Study of varieties and diversity of walnut forms in Kyrgyzstan *(reviewed paper)*

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Abstract: Die kirgisischen Mischwälder mit Walnuss- und anderen Obstbäumen zeichnen sich besonders durch eine enorme Formenvielfalt der Walnussbäume (*Juglans regia* L.) aus. In Kyrgyzstan hat die Selektion von Nussbäumen eine lange Tradition, und auch gegenwärtig wird noch immer anhand der geernteten Nüsse eine Auswahl getätigt. Beschrieben werden im Aufsatz Ziel, Kriterien und Resultate der Selektion viel versprechender Nussbaumformen aus Versuchsflächen wie aus Naturwaldbeständen.

Abstract: The peculiarity of Kyrgyzstan's walnut-fruit forests (*Juglans regia* L.) consists of a huge diversity of forms of walnut. The walnut selection has a long history in this country, and the selection out of natural seed population is still practiced. The author describes the selection goal, criteria and results of promising forms of walnut out of trial collection plots as well as in natural forest stands.

1. Introduction

Kyrgyzstan is a republic in Central Asia and covers an area of 198 500 km^2. It is a mountainous country, located within the Tien-Shan, the Pamir and the Alai mountain systems. The territory of Kyrgyzstan lies at altitudes of no lower than 500 m above sea level, with more than half of the country's territory at altitudes of between 1000 and 3000 m above sea level (Forest Encyclopedia 1985, p. 420).

In the Kyrgyz Republic, forested areas cover 4.25 % of the total country area and according to Kolov & Musuraliev (2001) are these forests home to 183 different tree and shrub species. In the south, unique walnut-fruit forests grow on the slopes of the Fergana and Chatkal mountain ridges, which are located right at the interface of the two great mountain systems of Tien-Shan and Pamir and the Alai.

The walnut forests cover a total area of 40 500 hectares. The main stands are located at altitudes between 1200 and 2200 m above sea level, and are found on slopes of differing exposition. It is worthwhile to note that the existence of walnut forests fosters soil protection, water protection, and water regulation – all functions of great importance in this region. In addition, these forests are of great importance to the local population, living in or near the forests, as a source of valuable fruits, timber, and medicinal raw materials.

The unique nature of the walnut-fruit forests in southern Kyrgyzstan is manifest in the fact that they are home to valuable wild fruit species such as walnut, pistachio, almond, apple, plum, hawthorn, cherry, rose-hip etc. Among other edible fruit yielding tree species we find a very special one, namely *Juglans regia* L., a species of walnut that makes up the main forest-forming species of all walnut-fruit forests in Kyrgyzstan.

The peculiarity of these forests consists of an extreme diversity of forms of walnut, which makes it possible to carry out continuous selection work in the walnut forest stands. The variety of the forms of walnut manifests itself in the first place in the size, mass, and form of the walnut fruit, which varies from round to oblong. Regarding the colour, this can vary from straw-yellow to dark brown and the nuts vary in taste from bitter to sweet and extremely oily varieties. As far as extracting the nut's kernel is concerned, the degree of difficulty ranges from easy to very hard and the mass of the nut from big to small. As for its biological aspects, walnuts can be subdivided into those that blossom early in the season and those that blossom late; those that have immunity to diseases and those that have none; those that bear fruit on a regular basis and those that are characterized by irregular fruiting; those that are high-yielding and those that are low-yielding. Moreover, there are walnut forms characterized by self-fertilization and forms that bear fruit without pollination of the female blossoms, etc.

Walnut selection has a long history and the simple selection method was carried out by favouring the natural seed population of good harvesting plants with ones with high quality walnuts. This method is still considered to be the best practice. Practically all the walnut varieties have been fostered based on selection of the best forms of seed origin.

Vavilov (1960) stressed the importance of selection of the wild walnut fruit forms and wrote: «If the primary task of the most important field cultures became intra-specific and even distant hybridization, then regarding the other objects mainly we have to use the local assortment including the wild resources. In the mountain ranges of Kyrgyzstan and Kazakhstan wonderful forms of the walnut are found that are available for direct cultivation».

