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REVIEW ARTICLE

A review of protection measures against the principal bean diseases in Ukraine

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We reviewed the main diseases of beans in Ukraine, their harmfulness and methods of protection. We summarized the harmfulness of the main bean diseases. In our opinion, the most common are anthracnose, fusarium, bacteriosis and virosis. We also provided an overview of protection the beans from major diseases. We established that Nespodivanka and Otrada varieties possess high resistance to diseases.
Key words: bean, anthracnose, fusarium, bacteriosis, virosis, harmfulness, disease resistance, crop protection.

Introduction

In recent years, beans have ceased to be a monopoly of gardeners and summer residents. This crop began to be grown on an industrial scale, in particular, agricultural holdings. One of the obstacles to obtaining high yields of beans is the large number of diseases of fungal and viral etiology. Fungi, viruses and other pathogens that infect plants mutate and adapt very quickly to new environmental conditions. Because of them, according to researchers, up to 15% of the total crop is lost. In addition, sometimes grain losses from disease can be 50% or more percent.

Beans (Phaseolus) - a plant of the legume family, grain legumes, which include more than 200 species. Common bean (*Phaseolus vulgaris*) is grown in many parts of the world (from the fourth to the third millennium BC; its places of origin are Central and South America). According to the shape and color, the common bean seeds are divided into four varieties: spherical, elliptical, rolled, kidney-shaped. In Ukraine, almost all varieties have white seeds. Common bean (Phaseolus vulgaris) is a herbaceous annual food plant belonging to the legume family. In beans, an intact, branched, erect stem 30 to 100 cm long (in shrubs). Leaves of ordinary beans trifoliate, long-petiolate. The flowers of this plant are white, purple or pink. They are located in the axillary tassels. They bloom from June to August.

According to Azi Gray, Vitmak, N.R. Ivanova, V.I. Budanova, the first finds of common beans were discovered in Peru around 7680-10000 BC, but there is no consensus on the origin of beans today. Miller considered the homeland of beans Australia, Rhine-Africa, K. Linnaeus - India. Works by S.M. Bukasova (1930), N.I. Vavilov (1931), P.M. Zhukovsky (1950) (Lisovij, 1999), based on the materials of expeditions and the results of field research of the bean collection (VIR) from Latin America, allowed to confirm the American origin of beans, which was written by Bailey, Parker, Becker - Delingen and others. The issue of beans distribution on the territory of Ukraine also remains controversial. M.F. Grushko believed that beans were imported from England in the 16th century, N.R. Ivanov, F.Kh. Bakhteeva - from Poland in the 18th century. However, the works of L.A. Chornoglazova (1887), P. Kuzmenko, A. Griboyedova (1893), A.A Bychikhin (1894) and others, confirm the fact that beans have been grown in Ukraine for several centuries (Genofond i selekciya, 1995). For the first time, the Kharkiv Regional Agricultural Station started work on the collection of local forms of beans in Ukraine according to S.M. Fridenthal in 1919. In 1928–1929, the Ukrainian Variety Network collected 690 samples, mainly from homestead farms, 120 of which were sown in 1932 at the Ukrainian Station of the All-Union Institute of Applied Botany and New Cultures. In 1934, the entire collection of beans from this station and 570 samples of the Ukrainian Variety Network, which had not been sown anywhere before, were transferred to the Kharkiv Research Station. In 1944, the All-Union Research Institute of Maize began collecting local forms of beans (Ivanov, 1961).

The aim of our review was to identify the bean lines with high potential for productivity and resistance to environmental factors and major diseases for the selection process. We also analysed the core results regards the Ukrainian breeders activity on beans resistance to main diseases.

Materials and methods

The study was performed in the V. Ya. Yuriev Plant Breeding Institute of National Academy of Agrarian Sciences of Ukraine by generally accepted methods and approved schemes of experiments (Metodicheskie ukazaniya, 1975; Shirokij unifikovanij, 2004; Kirichenko, 2009).

