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LIMITATION AND POTENTIAL OF WHEAT GROWING FOR FOOD SECURITY

OGRANIČENJE I POTENCIJAL GAJENJA PŠENICE ZA OBEZBEDJENJE HRANE

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Abstract: *Wheat is the staple plant species for production food and end food products for nutrition of majority world populations. The constraints of natural resources and an increase of human population, require increasing arable land for plant cultivation and improving crop yield for security of food. Existing limitations present a challenge to breeders to use classical and new biotechnological methods to create new varieties with higher yield, better quality and greater resistance to stress conditions. In addition, during cultivation, it is necessary to apply adequate crop nutrition and protection of crops from diseases and pests with mineral fertilizers in order to increase crop resistance and reduce the negative impact of stress factors, thus increasing yields.*

Key words: *wheat, breeding, biotechnology, environment, adaptation*

Apstrakt: *Pšenica je osnovna biljna vrsta za proizvodnju hrane i krajnjih prehrambenih proizvoda za ishranu većine svetske populacije. Ograničenja prirodnih resursa i povećanje ljudske populacije, zahtevaju povećanje*

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obradivog zemljišta za uzgoj biljaka i poboljšanje prinosa i kvaliteta za sigurnost hrane. Postojeća ograničenja predstavljaju izazov oplemenjivačima za korišćenje klasičnih i novih biotehnoloških metoda za stvaranje novih sorti sa većim prinosom, boljim kvalitetom i većom otpornosti na uslove stresa. Osim toga, u toku gajenja, neophodno je primeniti adekvatnu ishranu useva i zaštitu useva od bolesti i štetočina mineralnim djubrivima u cilju povećanja otpornosti useva i smanjenje negativnog uticaja faktora stresa, a na taj način i povećanje prinosa.

Ključne reči: *pšenica, oplemenjivanje, biotehnologija, životna sredina, adaptacija*

1. INTRODUCTION

Natural resources are exposed to the influence of dynamic phenomena on the earth, planet (lithosphere, hydrosphere, and atmosphere), the cosmos, as well as the influence of human activities. Some of the phenomena, the work of volcanoes, wind, earthquakes, hurricanes, glaciers, heat waves as well climate changes are natural sources of pollution as a result of fires, floods, erosion and degradation of soil and living communities (biocenosis) [1]. In addition, man, with his historical socioeconomic development, and especially today, has a significant impact on the impoverishment and degradation of the environment. Through this activities (industrialization, urbanization, militarization), man contributes to the increase in environmental pollution (air, water, soil), desertification, reduction of arable land and sources of drinking water, reduction of biodiversity [2]. Together, natural dynamic processes and occurrences and anthropogenic activities and changes disrupt the established balance in the biosphere, which hinders the production of the necessary amount of food, healthy food, water and air, as well as living space.

The food security was serious task for governments of all world state, scientist, farmers in the past when it took 102 years (1825-1927) to increase the population from one billion to two billion people. Food safety is especially important these days when the number of the world's population is increasing faster, which is confirmed by the fact that the increase in the number of inhabitants in the world from 7 to 8 billion was registered in a period of 12 years (2010-2022).

The increasing demand for food and energy presents serious growing global concern, in conditions when over a billion people are malnourished and when five million children under the age of five die of hunger every year [3, 4].

In today's conditions of reduction of usable land and water, the biggest challenge is how to provide these resources in a sustainable way, which is acceptable and useful for agriculture? Biotechnological methods of genome transformation and genetic engineering at the molecular level are used in plant breeding. An efficient methods is markers-assisted selection in creation of genotypes with the desired combination of genes [5, 6]. In growing plants, it is necessary to apply new technologies of nutrition, care and protection that are more effective in order to select plants more resilient to environmental stress factors which cause yield losses [7].

In agricultural production of edible cultivated plants, as well as wheat, characterized low yield until the mid-1960s, what is linked with developing new plant architecture in wheat breeding. Genotypes with a smaller height of stem were resistant to lodging and could be grown under conditions of intensive nutrition and the application of a larger amount of fertilizer. Also, the industrial production of agricultural machinery enabled the introduction of mechanization for more efficient application of fertilizers, pesticides, soil cultivation, as well as for mechanical sowing and harvesting of crops [8].

In permanent work plant breeders make arrangement of genes which contribute benefit for expression of better resistance to disease, drought tolerance, efficiency of nutrient absorption and increased yield and quality. The combination of favorable genes is the base for improving wheat production in different environment as well as in the future in climate change growing conditions [9].