In southern Kyrgyzstan walnut selection has been carried out by different researchers, such as Dyachenko (1934), Aksakov (1940), Sokolov (1949) and Zarubin (1954). However, the valuable walnut trees selected at that time were not fixed in kind and most of the relevant data have been lost. One significant piece of work on the selection of the best forms was Shevchenko's (Shevchenko 1976). He selected more than 220 types of walnut varieties, six of which were accepted by the state's variety testing centre. These are: Ak-Terekskiy, Gavinskiy, Desertniy, Oshskiy, Ostrovershinniy and Uygurskiy. The following forms all have special features: the Bomb (the size of a fruit), the Paper (the thickness of a shell), and the Clustery (multiple number of fruits on one fruit-stem). During the period of selection the main focus was on early-maturing forms. In all, 13 types of the early-maturing walnut forms were selected as seed and mother trees.

Taking the great importance of the preservation of selected valuable forms of walnut into account, in the period from 1965 to 1973, collection and parent gardens were installed on the area belonging to the Forest Trial Station of the National Academy of Science's Institute for Forest and Walnut Research using grafted saplings of the best walnut varieties. These test sites included both local species and those brought from other Soviet republics of the Central Asian region. These collection plots were intended not only for the purpose of supplying forestry institutions (the local leshozes) with the relevant graft and seed material, but also in order to study the local selection of walnut varieties, as well as those from other regions.

2. Research goal

The goal of this research is the selection of the best and promising forms of walnut on trial collection plots, as well as in the walnut forest stands, for the purpose of introducing these forms in the industrial culture within the walnut-fruit forests zone in Kyrgyzstan.

In order to achieve this goal, the following main tasks were set:

1. Assessment of both the local and foreign varieties of walnut on the trial plots based on economically valuable properties (yield and fruit quality) and biological properties (frost-resistance, resistance to diseases, and regularity of fruiting).
2. Selection of the most promising forms of walnut in the natural walnut forest stands, as well as in the walnut forest cultures in the walnut-fruit forests zone.

3. Research methods

In the process of study and assessment of the varieties and forms of walnut species, we employed generally accepted methods developed by the following scientists: Voronezh Central Scientific Research Institute for Forest genetics and selection, authors SCHEPOTYEV *et al*. 1976. For the assessment of varieties and selection of forms of walnut, phenological observations were carried out to determine the frost-resistance of the walnut trees, the resistance of the walnut varieties and forms to diseases. The peculiarities of the fruiting and yielding of varieties and forms were also studied, and the morphological properties of the walnut fruit identified. In the course of the phenological observation, the different phonological phases were taken into account: starting of the bud blooming, appearance of the first leaves, blossoming of male and female blossoms, ripening of fruits, yellowing and shedding of leaves.

When determining the frost-resistance, aspects such as frost damage to the buds, as well as the growth (increment) of recent years were taken into account. The assessment of frost-resistance was based on observation and assigned to a five-point scale:

5: no damage caused by frost;
4: slight damage inflicted by frost to the top buds and – singularly – to some of the one-year shoots;
3: total winterkilling of the greater part of the one-year growth and the single slight damage caused by frost to the two-year summer shoots;
2: total winterkilling of the greater part of the one-year growth and the slight damage inflicted by frost to the two-year and three-year summer shoots;
1: complete death of the one-year, two-year, and three-year summer shoots and part of the skeletal branches.

The following six-point scale was used to assess fruiting and yielding:

5: abundant fruiting; all the top buds had produced fruits, with several pieces as cluster. Many fruits were produced by the side buds;
4: fruiting was intensive; all the top buds had produced fruits, with several pieces on a shoot. Single fruits were formed by the side buds;
3: fruiting was average; less than a half of the top buds carried fruits, most with one piece in a cluster and only occasionally with 2 or 3 pieces;
2: poor fruiting; less than a half of the top buds carried fruits, most had only one piece per cluster;
1: fruiting was singular (single fruits here and there).
0: total absence of fruits.

The regularity of fruiting was judged on a three-point scale:

3: annually fruiting varieties with abundant fruiting in productive years, but average or poor fruiting in non-productive years;
2: varieties that only bear fruit in years with favourable fruiting conditions;
1: varieties whose fruiting is poor even in years with favourable fruiting conditions and that have no fruiting at all in the other years.

