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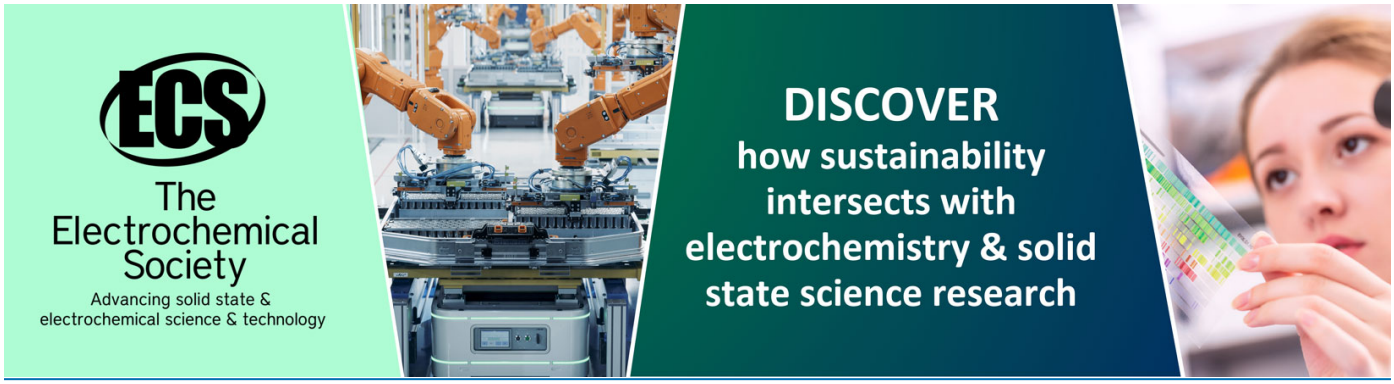

Study on the selection of the best forms of walnut in Uzbekistan

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Abstract. This paper provides information on the status of work on walnut selection in Uzbekistan. The requirements for the identification of commercially valuable forms of walnut, which are suitable for producing different sorts of walnut, are highlighted and defined. As well as, the presented forms are dedicated to the creation of new sort of walnut for cultivation in plantations in Uzbekistan.

1. Introduction

The natural range of walnuts is currently torn and preserved by individual small foci in Central Asia (Kugitang, Western Tien Shan, Nurata Range, Central Tajikistan, Hindu Kush and the Himalayas) The walnuts grows everywhere as an accompanying species in forests with a different basic composition (Afghanistan, China) [1].

Only in the Western Tien Shan have large tracts of tens of thousands of hectares or small populations survived, where the nut has been preserved as the main species in the forests together with fruit species, forming walnut-fruit forests in the territory of modern Kyrgyzstan and partially Uzbekistan [2].

Here, unlimited gene pool has been preserved, which can be used to create new sorts. Most likely, the nut spread throughout the world from the Central Asian regions, as trade routes passed through from Asia to the Middle East and Europe [3].

Since ancient times, as soon as trade routes between the most developed countries arose, walnut seeds, like other types of fruit trees, were brought with trade caravans from the places of its natural growth in Central Asia to the West and in the countries of the Middle East, from where it spread to with favorable climatic conditions, first in almost all southern countries of Europe, and then in North America.

The cultural range of walnuts already covered the countries of Central and Western Asia, as well as Southern Europe several millennia ago [4-6].

Currently, its cultural area has spread to all the middle latitudes of the Northern Hemisphere. Over the years of growing walnuts from samples imported from Central Asia, a number of varieties with good economically valuable qualities were created by artificial selection and hybridization in these countries, which are still grown there on an industrial scale by millions of tons per year.