Results

Beans are a valuable legume that is widely used by the population. Both ripe and unripe seeds, fresh and canned green beans are used in food. The nutritional value is determined by the increased protein content in the seeds (20-34%), which in its composition is close to animal protein and, depending on the method of preparation, is absorbed by the body by more than 75%. Beans are rich in essential amino acids, very important for the human body. The culture is distinguished by high taste. In terms of sown area, beans are the second largest legume in the world after soybeans (Zernobobovye, 2016).

Despite the large number of different advantages of common beans as a valuable high-protein crop, the volume of industrial production in the country remains insufficient. The reasons for this are low crop productivity, lack of varieties and proper equipment for mechanized harvesting, a number of negative organizational and economic factors, and the main sown areas are concentrated in the private sector, which are susceptible to various diseases (Lihochvor, 1999). The following diseases are most common in Ukraine: anthracnose, fusarium wilt, gray rot, white rot, bacteriosis, and viruses (Shpiler, 1976; Peresipkin, 2000; Markov, 2017). Air temperature and precipitation have a special effect on the infestation of plants with pathogens. On the one hand, weather conditions either promote the growth and development of plants, or vice versa and as a result lengthen or shorten their growing season. On the other hand, meteorological conditions also affect pathogens, promote or limit their reproduction, spread and penetration into plants (Luchna, 2008).

Anthracnose beans are the most common and harmful in the northwest of our country. The disease is caused by the fungus *Colletotrichum lindemutianum* Br. et. Cov. Plants are affected throughout the growing season, but more often, the disease manifests itself during the formation of beans (Lisovij, 1999; Kotova & Kungurceva, 2014). Anthracnose can develop at humidity of more than 60%, existence of drop moisture and air temperature of 15-19 °C. The disease causes significant damage in wet years. There is a liquefaction of seedlings. Affection of bean beans can be 75-90%, yield is reduced by 50%, and seed germination - by 33%. When sowing the affected seeds, under conditions of cold wet spring, it does not develop or gives weakened seedlings (Romanyuk, 2007). Symptoms of the disease can appear on all aboveground organs of plants throughout the growing season. On the leaves, anthracnose manifests itself in the form of brown angular spots with a brown border or necrosis of the veins and adjacent tissue. Necrosis in the form of dark depressed strips is observed on stems and petioles. With a strong manifestation of the disease, the stems in the affected areas are often broken (Peresipkin, 2000; Kirichenko, 2009). When young beans are affected, small reddish-brown round spots appear on them, which later merge. The spots take the form of ulcers, and a convex and hard border of red or orange color appears around them. Penetrating through the wings of beans, the pathogen of anthracnose affects the seeds, which are harden, shrivel and become covered with yellow-brown or black-brown spots of various shapes and sizes (Kotova & Kungurceva, 2014). Under conditions of high humidity, the spots develop a bright pink pasty mass of conidial sporulation of the pathogen. Mature conidia are spread by rain and wind on crops, affecting healthy bean plants (Kotova & Kungurceva, 2014; Markov, 2017).The main source of infection is the affected seeds, to a lesser extent - plant remains, where the causative agent of anthracnose is stored in the form of a mycelium (Peresipkin, 2000; Kirichenko, 2009). Along with anthracnose, fusarium wilt causes significant damage to bean crops. The causative agents of fusarium wilt are fungi of the genus Fusarium Link. The disease can manifest itself in the form of root rot and wilting of plants. These symptoms can be observed simultaneously (Kirichenko, 2009; Markov, 2017).