Resistance to diseases of the vegetative and reproductive organs of the walnut tree depends on its biological properties. For the assessment, only such diseases were taken into account where it was possible to discover the variety differences. One such disease, the most widely spread among walnut leaves and fruits, is brown spottiness or *Marconina juglandis*. We assessed the degree of damage inflicted by *Marconina juglandis* by applying a four-point scale:

4: no damage inflicted to leaves, shoots, and fruits;
3: small necrotic spots appeared on the leaves and fruits, sometimes in big numbers, without, however, merging;
2: necrotic spots of varying size appear on the leaves and fruits that tended to merge, covering the greater part of a leaf, shoot, or fruit;
1: big necrotic spots appear on the leaves and fruits and covered the greater part of the leaves, shoots, and fruits.

The quality of fruits is one of the most important indicators. In the course of the research we determined properties, such as the size and mass of walnut fruits, the kernel yield, the shell thickness, the shell cleavage, the easiness of extraction of a kernel, the kernel colour, etc. To assess the properties related to the quality of fruit of the different walnut varieties and forms, a point system was applied. The assessment of the nut mass was made by applying the following four-point scale, while the nuts were subdivided into the following size categories:

5: with a mass of 14,1 g or more;
4: with a mass ranging from 12,1 g to 14,0 g;
3: with a mass ranging from 10,0 g to 12,0 g;
2: with a mass ranging from 8,0 g to 9,9 g;
1: with a mass of 7,9 g or less.

In order to determine the fruit size the researchers took 25 nuts, characteristic of this variety or form, and, with the help of a slide gauge, measured the height h, the width (along the seam) – d_1, and the thickness (at sides) – d_2. We then determined the average indicators and assigned the fruit size to a place in this five-point scale:

5: very large nuts, more than 41,1 mm (h) and 34,1 mm (d_1 and d_2);
4: large nuts, 38,1–41,0 mm (h) and 32,1–34,0 mm (d_1 and d_2);
3: middle-size nuts, 35,1–38,0 mm (h) and 30,1–32 mm (d_1 and d_2);
2: small nuts, 32,1–35 mm (h) and 28,1–30,0 mm (d_1 and d_2);
1: very small nuts, less than 32,0 mm (h) and 28 mm (d_1 and d_2).

The assessment of the shell surface was made applying the following four-point scale:

4: smooth nut surface, with barely visible seams (ribs);
3: slightly wrinkled nut surface, with slightly protruding ribs;
2: wrinkled or uneven nut surface, ribbed;
1: very wrinkled and uneven nut surface, ribbed.

The assessment of the shell colour was made applying the following five-point scale:
5: light yellow shell colour;
4: light brown shell colour;
3: light grey shell colour;
2: brown shell colour;
1: dark brown shell colour.

The ease of extraction of the walnut kernel from the shell was determined by the quantity of effort that is necessary, and divided into a four-point scale:
4: kernel easily extracted as a whole;
3: kernel extracted in halves;
2: kernel extracted with a small effort, split into big and middle-sized piece;
1: kernel extracted only with difficulty, split into small pieces.

The kernel yield was determined for the dry nuts in the following way. The quantity of nuts (25 pieces) was weighed, then the kernels were extracted from the nuts, and weighed. The percentage of kernel yield relative to the weight of the whole nuts was determined and assigned a place on a five-point scale:
5: very high yield, with kernel making up 55 % or more of total nut;
4: high yield, with kernel making up 50–54.9 % of total nut;
3: medium yield, with kernel making up 45–49.9 % of total nut;
2: low yield, with kernel making up 35–44.9 % of total nut;
1: very low yield, with kernel making up 35 % or less of total nut.

The assessment of the colouring of the seed skin of the kernel was made with application of the following five-point scale:
5: light yellow colouring;
4: yellow colouring;
3: light brown colouring;
2: brown colouring;
1: dark brown colouring.

The assessment of the kernel taste and smell was made organoleptically with application of the following five-point scale:
5: very good taste, sweetish;
4: good taste, sweetish, oily;
3: middling taste;
2: bad taste, with a bitter flavour;
1: very bad taste, with a bitter flavour, rot, mould, etc.

The taste should be peculiar to walnut, without an alien flavour or smell.

The shell thickness (the sample contained 25 walnuts) was measured by a slide gauge in the middle part of a nut's fold and assigned to a three-point scale:
3: thin; shell thickness less than 1.2 mm;
2: medium; ranging from 1.3 to 1.6 mm;
1: thick; 1.7 mm or more.