According to Food and Agricultural Organization of the United Nation (UN FAO), the annual demand for walnuts is 200 million tons, while production is 3.5 million tons. The annual Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) reports an increase in demand for walnut

fruits. Over the past 5 years, there has been a doubling of walnut consumption in the USA and a jump in prices for it in Europe from 3.5 to 10 euros per 1 kg.
In 2018 - 2019, the production of peeled walnut kernels amounted to thousand tons: in China, 356.4; USA - 2273.4; Chile - 70.0; Iran - 45.0; Ukraine - 44.0; France - 15.4; in other countries - 71.6 thousand tons. It is known from the same information that 185 thousand hectares are occupied by walnut plantations in China, 86 thousand hectares in the USA, 60 thousand in Iran, and 59 thousand hectares in Turkey [7].
There are dozens of varieties of walnut bred in different countries of Europe, Asia and North America and differing mainly in the variation in the signs of fruits.
However, the possibilities of breeders in these countries are limited by the available genetic material brought there back in the distant past. The gene pool of walnut in natural forests is almost unlimited. Interest in growing nuts is currently only increasing [8, 9].
However, it so happened that in Central Asia - the birthplace of wild walnut - its varietal-based gardens are not grown.
The local population, over the years of civilization, created many excellent sorts of other fruit crops - apricot, apple, cherry plum, plum, grape, fig, peach, pear - and fixed them in the offspring, not a single walnut variety fixed in the offspring was bred due to difficulties its vegetative propagation.
Walnut is extremely common in a culture among Central Asian countries. In the foothill zone, it is found in almost every homestead farm, but all the trees differ in quality of nuts from each other. Among them there are many forms that are not inferior in economic properties to foreign varieties and even surpass them. However, nuts from such trees are only suitable for sale in local markets. In modern conditions, they cannot be exported for sale through distribution networks, since large batches of fruits with exactly the same varietal characteristics are required.
Meanwhile, Uzbekistan, like other Central Asian states, has advantages in creating new sorts of walnuts, since only in areas of natural growth of walnuts there is an unlimited set of genetic resources for breeding its varieties, which can differ not only in high quality fruits and annual sustainable abundant fruiting, but also resistant to pests and diseases, to early spring frosts, to extremely low winter air temperatures, to soil droughts, and many other advantages [10].
The cultivation of new sort of walnuts in Central Asia and the development of technology for their vegetative propagation began to be dealt with only less than 100 years ago, both in Kyrgyzstan, and in Tajikistan and Uzbekistan, where natural forest exist [9]. Over the years, hundreds of forms have been found in forests and household plots that are suitable for creating outstanding sorts that are superior in quality to those grown in the rest part of the world.
In Uzbekistan, some of them were already registered at the Research Institute of Horticulture, Viticulture and Winemaking named after Acad. M. Mirzaev, stored in the uterine garden, but not used for growing varietal seedlings. Several varieties of nuts were created at the Research Institute of Forestry more than 50 years ago and, unfortunately, have already been lost.
Over the past 25 years, the Uzbek Research Institute of Forestry has selected more than 100 forms of walnut with high economically valuable qualities. These forms need further investigation in order to select the best of them for translation into varieties that are not inferior to the world and even exceed them, from which industrial plantations can be created.
For the various reasons, not a single varietal nut plantation was created from these sorts and forms in the republic. In March 2017, by decree of the President of the Republic of Uzbekistan, the Resolution "On measures to increase the production of walnuts in the republic for 2017-2021" was adopted, which in the first stages provides for the creation of industrial plantations from imported varieties from the United States and the Turkish Republic, and subsequent - the cultivation of high-yielding walnut seedlings, taking into account their adaptation to the natural and climatic conditions of the respective regions.
Imported sorts of walnut are not tested in the republic and the possibilities for their cultivation are not known here. At the same time, Uzbekistan has the above potential of previously selected forms that

are not inferior to foreign varieties in either yield or quality of fruits, but at the same time adapted to local conditions.
It is only necessary to conduct additional research to select the best of these forms for fixing them in the offspring, to create collection-uterine gardens from them in order to receive grafting material when growing regional varietal seedlings, which can be created high-yield nut plantations in all areas of the republic suitable for it successful growth. At the same time, one should focus on obtaining walnut crops of at least 4 - 5 t/ha and higher, which are basically obtained in foreign countries like China, European countries, Iran, the USA, etc.

