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SELECTION AND GENETIC BASES OF INCREASING TOBACCO PERFORMANCE

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Introduction. Tobacco breeding is one of the main directions in crop production. Its major objective is to obtain high yields of generative and vegetative parts of plants. New highly productive tobacco varieties are a key to increased yields of this crop and its improved quality. They are progressively becoming integral elements of cultivation technologies of different crops [1, 2]. Today in Ukraine, scientifically sound creation of crop varieties with high-quality seeds and increased productivity, in particular of tobacco as an important technical crop, is a breeding mainstream. Tobacco seed production requires significant economic and energy costs to provide high-quality seeds in amounts needed for a given zone [3, 4].

Key words: *tobacco, variety, seed productivity, breeding, valuable traits.*

Literature review and objective articulation. To date, breeding is aimed at creating varieties that combine complex resistance to major diseases with high performance, quality of raw materials and adaptability to new areas of tobacco growing [5]. Breeders of the world were faced with a number of practical challanges, the main of which were: creation of a wide stock of starting material, replacement of ineffective local varieties with new more productive ones. Creation of large-leaved varieties remained the mainstream in tobacco breeding for the future [5]. Recently, due to the financial and economic crisis that engulfed the tobacco industry, there has been a complete depression in the tobacco seed production in Ukraine. Farms began to use seeds purchased outside of specialized research institutions, low reproductions and of dubious origin. Such practice led to a significant decrease in yields. Breeders faced the challenge of creating competitive tobacco varieties with a set of basic economically valuable features. There was a need to radically modify the breeding ways in order to improve the technological quality and to increase the lower limit of productivity under changing environmental factors. In tobacco growing, first of all, the requirements for commercial quality and technological properties have changed, which should be taken into account in the breeding process. Therefore, the creation of new varieties combining high seed productivity and stable leaf yield with high marketability will solve the urgent problem in tobacco breeding.

Purpose and objectives. Therefore, the study purpose was search for information and sources to select promising varieties of tobacco with high seed productivity for their further use in breeding, in particular, for the Transcarpathian region. To accomplish this purpose, we have to solve the following challenges: collect and review publications in which Ukrainian and foreign scientists reported their studies on the peculiarities of tobacco breeding; to select the most interesting and promising studies; to summarize data for further work; to establish patterns in the inheritance of seed productivity elements; to highlight peculiarities of creation of interspecies hybrids of tobacco; to analyze tobacco collections in terms of economic characteristics; to select tobacco varieties with valuable seed features; to choose the most promising ones with consistent expression of generative traits for breeding in the conditions of the Berehivskyi District of the Zakarpatska Oblast; and, basing on the obtained results, provide recommendations on the variety assortment to agrarian enterprises of the Zakarpatska Oblast in order to increase the efficiency of growing tobacco for seeds.

Articles and conference abstracts of Ukrainian and foreign authors as well as other resources on increased seed productivity and stable yield of leaves with high marketability were reviewed. Scientists of different institutions strived to improve seed qualities in new varieties: Research Station of Tobacco of NAAS, Uzhgorod National University, All-Russian Research Institute of Tobacco, Rustic Tobacco and Tobacco Products, Weizmann Institute of Science in Israel, Agricultural Research Organization in Israel, Queen Mary London University, Royal Botanic Garden in Richmond (UK), Ibarraki University in Japan, Osaka Prefecture University in Sakai (Japan).

We present our analysis and findings along summarized research trends. First, we consider Ukrainian researchers‟ studies, then foreign authors‟ works**.**

Study the effect of the growing period on major valuable economic characteristics. Scientists of the Research Station of Tobacco of NAAS have evaluated 11 tobacco varieties for several basic valuable economic characteristics and vegetation period length. There was a stronng correlation between the vegetation period length and ripening. Two tobacco varieties producing high seed yields (1.53 t/ha and 1.27 t/ha, respectively), but with long growing periods, were identified: Virginia 27 and Temp 321. Ternopilskyi 7 and Ternopilskyi 14 were more productive than the other varieties [6]. Having perused their work, we propose four promising varieties (Ternopilskyi 7, Ternopilskyi 14, Virginia 27, and Temp) to use in breeding and production.

Studies of the effects of biotic and abiotic factors on seed production. Scientists of Uzhgorod National University thoroughly analyzed the seed productivity of tobacco breeding material under the influence of different growing conditions. In another study, the seed quality variability was assessed, and its causes were discussed [8].