In a next step the economically valuable properties of walnut were determined as follows:
- the fruit quality, which was estimated at up to 5 points with the significance coefficient of 5 points;
- yielding, estimated at up to 5 points with the significance coefficient of 5 points.

The biological properties were assessed as follows:
- fruiting regularity, estimated at up to 3 points with the significance coefficient of 4 points;
- frost-resistance, estimated at up to 5 points with the significance coefficient of 4 points;
- resistance to diseases, estimated at up to 4 points with the significance coefficient of 4 points.

The coefficient of significance shows the importance of each of the features and used to determine the total score for the integrated assessment. Based on the total sum of points, comprising both of economically and biologically valuable properties, the value of the varieties and forms of walnut was assessed as follows:
5: very high, with a total of 81 or more points;
4: high, with total points ranging from 74 to 80;
3: middle, with total points ranging from 67 to 73;
2: poor, with total points ranging from 60 to 66.

4. Research results

4.1 Assessment of local and foreign varieties of walnut on the trial plots based on economically valuable and biological properties

In the period from 2000 to 2003, in the course of this research phenological observations were carried out with regard to the above-mentioned walnut varieties and forms. The resistance of these trees to frost and diseases, their fruiting and yielding peculiarities, fruiting regularity, as well as the morphological properties of fruit (the fruit quality) were studied.

Both local and foreign (from other regions) varieties of walnut grow on the collection and parent plots. The local varieties were selected in the territory of the walnut-fruit forests of Kyrgyzstan, while the foreign varieties were selected from other Soviet republics in the Central Asian region.

Table 1 presents the list of local varieties of walnut selected by SHEVCHENKO (1976) and foreign varieties of walnut selected by KALMYKOV (1969). The age of the trees ranges from 33 to 41 years.

The table shows that the average stem diameter of the above varieties ranges from 17 to 26 cm, average tree height from 6 to 12 m, while the crown from the north to the south ranges from 5 × 4 m and from the west to the east to 11x8 m. On the trial plots, these walnut varieties grow in the same environment sharing equal growth conditions. However, the fruiting of some of these trees is good, while the fruiting of the others is poor.

The walnut varieties differ in some parameters, such as the time of blossoming or resistance to external environmental factors. The ability and knowledge to select the most stable varieties and forms of walnut for the purpose of using them for the creation of walnut cultures with high productivity in the walnut-fruit forests zone is, therefore, of great importance. The selection of the best varieties requires the complex assessment of the existing walnut varieties and forms. It should be noted that this is the first assessment of the varieties and forms of walnut that takes both economical and biological properties into account.

4.1.1 Phenological observations

Based on phenological observations, late flowering walnut varieties and forms were identified. The date on which the majority of varieties and forms with early- and medium-flowering growing at an altitude of 1400 m starts to bloom lies between the 21st and the 26th of April, while the blooming of the varieties with late-flowering (such as Uygur, Sharptop,

Table 1: **Varieties and forms of walnut growing on the trial plots.**
Tabelle 1: Varietäten und Wuchsformen der Walnussbäume in den Versuchsflächen.

#	Varieties and forms	Average stem diameter (cm)	Average tree height (m)	Crown size (m × m)	Year of planting
Local					
1	Uygur	25	10	8×7	1965
2	Dessert	24	10	11×8	1970
3	Ak-Terek	24	9	8×8	1970
4	Sharptop	24	10	10×9	1970
5	Gava	22	9	8×8	1970
6	Osh	21	7	5×5	1973
7	Pecan-like	16	7	5×5	1972
8	Bomb	25	10	10×8	1970
9	Kyzyl-Mekhnat	17	6	5×4	1968
Foreign					
1	Guards	26	10	7×6	1965
2	Native land	25	11	8×6	1965
3	Anniversary	24	10	7×6	1965
4	Panfilov	25	11	6×6	1965
5	Bostandyk	26	12	8×6	1965
6	Pioneer	20	8	6×5	1968
7	Ideal	19	7	5×4	1968

Pioneer and Anniversary) occurs a little later, from the 27th to the 30th. It is important to note that the late-flowering walnut varieties evade the impact of spring frosts, which often happen in Kyrgyzstan's walnut-fruit forests zone in the third decade of April.