2. Methods

At the beginning of the study, the selection of the best available forms of walnut was carried out in order to identify their most valuable qualities necessary for industrial cultivation in the republic and to fix these forms as varieties in the mother garden.
The selection of the best forms the available materials was carried out in the forestry and on personal plots of local residents in the Bostanlyk district of the Tashkent region, in the Kattabogdan district of the Jizzakh region at the same facilities and in the collection and testing garden of the NIIILKh Arboretum.
As a result of the analysis, the most promising were selected for further variety testing from all the above-mentioned regions where selection was carried out.
Due to the large amount of work, out of the total number selected in previous years, only 36 of the most promising forms were studied, in order then to select a small number of forms as candidates for varieties that guarantee annual high yields of high-quality fruits. From the selected candidates for varieties, it is planned to create a uterine garden and use it in the future for growing varietal seedlings [11] for the needs of the republic.
For three years, these forms were studied in three directions: the morphological characteristics of the tree, the phenology of the main economically valuable phases of vegetative development, and the study of all the signs that are associated with the quantity and quality of fruits and fruiting. The morphological characters of each form, except for annually increasing tree sizes, practically do not change over the 4 years. The phenology of vegetative development and biometric indicators of fruits change annually and to obtain their averaged indicators over three years, observations were made in these areas.
The phenology of the selected forms was studied in the following phases of vegetation: the beginning of the bud; the beginning of shoot growth; beginning and end of flowering of female and male flowers; a presence of secondary flowering and its timing (if it is observed); terms of mass ripening of fruits; the beginning of yellowing of the leaves / 8 /. During flowering, the duration of the flowering coincidence of male and female flowers (dichogamy) was established. This is a very important indicator, which determines the need for the introduction of additional varieties or forms - pollinators on a nut plantation or in orchards in order to obtain maximum fruit yields.
During the passage of the fruit ripening phase, fruit samples were collected on all studied walnut forms, dried to constant weight and then measured.
Of the signs of fruit on annually selected samples were studied: the mass of the nut, the mass of the kernel, the percentage of kernel output, the ease of removing the kernel from the shell, the thickness of the shell, the color of the skin of the kernel. In addition, the infectiousness of trees and fruits with major pests and diseases was noted.
Below is a description of the averaged three-year indicators of the phenological phases of development and the main economically valuable traits of fruit-selected 36 best walnut forms, summarized in the Table 1.
In the selection, preference was given to forms with the following characteristics:
- with late dates of the beginning of vegetation and with late flowering, since they are less susceptible to spring frost, killing young ovaries, and, consequently, the harvest;

- forms with coincidence of flowering time (fully or at least partially) of male and female flowers, guaranteeing good pollination and increased yields, while avoiding the inclusion of additional varieties of pollinators in the composition of plantations;
- forms resistant to the main pests and diseases of the nut, which significantly reduce the yield of walnut, especially in the years of their outbreaks;
- forms with a large number of fruit buds, laid annually not only on the tops of growth shoots, but also on the lateral fouling, and each bud should form a fruit with several (2-5 or more) nuts;
- the selected forms have a mass of nuts above the average size - from 12 g or more, thin solid, without holes, 1.0 - 1.5 mm thick shell, preferably a high kernel yield - above 55%, a light kernel skin, good extractability of the kernel in halves or whole and good external signs;
- relatively drought-and heat-resistant forms, which can significantly expand the cultural range of walnut;
- with fruit ripening at the same time for easy harvesting.

3. Results and Discussions

Table 1 shows that out of 36 selected forms with medium and late periods of the beginning of vegetation and flowering (which completely coincided during the observation period), there are 13 forms that were preferred during selection of forms to avoid early spring frosts during flowering; to create a uterine garden - 14/26; 1F; 1/25; 12/5; 14/6; 14/31; 14/30; 10/7; 9/15 in Darkhan, 308N in Farish and Sidge 9 and 55BGS in Bostanlyk.