2. AGRICULTURAL RESOURCES

2.1. DEPLETION OF LAND AND WATER

Due to industrialization, urbanization, illegal land use, and over-exploitation of cultivated land [10–12], the cultivated land is gradually decreasing all over the world [13]. The industrialize in world countries influenced on intensive migration of rural population to industrial centers and the development of numerous urban places. In industrialize country, the agricultural land used more and more for construction of factory, roads, highways and residential building etc. The left farming land is fragmented and reduced agricultural area for profitable yield production. The labors in industrial sectors lived in the cities and far away from farms. Farmers leave their plots mostly employed in industrial sector led to a decrease in grain production, which led to higher demand and increased prices, as well as dependence on the import of wheat seeds from other countries.

Increased incomes, especially in recent years, have contributed to a change in consumer demand for food, which significantly influences farmers to focus on new production and grow new valuable crops to meet consumer needs [14, 15].

Based on the current way of land use, it is estimated that by 20230, about 3.7% of farmland in the world will disappear, and this will be especially pronounced in developing countries. Cultivated land decreases and food crises continue to spread in many region of the world and global food insecurity will increase, considering that in the recent 50 years global food demand increased twofold [16], and demand for cultivated land increased. Also, the increasing in the production of plant species for other purposes, such as for animal feed, biofuels and other industrial products [17], contributes to the reduction of the production of crops for human consumption, whose share is about 62% in the total plant production, as and reducing the amount of food for people.

For the successful production of vegetable crops, soil moisture is needed, which is provided by water deposits from the atmosphere and by irrigation from surface water. The amount and distribution of rainfall are not synchronized with the critical stages of development of plant species, which are important for achieving yields. This is the reason for using surface water for irrigation. Irrigation is conducted for approximately 24% of croplands and have share for 34% of agricultural production. Without irrigation the global production of cereals would be decreased up to 20%, which require more land for production the same amount of food [18]. Thus, 70% of fresh water in the world is used for irrigation. In areas with arid conditions, the lack of water for irrigation affects yield reduction, so in the dry conditions of China, an 8% reduction in wheat production was found. The lack of water significantly threatens the production of other essential crops that are irrigated (rice), which represent the basic food for a large population of the world's population [19, 20].

The water scarcity occurs as physical lack of water where natural water resources are over-exploited, and economic water scarcity where there is insufficient investment in and maintenance of water distribution systems and infrastructures [21]. Both types of water shortage are uncertain in climate change condition but they are influence to change and adapt agricultural land use for crop production. Except that water scarcity affects the migration of people from rural to urban places within country as well as migration to foreign country. People's abandonment of property and land, which creates additional problems in providing food, housing, as well as inclusion in any type of business and work in other countries. Often at the home leave women and children and many of the difficulties associated with water scarcity tend to disproportionately burden women [22]. It's evident that water scarcity links rural and urban ecologies of vulnerability.

3. ABIOTIC AND BIOTIC STRESSES

Wheat is produced globally than any other crop because wheat is source of proteins and other nutrients for more than 70% of world population. This is a reason that wheat is a plant species that is grown in areas of different geographical latitudes and at different altitudes, on soils of different types and fertility, and in conditions of different temperature variations as well as illumination (day length). In these areas, is grown wheat that are adapted to different growing conditions and are exposed to specific areal abiotic and biotic stress factors.

Wheat crops are exposed to numerous environmental stress conditions (abiotic and biotic). The extremely high temperatures cause loss of wheat yield and other plant species [23]. In recent three decade average temperature has increased in average about 0.7 °C and due to extreme temperature with lethal consequence for several thousand people and high damages of crops [24]. If this trend were to continue, by the end of the 21st century, there could be an increase in the average temperature on Earth in the range of 1.4 °C to 5.8 °C, and there would be a greater increase in the temperature of land and sea [25]. In agricultural production drought and water deficit affect yield loss in wheat, as well in other crops. The yield loss is the highest when drought stresses occur at the phase of heading, pollination [26, 27]. Drought is a quite often natural hazard in Serbia and dry years were particularly frequent in the last two decades of the 20th century and beginning of 21 century [28, 29]. Drought is caused by climate variability, which cannot prevent, but its negative effect can mitigate through determination and monitoring of various parameters as the amount of available water, crop condition, the degree of degradation of land, the requirements for introduction of irrigation. Also, water shortage with drought cause significant damages in numerous continents including Europe [30]. To increase yield in abiotic stress conditions such as drought and salinity, it is necessary select the best genotype grown in optimal condition and adjust scientific farming measures in cultivation under stress conditions [31].