For practical application, walnut varieties and forms with a short vegetation period are of great importance, such as Uygur, Anniversary and Pioneer, which all have a short vegetation period (165, 169 and 173 days, respectively), while the length of the vegetation period of other walnut varieties ranges from 176 to 186 days.

Since the length of the frost-free period at an altitude of 1700 m above sea level (m a.s.l.) is approximately 162 days, and approximately 172 days at an altitude of 1500 m a.s.l., this means that walnut varieties like Uygur can be successfully grown, not only in the lower sub-belt, but also in the upper sub-belt in altitudes of between 1700 and 1900 m a.s.l. Other walnut varieties that have longer vegetation periods flourish on sites located below 1700 m a.s.l. The knowledge of the length of the vegetation period makes it possible to determine which forest growth conditions in the walnut-fruit forests zone are most appropriate for growing a specific walnut variety, in order to achieve high yields.

With regard to blossoming, two types have to be differentiated; the protogynic and protandric walnut varieties. Protogynic walnut trees are those whose female blossoms start blooming earlier than the relevant male ones, while protandric walnut trees are those whose male trees bloom before the female. Many researchers noted the existence of the phenomenon of protogyny and protandry with regard to the walnut species (Zarubin 1954, etc.). Based on the data resulting from the phenological observations, the varieties Uygur, Dessert, Ak-Terek and Pioneer are protogynic, while the variety Osh is protandric.

According to our observations carried out between 2000–2003 of the varieties and forms of walnut grown on the collection and parent plots, Uygur, Dessert, Sharptop, Pioneer turned out to be protogynic, while the variety Osh proved to be protandric. This means that the walnut trees currently growing on the trial plot, resulting from vegetative reproduction, inherited and preserved the properties of the parent trees as far as their type of blossoming is concerned.

4.1.2 Frost-resistance of walnut varieties

In the walnut-fruit forests zone in southern Kyrgyzstan, late Spring frosts are a frequent occurrence and they inflict considerable damage, not only to newly arrived young walnut leaves and blossoms, but also to the shoots of growth of the previous few years. The average date of the last Spring frost is the 23rd of April and temperatures can drop to as low as minus 7 °C. On the trial plots where this research was carried out, the late Spring frosts brought different degrees of damage to the walnut varieties. Varieties such as Uygur, Sharptop, Pioneer or Anniversary were damaged to a smaller degree and resulted in the winterkilling of only the top buds and – partially – of one-year shoots. Their frost-resistance was estimated at 4 points. On the trees of other walnut varieties such as Bomb, Bostandyk, Panfilov, Osh, Dessert, Ak-Terek, Gava, Pecan-like or Ideal, more damage was observed; a larger proportion of one-year shoots was damaged and there was also single damage inflicted to two-year shoots. For this reason, their frost-resistance was estimated at 3 points. The smaller degree of damage inflicted by the frosts to certain walnut varieties can be explained by the fact that the vegetation period of these trees starts later, so they were less influenced by low temperatures. As for the fast-ripening walnut forms, we observed the winterkilling of not only one-year shoots but also of two-year and three-year shoots, and therefore their frost-resistance was estimated at 2 points.

4.1.3 Disease resistance in different walnut varieties

Regularly each year, the fungal disease *Marconina juglandis* infects both the leaves and the fruits of practically all walnut varieties, but to varying degrees. For instance, varieties such as Uygur, Osh, and Pioneer, which are resistant to *Marconina juglandis,* are only slightly damaged and manifest spots of different sizes on their leaves and fruits. However, these spots do not merge. The ability of these walnut varieties to withstand diseases was estimated at 3 points. The trees of other walnut varieties are damaged to a greater degree by *Marconina juglandis,* resulting in necrotic spots of different sizes on the leaves and fruits. These spots merged and covered the larger part of the leaf or the nut. This is why the resistance of these walnut varieties to diseases was estimated at 2 points.

4.1.4 Characteristics of fruiting and yielding of walnut varieties

Of the walnut varieties and forms growing on the trial plots, only varieties such as Uygur, Sharptop, Anniversary, Bostandyk, Panfilov, and Pioneer have the capacity to produce fruit on the top buds as well as on the side buds, which makes them more yielding. Contrary to these varieties, many others are characterized by a low yield level because their fruiting capacity is based on the single shoots formed by the top buds (for instance the walnut variety Dessert).