Table 1. Promising forms of walnut pointed in 2019 for subsequent propagation and implementation in industrial walnut cultivation

	Flowering phenology				Characterization of fruits of promising forms							
№ of the form	Flowering period	Coincidence of flowering time of male and female flowers	Amount of coincidence flowering days	Type of dichogamy	walnut mass, g	weight of the	kernel output,t %	shell thickness, mm	Peel kernel colour	extractability of the kernel	The number of fruits in fertility	Sustainability to pests and disease
NIIILH experimental farm Darkhan												
4/25	medium	coincidence	7	homogam	13.4	8.3	61.9	1.1	bright	entirely	2 -3	high
5/11	medium	coincidence	8	protogin	13.5	8.0	59.3	1.2	bright	half	3 and more	mediu m
6/17	medium	coincidence	9	protogin	12.0	6.2	51.7	1.0	brown	quarter	2 - 3	high
5/31	medium	coincidence	8	homogam	14.9	8.1	54.4	1.4	bright	quarter	3 - 4	high
7/19	early	coincidence	8	protogin	13.4	8.4	62.7	1.4	light brown	half	2 - 3	high
12/4	late	coincidence	7	protogin	11.5	7.6	66.1	1.0	light brown	entirely	3 and more	high
12/1 5	medium	coincidence	8	homogam	15.0	8.7	58.0	1.4	bright	half	3 and more	high
12/3 6	medium	coincidence	6	protogin	14.1	8.9	63.1	0.9	bright	entirely	3 - 4	high
13/9	late	coincidence	5	protogin	16.0	7.5	46.9	1.9	light	entirely	2	high

									brown			
14/33	medium	coincidence	8	protogin	11.2	8.1	72.3	1.5	creams	entirely	2 - 3	medium
14/26	late	coincidence	8	homogam	7.2	4.3	59.7	0.8	bright	half	2 - 3	high
Hur	late	coincidence	6	protogin	12.1	7.2	59.5	1.3	bright	entirely	3 - 4	low
1/25	late	coincidence	7	protogin	14.7	8.4	57.1	1.2	light brown	half	2 - 3	medium
2/31	medium	coincidence	8	protogin	15.0	8.5	56.7	2.0	light brown	entirely	3 and more	high
12/5	late	coincidence	6	protogin	11.1	7.7	69.4	1.1	creams	entirely	3 - 4	high
14/6	late	coincidence	6	protogin	10.1	5.8	57.4	0.9	light brown	half and quarter	2 - 3	medium
14/31	late	coincidence	6	protogin	15.8	9.4	59.5	1.1	brown	entirely	1 - 2	high
14/30	late	coincidence	6	protogin	16.7	9.5	56.9	1.5	brown	half	2 - 3	medium
10/7	late	partial coincidence	5	protogin	13.0	7.2	55.4	0.7	bright	entirely	1 - 2	high
9/29	medium	partial coincidence	6	protogin	13.5	7.9	58.5	1.1	brown	quarter	1 - 2	medium
9/15	late	partial coincidence	5	protogin	14.4	8.1	56.3	1.3	bright	half	2 - 3	high
Kattabog district of Jizzakh region												
81FRSH	early	no coincidence		protogin	17.2	9.3	54.1	1.2	yellow	entirely	1 - 2	high
31RSH	early	weak	3	protogin	17.2	7.9	45.9	1.5	yellow brown	entirely	3 - 4	high
308N	late	partial coincidence	7	protogin	16.1	8.3	51.6	1.6	light brown	entirely	1 - 2	high
20FRSH	medium	coincidence	9	protogin	12.6	6.7	53.2	1.2	yellow	entirely	3 - 4	high
92FSH	medium	coincidence	8	protogin	10.9	7.1	65.1	0.5	yellow brown	entirely	2 - 3	high
304FR	medium	no coincidence		protogin	13.0	7.6	58.5	1.0	yellow brown	entirely	3 and more	high
305YM	medium	coincidence	7	protogin	12.7	6.7	52.8	1.2	light yellow	entirely	1 - 2	high
Bostanlyk district of Tashkent region												
35KRK	medium	coincidence	8	protogin	10.0	5.2	52.0	1.3	light brown	entirely	2 -3	high
29KRK	medium	partial coincidence	5	protogin	12.6	7.2	57.1	1.2	light brown	entirely	1 -2	high
221KRK	medium	coincidence	11	homogam	11.5	6.6	57.4	1.2	yellow brown	entirely	3 and more	high
Cij.8	early	coincidence	10	homogam	13.1	7.5	57.3	1.4	light yellow	entirely	2 -3	high
Cij9	late	coincidence	11	homogam	15.6	6.4	41.2	2.0	yellow brown	half	2 - 3	high
65nan	early	partial coincidence	5	protogin	13.2	7.2	54.5	1.3	light	entirely	3 and more	high
55BGS	late	coincidence	12	homogam	13.1	6.8	52.0	1.5	light brown	entirely	3 - 4	high
202YKT	medium	partial coincidence	7	protogin	10.0	6.9	69.0	1.3	light yellow	entirely	3 - 4	high