The effect of global warming on wheat yields is of prime concern worldwide. The extreme heat waves have negative influence to yield in wheat, so that is an increase of 1 °C of seasonal temperatures determines a decrease in yield depressed 3 to 4%, [32] and similar effect is in soybean (3.1%) and maize (7.4%) [33].

The increase of atmospheric CO_2 has contrast effects on crops, so that may increase in plant photosynthesis and growth an in contrary may negatively affects the nutritional quality of crops as well as their health status (example: increase in barley yellow dwarf virus infections in wheat under elevated CO2 levels) [34-35]. However, Intensive agriculture, during long-term period, may reduce the carbon content in the soil, which level is possible reverse by dynamic process in in interaction of plant roots, rhizosphere and soil [36].

Water deficit is a limiting factor of plant growth and development in each phase flowering, pollination, and grain-filling, and in the end limiting factor for yield of crops worldwide [37]. In case of abundant rainfall may have a positive effect on the formation of yields and quality. However, abundant rainfall may have a negative effect on plants in different stages of development (pollination, flowering, harvest) due to higher relative humidity, which represents favorable conditions for the development and attack of pathogens, emergence diseases and damage due to reduced pollination, intensive respiration and reduced yields [38, 39].

The pests and diseases cause serious yield losses in average between 10-30% per year, depends of type of pests and diseases and plant crops and their interaction with environmental conditions. The yield losses related to each alone pest have share in average of 14–25% of the total global agricultural production [40, 41]. Insect such, aphids, stem borers (*Sesamia inferens*), Hessian flies (*Mayetiola destructor*), wheat midges (*Sitodiplosis mosellana*), and cereal leaf beetle (*Oulema melanopus* L.), are the serious harmful insects on cereals, which not only cause direct damage but also transmit virus diseasess [42-46]. In study [47] was established that the bird cherry-oat aphid (*Rhopalosiphum padi*) causes more damage to wheat than the green bug aphid (*Schizaphis graminum*) during the seedling stage, but at the flowering stage greenbug aphid causes more damage than bird cherry-oat aphid. The protection from insect pests in wheat production is essential by application insecticides and can be profitable up to 10% of cereal crops. Considering the harmful impact of insecticides on human health and the environment, other pest control methods are being developed, such as biological control agents, cultural practices, and the use of resistant crop varieties [48].

The losses of yield due to pests was established every year in average 26% of soybeans, 28% of wheat, 31% of maize, 37% of rice, and 40% of potatoes [49] while in tomatoes, and sunflowers, was in the range of 15–30%. Also, yield losses caused in average by pathogens (16%), animal pests (18%), and weeds (34%) [50].

Crop diseases cause significant food and economic losses which vary depend of seasons and geographical location. The risk of spreading crop infection of 80 pathogens to higher latitudes in the future and harming crop production in the catches of climate change is predicted [51]. Diseases cause great damage in wheat production, and the reasons are in reduced genetic variability, i.e. increased uniformity, which resulted from the use in breeding of a small number of varieties with high trait value, as well as the development of new pathogen strains in changing climate conditions [52]. The diseases such as leaf and stripe rust, *Fusarium head blight*, *Septoria leaf blotch*, spot blotch, tan spot and powdery mildew cause the significant economic losses [53]. In a study of wheat production was estimated that one of next disease: leaf, stripe and stem rust, *Septoria tritici blotch* and *Fusarium head blight*, caused annual losses more than 62 million tons, what is high economic losses [54].

The system of growing plant species in monoculture created favorable conditions for the development and harmful effects of phytopathogens (fungi, bacteria, viruses, nematodes). The system of growing plant species in monoculture created favorable conditions for the development and harmful effects of phytopathogens (fungi, bacteria, viruses, nematodes) which could be prevented by applying the crop rotation system, as well as the combined sowing system, which would increase the barrier to the spread of diseases [55].

4. BREEDING AND LIMITATION

Genetic uniformity as well as reduced genetic diversity is a limiting factor for successful breeding and creation of varieties with greater adaptive capacity, as well as higher yield and better quality. On the contrary, the great genetic variability of the genotype has an important role in mitigating the impact of the limiting values of climatic factors and adaptations to climate change, which contributes to the provision of food and the quality of life of people.

The strategy of developing adaptations directed to create genotypes, which are resistant to climate changes, which achieve high yields in conditions of high humidity and extreme temperatures [56]. The creation of genotypes resistant to drought and heat makes it possible to maintain productivity and reduce the risk of climate change in agricultural production [57, 58].