Harmfulness of root rot of beans depends on the period of development in which the plant was affected and is not limited to quantitative losses. With the strong development of the disease significantly reduces the quality of the crop. Fusarium wilt is a significant danger for seedlings - root rot, hypocotyl, and cotyledons are observed. Under the action of toxins and enzymes, the tissue cells of the roots of the affected plants soften and break down. The affected areas become dark brown. They form ulcers and cracks of varying depth. With severe damage, young plants are suppressed and then dry up. On older plants, beans darken and die off the roots or base of the stem (Peresipkin, 2000; Kirichenko, 2009; Markov & Ruban, 2014; Bezugla & Kobizyeva, 2015; Markov, 2017). The following samples have individual resistance to fusarium wilt (lesions on a natural background - 3 points): Kharkivska 9, Triumph, Filetty and others (Bezugla & Kobizyeva, 2015). During wilting, there is a loss of turgor, drooping of the top, drying and twisting of the leaves, browning and cracking of the root neck tissue, rot and death of the main and lateral roots. Such plants are easily pulled out of the soil. Beans are formed in small quantities with small immature seeds. With severe damage, complete infertility can occur.

According to the research of OV Mazur, the stability of varietal samples of common beans depended on varietal characteristics, as well as weather conditions that developed during the growing years. The highest resistance to fusarium wilt was observed in 2016, the resistance rate ranged from 76.6 to 91.2%. Lower resistance to disease was observed in the stressful conditions of 2015, when there was a shortage of moisture and high temperatures. In the second half of the growing season, high temperatures contributed to increased plant damage by fusarium wilt (Mazur, 2018).

Gray rot of beans is widespread. The causative agent is the fungus Botrytis cinerea Pers. Penetrates plants through mechanical damage. The development of the disease is facilitated by moderate warm weather with heavy rainfall. Under such conditions, all aboveground organs are affected, and most of all - beans (Peresipkin, 2000; Kirichenko, 2009).

Harmfulness of gray rot is the deterioration of marketable and sowing qualities of bean seeds, a sharp decrease in germination and yield. Manifested on the leaves (underside), stems, root collar and beans in the form of brown-green wet spots with a gray fluffy coating of mycelium with conidial sporulation of the pathogen. Subsequently, small dark sclerotia are formed on the plaque. With severe damage, rot of the affected organs, breaking of stems, leaf fall are observed. Ulcers are formed on the

affected beans (Kirichenko, 2009; Markov, 2017). In addition to gray rot, the white rot was registered. The causative agent of this disease is fungus *Sclerotinia sclerotiorum* (Lib) de By. It is able to infect the beans through the root system. Favorable conditions for the development of white rot are created in warm weather with prolonged rainfall. Symptoms of the disease are manifested on all organs of bean plants that rot, especially in contact with soil. At defeat of stalks, on the bottom part, damp spots on which the white loose plaque of a mycelium develops are formed. Subsequently, black sclerotia are formed on it. Affected by white rot, bean tissues turn brown and rot. When plants are damaged in the second half of the growing season, they lag behind in growth, turn yellow and bear little fruit (Lisovij, 1999; Peresipkin, 2000; Kirichenko, 2009). Compared with diseases of fungal etiology, bacterial are the most harmful and common in all areas of bean cultivation. The most common bacteria that can infect beans are: *Xanthomonas phaseoli* (E. Smith) Dowson, *Xanthomonas phaseoli v. fuskans* Burkholder, *Corynebacterium flaccumfaciens* (Hegges) Dowson, and *Pseudomonas medicaginis v. phaseolicola* (Burckh). All pathogens of bacteriosis can affect both parenchymal tissues and the vascular system. External symptoms of beans affected by these pathogens are very similar (Beltyukova, 1961; Shpiler, 1976; Bakterialnye bolezni rastenij,1981; Kirichenko, 2009; Peresipkin, 2000; Markov, 2017).

Harmfulness of diseases of bacterial etiology is to reduce germination and deterioration of seed quality. With severe damage to bean plants by bacteriosis, there is a complete loss of yield, as the activity of photosynthesis is significantly weakened. Plants suffer the most during the period of seed filling. In addition, Xanthomonas phaseoli bacteria can easily adsorb the common bean mosaic virus. On the surface of plants, the virus is very unstable, and it penetrates faster into plants and infects them in the presence of bacteria (Shpiler, 1976; Kirichenko, 2009).