The influence of natural conditions on qualitative and quantitative parameters of tobacco seeds is of importance in studies [9]. Observations of the growth and development of generative traits indicated that there was a need for selection of biotypes that would be hereditarily able to withstand negative environmental factors, with a high genetically determined yield capacity and quality without reduction in the seed productivity [10]. Thus, varieties with short growing periods and maturation of 50% of capsules by September 5 were the best to meet specifications [11, 12].

Comprehensive analysis of the breeding material demonstrated that the seed weight per capsule was rather a genetic feature than an effect of growing conditions on the genetic potential fulfillment of a variety.

Evaluation of tobacco breeding material for seed and pollen productivity. Female heterogeneity results from different positions of seeds on the mother plant. Even if genetic and environmental factors are identical, different locations of seeds cause their heterogeneity [9]. This was observed on plants with various inflorescence density, width and height and correspondingly various ability to produce viable pollen, the quality of which is determined by its place on the mother plant. The variability of pollination effectiveness varies depending on weather during anthesis and pollination [10]. An increase in the tobacco inflorescence size was shown to have a positive effect on the seed productivity of plants, though larger inflorescences more strongly respond to changes in the weather conditions during the development. However, this did not prevent from selecting varieties that combine high seed productivity with high vegetative mass. Environmental heterogeneity of seeds is attributed to differences in the conditions of seed formation [13]. From these studies, it was found that external conditions affected not only the lengths of development phases and phases of seed maturation, but also the profiles of pollination, seed formation and maturation.

Analysis of the above publications indicates that of 282 accessions of the basic tobacco collection, there were 29 varieties with high seed production, which can be used in breeding, in particular the following varieties can become of wide use in production of cigar raw material: Sobolchskyi 15/21, Erho 23, C-11, Syharnyi 99.

Patterns in the inheritance of seed productivity elements. Scientists of the All-Russian Research Institute of Tobacco, Rustic Tobacco and Tobacco Products obtained sterile interspecies hybrids by distant hybridization of *N. tabacum* with wild species of the genus Nicotiana of the section Suaveolentes (*N. rosulata* and *N. debneyi*) and of the section Tomentosae (*N. otophora*

and *N. setchelli*). Using *in vivo* and *in vitro* polyploidization, they developed interspecies fertile hybrids – amphidiploids representing the section Tomentosae [14, 15, 16].

After studies of pollen in amphidiploids, the inflorescence morphology and seed productivity of fertile interspecies hybrids were investigated. Hybrids with *N. debneyi* chromosomes were tall, while hybrids with *N. rosulata*, or *N. otophora*, or *N. setchellii* chromosomes were significantly shorter. The most loosely spreading inflorescence with a large diameter was found in amphidiploids with chromosomes from *N. debneyi* and *N. setchellii*, and, in hybrids from *N. rosulata* and *N. otophora*, it was more compact [14, 17].

The number of seed capsules per inflorescence in hybrid plants varied from 10 to 164. Fertile interspecies hybrids from *N. setchellii* and *N. otophora* had the smallest numbers of capsules. Seed capsules were small in all amphidiploids [15, 18].

Having reviewed the results of these studies, we concluded that the inflorescence shape and seed productivity of amphidiploids were influenced by pollinator species, because they differed in all these traits from the original parental varieties, which were the female form and pollinators.

***Peculiarities** of the creation of interspecies hybrids of tobacco, difficulties arising in the process and ways to overcome them.* Israeli scientists revealed that tobacco genes could be transmitted pass from transgenic crops to sexually compatible wild relatives through pollen flow [19]. In this study, interspecies sexual hybridization was performed between a transgenic alotetraploid, transgenic softener *N. tabacum,* and a diploid wild species *N. sylvestris*. *N. sylvestris* plants were pollinated manually. >75% of pollen was sterile in F_1 interspecies sexual hybrids, and they produced no seeds. When it was crossed as a pollen donor for *N. sylvestris*, the offspring produced almost no germinating seeds [19]. From this study, it is clear that the risk of gene transfer in crossings with *N. sylvestr* is low. This transgenic species can be cultivated without concern, as F_1 interspecies sexual hybrids will be 75% sterile and produce no seeds.