With the simultaneous (homogamous) flowering of male and female flowers on one tree, guaranteeing good pollination and fruit setting on it, it turned out 4-4/25; 5/31; 12/15 and 14/26 in Darhaney 4 in Bostanlyk - 221 KRK; Cij8; Cij9; 55BGS.
There are 13 trees with dichogamy, but with a longer flowering coincidence (more than 7 days) from the selected forms, 13 pcs with a short period (4-6 days), and 2 with completely different flowering periods. It turned out to be 12 trees with protandric flowering and 16 trees with protogynic. The number of days of coincidence of flowering during dichogamy varies every year depending on the weather, and this indicator served as a factor in the transfer to unpromising forms for short periods of coincidence, when selecting promising forms.
Important indicators in the selection of the best forms are the mass of one nut, the mass of the kernel and the thickness of the shell on which the yield of the kernel depends [12, 13, 14], as well as the light color of the shell of the kernel on which the sorting of the nuts depends [15, 16]. In the observed forms of walnut, only 5 had a kernel weight of less than 12 g (10 - 11.5 g) and only one (14/26) had small nuts - 7.2 g.
In all the observed forms, except for 2 - 2/31 and Sij9, the shell thickness was less than 2 mm, and in 25 of them - less than 1.5 mm.
Due to this, the percentage of kernel yield in only two forms turned out to be less than 50%, in six forms more than 60%, and in one even more than 70%. In the analyzed 23 forms of walnut, the color of the kernel shell is light, in 9 forms light brown, and only 4 forms are brown. In almost all forms, the extractability of the kernel of the shell nuts is good - either in whole or in halves, and in only four – quarters.
According to the results shown in Table 1, by coincidence, the majority of all of the above factors, 17 forms were selected - candidates for sorts for the creation of mother liquor for the purpose of further final selection as sorts and growing varietal seedlings from them: 1/25; 4/25; 5/11; 5/31; 9/15; 10/7; 12/4; 12/5; 12/15; 12/36; 14/26; 14/30 and 14/33 from the garden of the farm “Darhan”, 202 NKT and 221KKK from Bostanlyk and 20FRSh and 308N from the Nurata Range in the Kattabogdan district.

4. Conclusions

Thus, according to the results to identify economically valuable forms of walnut, it can be concluded that Uzbekistan, along with other countries of Central Asia, is a source of an extensive gene pool of walnuts, which can be used for selection of new sorts that exceed the set of valuable traits available in world sort production. Hence, only a small part of the valuable forms allocated by the local population were used in this work and the gene pool of wild forests, where walnut is the main forest-forming species, is not involved at all.

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