The first signs of bacteriosis are clearly visible on the stairs in the form of spots on the cotyledons or deformation of the seedlings. Later, the disease becomes dormant – by the time of budding external symptoms on plants are almost invisible. During the growing season, bacteria penetrate into bean plants due to mechanical damage to the surface or stomata and develop in the intercellular spaces of parenchymal tissue, which are rapidly destroyed. Under the action of bacteria, cells are macerated. At strong reproduction of bacteria blockage of vessels is observed. Frequent rains, excessive dew and moderate air temperature contribute to the development of bacteriosis (Bakterialnye bolezni rastenij,1981; Peresipkin, 2000; Kirichenko, 2009).

Infection of seeds with bacteria is very dangerous, as they are localized not only in the seed coat, but also in the middle of the seeds and are difficult to expose to pesticides. Yellow spots appear on the affected seed, which makes it wrinkled (Kirichenko, 2009). In addition, one of the hallmarks of bacteriosis is wilting, caused by bacteria entering the vascular system of bean plants. Plants begin to suffer from lack of water due to blockage of blood vessels. During the day, the leaves lose turgor, wither and droop. At night, as the temperature drops and evaporates, they rise and take on a normal appearance. However, with the strong development of the disease, the plants wither completely (Shpiler, 1976; Peresipkin, 2000). Otrada and Veselka varieties have a fairly high resistance to bacterial and fusarium wilt (Bezugla, 2016). At the Institute of Plant Breeding, 77 samples of beans with individual resistance to bacterial wilting were isolated (Unexpected, UD0303568 from Ukraine; UKR001: 02256 from Bulgaria; UD0303615 from Canada, see Bezugla & Kobizyeva, 2015). Of the viruses on beans, common or green mosaic, yellow mosaic and dotted stripes are common.

The causative agent of common or green mosaic beans is Bean common mosaic virus. The virus causes various disorders of the anatomical and morphological structure of the leaves: the tissues become loose, the conducting vessels are deformed, the number of chloroplasts decreases, their normal shape and normal placement in the cells are disturbed. Harmfulness of the disease largely depends on the susceptibility of the variety to the virus, the age of the plants in which the infection occurred, as well as weather conditions.

The pathogen causes severe suppression of susceptible varieties at the beginning of the growing season. Affected plants have the mosaic color of the leaves. The leaf blades thicken, become hard and brittle, and the shoots acquire a depressed atypical appearance. The most obvious symptoms of the virus are manifested on the first trifoliate leaf: mosaic color with the formation of blistering swellings on dark green areas (Markov, 2017; Kirichenko & Kovalenko, 2018).

In appearance, the affected seed is no different from healthy. Formed on mosaic plants, it transmits the infection to the seedlings during germination. However, it should be remembered that not all seeds from diseased plants give affected shoots. The level of seed infection depends on the variety and is an important indicator of its susceptibility to the virus. In highly susceptible varieties of beans seed infection is 30-48%, sometimes up to 70%, in moderately susceptible - 8-20%, and in relatively resistant does not appear (Kirichenko, 2009). The causative agent of yellow bean mosaic is bean yellow mosaic virus. Affected plants lag behind in growth and acquire a bushy shape due to the fact that the internodes shrink. Beans in such plants are either not formed at all, or they are small, mosaic with a small number of seeds. The surface of the affected leaves is covered with light yellow spots, and later becomes bumpy. Unlike ordinary mosaic, the transition of the affected tissue to healthy occurs gradually. The leaves become brittle, yellow and curl. The plate of the affected leaf falls down from the place of attachment to the petiole, which distinguishes this disease from ordinary mosaic. The development of the disease is facilitated by moderate humidity and air temperature of 23-27 °C (Kirichenko, 2009; Markov, 2017).