Scientists at the Royal Botanic Gardens (Richmond, UK) examined allopolyploids of Nicotiana (Solanaceae). They found that all polyploid species of the genus had originated independently approximately less than 1 million years ago. The section *N. polydicliae* (consists of two species) evolved over 1.5 million years ago, *N. repandae* (four species) evolved for 4 million years, and the section *N. suaveolentes* (35 species) is about 6 million years ago. [20]. As far as we know, the study by British scientists is the first report about a significant lag phase of the section *N. suaveolentes* in South America and its plenitude in Australia 6 million years later.

Agrarian researchers of Ibarraki University (Japan) obtained hybrid seedlings from crossing *N. tabacum* ×*N. suaveolens* [21]. One hundred and seventeen hybrid seedlings were obtained through *in vitro* pollination and egg culture. Hybrid seedlings grown at 36°C showed no lethal symptoms. As to hybrid seedlings used for further experiments, the temperature was reduced from 36°C to 28°C immediately after germination, the growth stopped, and lethal symptoms appeared [21]. Having analyzed the Japanese scientists‟ data, we suggest that the hybrid lethality is mainly caused by interactions between coexisting heterogeneous genomes, rather than effects of cytoplasmic genes.

Osaka Prefecture University (Sakai, Japan) continued the problematics started by previous researchers of tobacco hybrid lethality observed for hybrid seedlings from crossing *Nicotiana suaveolens* and *N. tabacum*. The authors of this article investigated mechanism underlying the darkening of dead seedling tissues. Treatment of hybrid seedlings with an inhibitor, L-2-aminooxy-3-phenylpropionic acid, inhibited blackening and reduced the phenolic content in hybrid seedlings [22]. Thus, we understood that programmed cell lethality is involved in hybrid lethality and phenolic compounds may be a cause of tissue darkening associated with hybrid lethality.

Scientists at Tokyo University of Agriculture and Technology also developed a technique for producing mature hybrids in an artificial culture. In this study, the authors found that some surviving hybrids spontaneously or due to artificial cultivation did not have the distal part of the Q chromosome, that is, it contains the gene responsible for lethality [23]. The results showed that chromosomal instability during meiosis in amphidiploid *N. tabacum* as well as upon artificial cultivation of hybrid seedlings is involved in overcoming hybrid lethality in interspecies crosses with the genus *Nicotiana*.

Results and discussion. The article analyzes and summarizes the studies of Ukrainian and foreign scientists in order to solve urgent challenges in tobacco breeding for increased performance.

The findings were as follows: The influence of vegetation period on major valuable economic characteristics is described. The effects of biotic and abiotic factors on the seed productivity were evaluated. Relationship between the inflorescence shape and seed productivity was determined. Breeding material of tobacco was assessed for seed and pollen productivity. Tobacco variety models were optimized to increase the seed productivity.

The patterns in the inheritance of the seed productivity elements and the peculiarities of creation of interspecies hybrids of tobacco were established. The difficulties arising in the process and ways of their overcoming are considered. The tobacco collections were analyzed in terms of economic characteristics. To obtain hybrids with high heretability of the seed productivity elements, it is necessary to involve varieties and collection accessions with different variability profiles (where female forms give a high vegetative mass and male forms show a high seed productivity) in hybridization.

Conclusions. The following varieties can be sources of the valuable feature, high seed productivity, under the conditions of the Zakarpatska Oblast: Amerikan 311, Bravyi 200, Zhovtolystnyi 36, Makhorkovydnyi 28, Temp 400, Erho 23, Basma 99, Zahradni 8, Ukrainskyi 12, Ternopilskyi 14, Berley 38, Virginia 27, Venherskyi Ohorondii, and Krupnolystnyi.

We recommend the following tobacco varieties with high seed productivity and high-quality vegetative mass to agrarian enterprises of the Zakarpatska Oblast: Amerikan 20, Sobolchskyi 15, Ternopilskyi 7, Ternopilskyi 14, Virginia 27, Temp, Ukrainskyi 18, Ukrainskyi 27, Zakarpatskyi 1, and Kerti.

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СЕЛЕКЦІЙНО-ГЕНЕТИЧНІ ОСНОВИ ПІДВИЩЕННЯ ПРОДУКТИВНОСТІ ТЮТЮНУ

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Мета дослідження. У статті проведено аналіз та узагальнення досліджень вітчизняних та зарубіжних учених з метою вирішення нагальних питань з селекції тютюну на підвищену продуктивність. Метою дослідження став пошук інформаційно-джерельного забезпечення з метою підбору перспективних сортів тютюну з високими показниками насіннєвої продуктивності та для подальшого використання в селекційному процесі.