Plant breeding solves problems in agriculture related to climate change. Varieties are created that are resistant to the effects of climate change, varieties that are more economical (less investment/higher yield), which affects the reduction of greenhouse gas emissions from agriculture. The genetic diversity of plants plays an important role in the maintenance of the species, which is the source of genes for various mechanisms of adaptation to biotic and abiotic stress factors and new combinations of genes that increase the resistance of the genotype to changes in the ecosystem [59].

To create varieties resistant to climate change, the breeding is necessary conduct on the based on genetic variability. The sources of favorable genes for greater adaptability to climate change condition are in wild relatives, local populations, old varieties of mutant lines [60]. Wild germplasms, which contain resistance genes, were introduced in cultivated crops [61]. Effective genetic improvement of yield varieties in breeding can be achieved using genetic variability, modern biotechnological methods, molecular markers, gene transfer and manipulation [62, 9].

Molecular breeding, gene mapping, insertion and deletion of gene sequences in the genome of a plant species is the basis for creating genotypes resistant to abiotic and biotic stress factors [63, 64]. Genotypes created by breeding are characterized by a combination of genetic traits, which contribute to adaptation to climate changes (temperature, precipitation, wind) that vary in seasons and regions [23, 65], and affect yield and quality variation [66-69].

Genome sequencing is a significant advance in the identification of genes and determination of genetic control of traits that can be used in breeding and more efficient cultivar creation level. This method made it possible to study molecular markers such simple sequence repeats (SSRs) single nucleotide polymorphisms (SNP), and copy number variations (CNV) identification of genetic variations such as insertions and deletions (INSDEL) translocations and inversions at the whole-genome level [70].

Genome sequencing enables further study of gene functions and structures [71]. Comparative analysis of genomes contributes to the identification of changes that have been conserved during evolution roles [72]. The possibility of predicting gene function and gene manipulation, i.e. insertion or deletion of genes in the process of creating varieties is a contribution to increasing the yield and quality of the plant species and thereby increasing food production and quality of nutrition [73]. The identification of the function of genes that control key stages of development has a significant contribution in the creation of species tolerant to different biotic and abiotic conditions [74]. Molecular breeding, using molecular markers, contributes to progress in the selection of varieties with improved traits of interest using appropriate molecular markers [69].

5. CONCLUSION

Existing land and water resources are limited and decreasing due to degradation under the influence of natural disasters, intensive construction of urban and industrial and transport facilities on fertile land, as well as due to farmers' improper processing and use in agricultural production. This situation makes it difficult to produce wheat and other edible agricultural crops to ensure a sufficient amount of food. In addition, the limiting factors for wheat production are abiotic stress factors (all temperatures, low rainfall, soil salinity, UV radiation, elevated CO_2) and biotic stress factors, diseases and pests (insects, fungi, bacteria, viruses), which cause a decrease in yield every year on average of 10-30% and in many cases the damage can be up to 100%. Also, in the future, the main task must be combining integrated disease and pest management, increase adaptability to change (warmer) climates and abiotic stresses, and sparing use of water and other resources. To reduce yield losses of wheat and other crops, it is necessary to monitor changes over a longer period of time, and invest in innovative research, which would be economically justified.

It is difficult to find a solution that would be generally applicable, efficient and economically profitable due to the different bio-economic values of yield loss, which vary in seasons and regions. The need to produce more food is imposed by the continuous increase in the population on world, which is a challenge and a task for statesmen, scientists and producers to find solutions for more efficient production and increase of wheat yields and to ensure sufficient food for the human population. Abiotic and biotic stress factors in some regions act long-term and in others short-term, which is necessary to know in order to develop a strategy for creating adaptive wheat genotypes to stress factors.

For successful cultivation in climatic change condition, is necessary in breeding program create genotypes with advanced yield, quality and resistance to biotic and abiotic stress factors. In climate change condition each genotypes change behavior and affecting ecosystem changes. For these reasons, is necessary collect and conduct characterization of germplasm for choice parents for crossing and creation cultivars resilient to climate change. The very important is develop proper integrated management, such as models to predict the risk infection index, mechanisms of seed manipulations, genetics and breeding for resistance, and biological control are also considered.

Molecular breeding, using molecular markers, contributes to progress in the selection of varieties with improved traits of interest using appropriate molecular markers. Genomics-assisted breeding is very efficient method in creation new varieties with improved yield and quality as well increased resistance to biotic stresses. Molecular breeding overcome insufficiency of traditional plant breeding on the base of pedigree related to narrow the genetic diversity through the selection of more related individuals. By using modern biotechnological methods breeders can create wheat varieties with improved adaptability, that are resistant to pests and can reduce the impact of pests on wheat yields. These technologies will become increasingly important for ensuring global food security.

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