When affected by dotted stripes of beans (pathogen - Nicotiana virus), the veins of the affected leaves become reddish-brown. The tissues inside the veins become gray-green. The leaves wither and dry out. On the affected beans it manifests itself in the form of slightly depressed reddish-brown spots of indeterminate shape, placed in groups, forming stripes and circles. Variety samples UD0303543 - 89.6%, UD0303557 - 84.4%, UD0303610 - 83.7% differ in resistance to viral infection (Mazur, 2018). It is known that in beans, resistance to viruses, determined by the resistance gene I, manifests itself in the form of a hypersensitive reaction "black root". Infection with some strains of the common bean mosaic virus causes discoloration of the roots and stems, rapid wilting of the plant (systemic necrosis) and often the death of the entire plant (Gorova et al., 2016; Kirichenko & Kovalenko, 2018).

In order to limit the prevalence of these diseases, it is necessary to create conditions for normal growth and development of bean plants. Keep in mind that the application of high doses of nitrogen leads to intensive disease damage to plants. Molybdenum is an essential trace element in the early stages of bean development. Under its influence increases the resistance of plants to anthracnose, bacterial diseases. The weight of 1000 seeds and yield also increase (Ivanov, 1961; Markov & Ruban, 2014).

From the work of S.I. Chornobrivenko and other scientists in different years, new high-yielding varieties of beans resistant to diseases and pests were created and put into production. The main methods of selection were hybridization with advanced selection techniques – experimental mutagenesis using chemical mutagens, individual and mass selection (single and multiple, see Chornobrivenko, 1971). Beans are more demanding on soil fertility than other legumes. One of the main conditions for obtaining high yields is to place it in weed-free fields. The best precursors for beans are winter cereals and row crops. The system of tillage for beans is not much different from tillage for other legumes. Early plowing is the most effective in growing beans, late plowing causes a significant reduction in yield (Minyuk, 1991). It is necessary to adhere to the sowing rate and depth of seed wrapping in the soil. Liquefied crops of beans are more intensively affected by viral diseases, thickened crops - by root rot, anthracnose, gray and white rot. As the depth of seed wrapping increases, the infestation of plants with fusarium root rot increases.

Beans should be sown at the optimal time. When sowing in unheated soil, seed mold is observed, its germination is reduced, and seedlings die. In the late stages of sowing, bean plants are more intensively affected by anthracnose, bacterial and viral diseases (Minyuk, 1991; Lihochvor, 1999; Mazur et al., Dudchak, Vilchinska, 2016; Markov, 2017).

Creation and introduction into production of high-yielding varieties with group resistance to the most common and harmful diseases is one of the most cost-effective and environmentally friendly measures. Among the zoned varieties of beans with high field resistance to most common diseases are characterized by varieties: Rainbow, Galaxy, Bukovynka, Dnipro, Mavka, Nadiya, Otrada, Pervomaiskaya, and Podolyanochka. According to the results of previous research conducted by us in the conditions of the State Enterprise "Elite" of the Institute of Plant Breeding. V. Ya. Yuriev noted that anthracnose, fusarium root rot were manifested in the following varieties: Madera, Yasochka, Slavia, Panna Limilaght, and Goldmari. The prevalence ranged from 12-20%. A careful analysis of the obtained results shows that the most valuable varieties were Unexpected, Otrada in the growing season of 2018. Imperfection of crop assortment, especially in terms of disease resistance, lack of research related to determining the principles of selection of bean samples for culture selection for resistance to pathogens, the nature of the relationship between resistance and the main economic characteristics, determining the species composition of the most harmful diseases, as well as patterns of inheritance of stability, determine the relevance of this area of research.

Disease resistance is only one of the features of the future variety, so the varieties that are created should have a balanced development of all elements of productivity and disease resistance, and not the maximum value of a single trait (Luchna, Petrenkova, 2010).

Conclusions

Literature review indicates that beans are grown around the world. Pathogens of this culture of viral and fungal etiology is very large. With the increase of sown areas of bean crops, the number of pathogens increased. Therefore, in order to control, the resistance of varieties to pathogens should be observed. Imperfection of crop assortment, especially in terms of disease resistance, lack of research related to determining the principles of selection of bean samples for culture selection for resistance to pathogens, the nature of the relationship between resistance and the main economic characteristics, determining the species composition of the most harmful diseases, as well as patterns of inheritance of resistance, determine the relevance of this area of research.

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