Матеріали і методи дослідження. Матеріалом для досліджень слугували статті та матеріали конференцій вітчизняних та зарубіжних авторів, а також інші ресурси стосовно підвищеної насіннєвої продуктивності та стабільної врожайності листків з високою товарною якістю.

Обговорення результатів. В результаті зібрано і проаналізовано літературні джерела, в яких вітчизняні та зарубіжні вчені висвітлили свої дослідження стосовно особливостей селекції тютюну. Виявлено вплив вегетаційного періоду, біотичних і абіотичних факторів на зміну насіннєвої продуктивності. Оцінено різні форми суцвіття за насіннєвою продуктивністю. Встановлені закономірності успадкування елементів насіннєвої продуктивності, особливості створення міжвидових гібридів тютюну. Розглянуті труднощі, які виникають в процесі та способи їх подолання. Проведено аналіз тютюнових колекцій за господарськими ознакам.

Висновки. Таким чином наведено теоретичне узагальнення і науково обґрунтоване вирішення важливого наукового завдання щодо визначення насіннєвої продуктивності сортів та селекційного матеріалу тютюну. Встановлено особливості успадкування ознак насіннєвої продуктивності. Підібрано сорти з дуже високими показниками насіннєвої продуктивності для створення базової колекції, яка буде використана в подальшій селекційній роботі: Американ 311, Бравий 200, Жовтолистний 36, Махорковидний 28, Темп 400, Ерго 23, Басма 99, Заградні 8, Український 12, Тернопільський 14, Берлей 38, Вірджинія 27, Венгерський огородній та Крупнолистний. Дано рекомендації агроформуванням Закарпатської області щодо асортименту тютюну: Американський 20, Соболчський 15, Тернопіль 7, Тернопіль 14, Вірджинія 27, Темп, Український 18, Український 27, Закарпатський 12, Керті.

Ключові слова: *тютюн, сорт, насіннєва продуктивність, селекція, цінна ознака.*

СЕЛЕКЦИОННО-ГЕНЕТИЧЕСКИЕ ОСНОВЫ ПОВЫШЕНИЯ ПРОИЗВОДИТЕЛЬНОСТИ ТАБАКА

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Цель исследований. В статье проведен анализ и обобщены результаты исследований отечественных и зарубежных ученых по проблеме решения неотложных задач селекции

табака с учетом повышения производительности. Целью исследования было проведение информационного поиска источников для подбора перспективных сортов табака с высокими показателями семенной продуктивности и дальнейшего использования в селекционном процессе.

Материалы и методы. Материалом для исследований стали статьи и материалы конференций отечественных и зарубежных авторов, а также другие ресурсы относительно повышенной семенной продуктивности и стабильной урожайности листьев с высоким товарным качеством.

Обсуждение результатов. В результате собраны и проанализированы литературные источники, в которых отечественные и зарубежные ученые осветили свои исследования относительно особенностей селекции табака. Выявлено влияние вегетационного периода, биотических и абиотических факторов на смену семенной продуктивности. Оценены разные формы соцветия по семенной продуктивности. Установлены закономерности наследования элементов семенной производительности, особенности создания межвидовых гибридов табака. Рассмотрены трудности, возникающие в процессе селекции и способы их решения.

Выводы. Таким образом, приведены теоретическое обобщение и научно обоснованное решение важной научной задачи по определению семенной продуктивности сортов и селекционного материала табака. Установлены особенности наследования признаков семенной продуктивности. Подобраны сорта с очень высокими показателями семенной продуктивности для создания базовой коллекции, с целью использования в дальнейшей селекционной работе: Американ 311, Бравый 200, Желтолистный 36, Махорковидный 28, Темп 400, Эрго 23, Басма 99, Берлей 38, Вирджиния 27, Венгерский огородный и крупнолистный. Даны рекомендации агропредприятиям Закарпатской области относительно ассортимента табака.

