven shell with a diameter of 18–25 mcm.

The analysis of meteorological conditions in different years of the research showed that the damage of alfalfa caused by the downy mildew pathogen in the first two decades of the growing season is important for the further development of epiphytotia, and even favorable conditions in the second half of summer cannot compensate for the lost opportunities for the re-infection of alfalfa. However, in addition to the influence of the meteorological conditions, the spread of the downy mildew is affected by the competitive relations with the pathogens of other diseases, mainly the brown spot one.

Conclusions and propositions

1. Our research shows that the phenology of alfalfa and the development the diseases of fungal etiology in it, which showed the greatest harmfulness, depend on the seasonal dynamics of the meteorological conditions, and the technology of growing the crop itself.

2. To limit the development of alfalfa diseases, we recommend using the integrated protection system developed by us, which includes: the introduction of promising varieties Vlasta and Unitra, which are characterized by group resistance to fungal diseases. It is necessary to adhere to crop rotation and sow alfalfa not earlier than after 3–4 years, and to comply spatial isolation of more than 1 km between the grass seeds and fodder crops.

3. Before sowing alfalfa, the seeds should be treated with 50% WP Benomyl 2 kg/1t with zinc sulfate 0,02 kg/t.

4. When carrying out summer wide-row crops with a row width of 70 cm, in spring one should use harrowing and stubble combing out. With the application of the data for the short-term prediction of the alfalfa diseases development, it is necessary to spray the alfalfa seed crops in the budding phase with 25% e.c. of Tilt with a consumption rate of 0,5 l/ha and zinc sulfate 0,02 kg/ha. It is also recommended to purify the seeds by drying and bringing their moisture to 13-14%. All these measures will make it possible to obtain high and stable yields of the alfalfa seeds.

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