The fruiting capacity of the fast-ripening walnut forms that grow in the valley zone in an environment of the human-induced irrigation is very good. However, in the walnut-fruit forests zone, the majority of the fast-ripening walnut forms have a poor fruiting capacity, despite the fact that the trees form fruits at both top and side buds. The main reason for this is that many fast-ripening walnut forms have poor resistance to both autumn and spring frosts as far as their one-year shoots and second-year growth is concerned.

The results of the study regarding the peculiarities of the fruiting and yielding of the walnut varieties growing on the collection and parent sites and on the trial plots showed that, based on the criterion of the quantity of nuts collected from one tree, there are three categories; high-yield, medium-yield and low-yield. Of 12 walnut varieties, only three (Uygur, Sharptop and Pioneer) can be deemed high-yield, while the remaining varieties fell into medium- or low-yield categories. It should further be noted that their fruiting is not regular. High-yield walnut varieties whose fruiting is based on the top and side buds were estimated at 4 points, while the varieties whose fruiting is based mainly on the top buds were estimated at 3 points and the walnut varieties with a poor fruiting capacity at 2 points.

As far as the fruiting regularity is concerned, there are the walnut varieties whose fruiting is regular. In productive years, the yield of these varieties is abundant and even in non-productive years they frequently bear fruit. On the other hand, there are varieties whose fruiting is irregular and who only bear fruit in the years that are favourable for fruit yield. Of the observed walnut varieties, those that have regular fruiting are the Uygur, Sharptop and Pioneer, (with the exception of the years with late Spring frost). These varieties were accorded three points, while the other walnut varieties, such as Ak-Terek, Gava and Dessert, characterized by irregular fruiting, were accorded two.

4.1.5 Fruit quality

The nuts of the ordinary walnut forms growing in the natural walnut forest stands are mostly small in size and of poor quality and taste. According to the data provided by SOKOLOV (1949), only 11% of the total yield could be judged to be of good quality, while the remaining nuts fell into the category of small or very small nuts. As far as the shell thickness is concerned, around 80% of nuts have a medium thick or thick shell, while only 20% of nuts are thin-shelled. The average weight of one nut is 8.4 g.

It should be noted that the selected walnut varieties, growing on the above-mentioned sites in Kyrgyzstan, are as good as the best walnut varieties growing in other parts of the world. In Russia, for example, the average weight of the walnut varieties ranges from 11.8 to 16.2 g, in the Ukraine from 13.0 to 15.1 g, in Moldova from 9.9 to 17.3 g, and in Kyrgyzstan from 9.5 to 14.1 g. As far as the yield of kernel from the shell is concerned, the best varieties in Russia are characterized by a kernel yield ranging from 42.6 to 64.3 %, in the Ukraine from 37.6 to 60.4 %, in Moldova from 45.6 to 59.4 %, in the USA from 47.0 to 58.0 %, and in China from 45.7 to 54.1%. Regarding the fat content of the nut kernel, the best varieties in Russia have by a fat content that ranges from 58.5 to 70.2 %, in the Ukraine from 52.0 to 72.7 %, in Moldova from 65.8 to 69.8 and in Kyrgyzstan from 62.0 to 74.0 % (MAMADJANOV 2001).

Table 2: **The fruit quality indicators of the local walnut varieties.**
Tabelle 2: Indikatoren der Fruchtqualität lokaler Walnusssorten.

Morphological properties of fruit	Ak-Terek	Gava	Dessert	Sharptop	Osh	Uygur
Fruit mass (g)	11.8	9.5	12.4	11.7	10.1	14.1
Kernel yield (%)	50.5	50.8	52.2	45.7	54.1	48.8
Fruit size measured by the cross diameter (mm)	32	31	33	34	34	35
Shell thickness (mm)	1.4	1.2	1.1	1.5	1.0	1.5

At present, according to international requirements, the best walnut varieties should have nuts with light yellow kernels, which should make up more than 45.0 % of the total nut and be easily extractable from the shell. The size of the nut – measured at the widest part of the diameter – should be 32 or more mm (CALCAGNI 2004).