Ключевые слова: *табак, сорт, семенная продуктивность, селекция, ценный признак.*

SELECTION AND GENETIC BASIS OF INCREASING TOBACCO PRODUCTIVITY

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Purpose. The article analyzes and summarizes studies of Ukrainian and foreign scientists in order to address pressing issues of tobacco breeding for increased performance. The study purpose was to search for information and sources in order to select promising varieties of tobacco with high seed productivity for further use in breeding.

Materials and methods. Articles and conference abstracts by Ukrainian and foreign researchers were reviewed; other resources related to increased seed productivity and stable yield of leaves with high marketable quality were analyzed.

Results and discussion. The article analyzes publications in which Ukrainian and foreign scientists reported their results on the peculiarities of tobacco breeding. The effects of the vegetation period as well as of biotic and abiotic factors on the seed productivity are described. Different shapes of inflorescence were evaluated for seed productivity. Patterns in the inheritance of seed productivity elements and peculiarities of creation of interspecies hybrids of tobacco were established. The difficulties arising in the process and ways to overcome them are considered. Tobacco collections were analyzed in terms of economic characteristics.

Conclusions. Thus, the article presents a theoretical generalization of and a scientifically sound solution to an important scientific problem of determining the seed productivity of tobacco varieties and breeding material. The patterns in the inheritance of seed productivity traits were established. The following sources of very high seed productivity, with a high genetic

potential for the conditions of the Transcarpathian region, were selected for building up a basic collection and its subsequent use in breeding: Amerikan 311, Bravyi 200, Zhovtolystnyi 36, Makhorkovydnyi 28, Temp 400, Erho 23, Basma 99, Zahradni 8, Ukrainskyi 12, Ternopilskyi 14, Berley 38, Virginia 27, Venherskyi Ohorodnyi, and Kruprnolystnyi. Recommendations were given to agrarian enterprises of the Zakarpatska Oblast regarding the tobacco assortment: Amerikan 20, Sobolchskyi 15, Ternopilskyi 7, Ternopilskyi 14, Virginia 27, Temp, Ukrainskyi 18, Ukrainskyi 27, Zakarpatskyi 12, and Kerti.

Key words: *tobacco, variety, seed productivity, breeding, valuable traits.*

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YIELD LEVEL AND STABILITY IN CORN HYBRIDS OF DIFFERENT RIPENESS GROUPS

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The maximum and average yield levels and stability in corn hybrids of different ripeness groups, with high agronomic stability, giving consistently high yields under deteriorating growing conditions, were determined. In 2016–2018, the maximum average yields were produced by mid-early hybrids Vektor (8.13 t/ha), KhA Bolid (8.19 t/ha), Arho (8.13 t/ha), and by mid-ripening hybrid UKhL 228/KhA 408 (7.10 t/ha), which exceeded the corresponding conditional check hybrids by 23–24%. The female form of Vektor and Arho was originated from interline hybrids; and the female form of KhA Bolid and UKhL 228 / KhA 408 - from exotic plasm. Based on trial results, three mid-early corn hybrids, Liubchyk (FAO 240), Stavr (FAO 290) and Vektor (FAO 270) were included in the State Register of Plant Varieties Suitable for Dissemination in Ukraine.

Key words*: corn, yield, hybrid, ripeness group.*

Introduction. The creation of highly heterozygous hybrids is based on diverse starting material, and its effectiveness depends on how well it was studied under specific agro-climatic conditions. The main objective of breeders is to combine valuable economic and biological traits and features in one genotype, which would allow for fulfillment of the genetic potential and ensuring maximum yields with the lowest costs of cultivation [1, 2, 3].

Literature review. Modern heterosis corn breeding aimed at solving the main challenge – to increase yields of hybrids - requires starting material of various origins for breeding programs and development of new approaches to its use [4, 5].

Producers‟ stringent requirements for current corn hybrids encourage the search for new more efficient breeding technologies, revision and updating of breeding mainstreams, expanding the genetic basis of starting material and prompt response to market demands. Increased yields, reduced harvest moisture in grain, resistance to diseases and pests, and stable reproduction of valuable economic characteristics under widely varying environmental conditions remain the most important trends in breeding [6, 7, 8].

Purpose. To determine the yield and agronomic stability of new corn hybrids bred at the Plant Production Institute named after V.Ya. Yuriev of NAAS under climatic changes.

Materials and methods. The study was conducted in the Laboratory of Corn Breeding and Seed Production of the Plant Production Institute named after V.Ya. Yuriev of NAAS in the scientific

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