As can be seen from *table 2*, the nuts of the local walnut varieties growing on the trial plots meet the requirements of the international standard: the average weight of the nut ranges from 9.5 to 14.1 g; the kernel yield from 45.7 to 54.1% and the size of the nut more than 31 mm. In most cases, the nuts have a thin shell with shell thickness in the range from 1.0 to 1.5 mm. When assessing the walnut varieties by the complex of the fruit morphological properties, (the average weight of the walnut, the difficulty to extract the kernel from the shell, the thickness of the shell, the colour of the kernel, etc.) all local varieties were estimated at 5 points.

4.1.6 Results of the complex assessment of walnut varieties

For the purpose of making the final and complete assessment, identification and selection of the most promising walnut varieties, we now have the data on yielding capacity, fruiting regularity, resistance to spring frosts and diseases and fruit quality of the local and foreign walnut varieties and forms.

Table 3 features the results of the assessment of the local and foreign walnut varieties and forms according to their economically valuable and biological properties. The sum of points was obtained by multiplication of the points of each property with a relevant coefficient. For instance, the Ak-Terek walnut variety had 5 points for the quality of its fruit that were then multiplied by the relevant coefficient, giving it a total of 25 points; the same variety had 2 points with regard to its resistance to diseases and resulting from the multiplication of 2 points by the relevant coefficient, it obtained a total of 8 points, etc. As shown in *table 2*, by adding the points of each property, we eventually obtained the total sum of points for each walnut variety and form.

The best varieties were determined by the highest number of points and forms and were thus easily identified. This kind of assessment makes it possible to identify the most promising walnut varieties and forms for subse-

Table 3: **Assessment of the known varieties and forms of walnut by the complex of biological and economically valuable properties.**
Tabelle 3: Bewertung der bekannten Varietäten bzw. Kulturformen von Walnussbäumen nach biologisch und ökonomisch wertvollen Eigenschaften.

#	Varieties and forms	General assessment of the fruit quality (points)	Yielding (points)	Fruiting regularity (points)	Frost-resistance (points)	Sustainability to disease (points)	Total sum of points	Grade by complex (the average assessment on the features complex)
	Coefficients	***5***	***5***	***4***	***4***	***4***		
Local								
1	Ak-Terek	25	15	8	12	8	68	3
2	**Uygur**	**25**	**20**	**12**	**16**	**12**	**85**	**5**
3	**Sharptop**	**25**	**20**	**8**	**16**	**8**	**77**	**4**
4	Gava	25	15	8	8	8	64	3
5	Dessert	25	10	4	12	8	59	2
6	Pecan-like	20	10	4	12	8	54	2
7	Osh	25	15	8	8	12	68	3
Foreign								
1	Guards	25	10	8	12	8	63	3
2	Bostandyk	25	20	8	12	8	73	3
3	Panfilov	25	20	8	12	8	73	3
4	Anniversary	25	15	8	12	8	68	3
5	Ideal	20	15	8	12	8	63	3
6	**Pioneer**	**25**	**20**	**12**	**12**	**12**	**81**	**5**

quent large-scale reproduction in the walnut-fruit forests zone of Kyrgyzstan from amongst the local and foreign walnut varieties. Clearly, the inherent possibility of a walnut variety and form to realize its potential is, in fact, a proof of its stability and sustainable productivity.

As *table 3* shows, of all the existing walnut varieties and forms the Uygur (85 points), Sharptop (77 points) and Pioneer (81 points) varieties obtained the highest overall score. These are the best varieties, not only with regard to the quality of their fruits, but also regarding their yielding capacity. In contrast to some of the other walnut varieties, they bear fruit on a regular basis and, due to late blossoming, are more resistible to frost and less infected by the disease *Marconina juglandis.*

As for the other walnut varieties, the middle level walnut varieties have the following total sum of points: Bostandyk, 73 points; Panfilov, 73 points; Osh, 68 points; and the Anniversary variety, 68 points. These walnut varieties are inferior to the above-mentioned superior varieties as far as fruiting regularity and resistance to diseases are concerned.

The following walnut varieties and forms obtained the lowest number of points in the assessment: the Dessert variety, 59 points; the walnut form Pecan-like, 54 points; and the fast-ripening forms, 63 points. The variety Dessert, the form Pecan-like, and the fast-ripening walnut forms are characterized by a low degree of resistance to frost, as well as by their poor fruiting and yielding capacity – they bear fruit quite rarely. These walnut varieties and forms might fare better in the environment of human-induced irrigation in the valley zone, as in warmer regions the good quality walnuts could provide good yielding.

Based on an analysis of the data featured in *table 3*, we have every reason to state that the best walnut varieties and forms according to the above-described economical and biological criteria are the walnut forms of Uygur, Sharptop and the foreign variety Pioneer and the most suitable varieties and forms for the soil and climatic conditions of the walnut-fruit forests zone southern Kyrgyzstan. Their average number of points resulting from the assessment by the complex of economically valuable and biological properties is 4 or higher and they are recognized as being the most promising for large-scale industrial introduction in these forests and the recommended species when it comes to the creation of the walnut cultures with high productivity.

4.2 Selection of the new promising forms of walnut

The selection work carried out during a 5-year period (1999–2004) in the territory of the walnut-fruit forests made it possible to select a number of valuable new forms of walnut. The selection of the new walnut forms was carried out by the assessment of existing walnut stands and by information obtained from the local population. The selected walnut forms were assessed by applying the same methods as those employed to assess the walnut varieties growing on the trial collection plots. In the process of selection, the task was to identify the best walnut forms, not only with regard to the quality of nuts, but also with regard to biological properties, such as the regularity of fruiting or resistance to frost and diseases. During the whole period of this work, we selected 17 different walnut forms. Of these 17 walnut forms, 6 walnut forms were selected as the most promising: 3A, 4A, 10A, 11A, 12A and 2K based on the complex of the biological properties (the fruiting regularity, frost-resistance, resistance to diseases) and the economically valuable properties (the yielding, fruit quality). The sum of points resulting from this assessment ranges from 76 to 85 points. These are the best walnut forms, which are characterized by good yields, regular fruiting, resistance to frost, and at the same time, have fruits of good quality. The newly selected walnut forms which are characterized by parameters such as the nut weight of more than 10 g, kernel yield of more than 45,0 %, light yellow colour of the kernel and the easiness to extract the kernel from the shell are not inferior to the known best walnut varieties such as the Uygur, Sharptop, and Pioneer.

Of all the selected trees, the walnut forms 3A, 4A and 11A bear fruits, even in years when late spring frosts occur. Regarding the walnut form 10A, during the florescence period, the blossoming of female and male blossoms coincides and this is why this tree bears fruit on a regular basis. The walnut forms 18A and 3K were selected as these forms have large fruit, with a nut mass of more than 12,0 g. However, contrary to the other walnut forms, they do not bear fruit on a regular basis, while their total sum of points resulting from the assessment of the complex of properties ranges from 67 to 71 points.

The walnut forms 2A, 9A, 15A are characterized by the regular fruiting, good yielding, and resistance to frost. At the same time their shortcomings include thick nut shells, difficult to extract the kernel from the shell, and low yield of kernel.

They therefore reached total points ranging from 67 to 71. Such walnut forms should be used for the purpose of hybridization to obtain new walnut forms or to use the seeds to plant forest cultures for timber harvesting purposes. The walnut forms 7A and 14A, with a total sum of 71 points, were selected as regularly fruiting forms; the walnut form 13A with the total sum of 68 points was selected as one with a thin nut shell; the walnut forms 8A and 17A with the total sum of 63–67 points were selected as fast-ripening forms; and the walnut form 6A with the total sum of 67 points was selected as walnut form with burls.

The selection of fast-ripening species and the species containing burls was never done before, despite the fact that these walnut forms are available in the walnut stands. The fast-ripening forms have a short vegetation period; they terminate the vegetation sooner and are therefore better prepared for the winter period. In the natural walnut forest stands, many trees can be observed which have burls both in the root area and on the stem. The burl timber is highly valued and widely used for production of expensive furniture and artistic goods, for furnishing, etc. The selection and reproduction of the best burl forms are therefore of great scientific significance and practical importance.

Eventually, from the selected walnut forms we singled out the following elite forms: 3A, 4A, 10A, 11A, 12A and 2K, which have the average grade of 4 and 5 points. Forms selected based on individual properties, such as 18A and 3K (large fruit), 13A (thin nut shell), 7A and 14A (regular fruiting), 8A and 17A (fast-ripening), 6A (burl form) and 2A, 9A and 15A (good yielding) all achieved an average grade of 3 points. They obtained passports as the most promising walnut forms. These passports contain the following data: location, description of the relevant tree, the purpose of using seeds or grafts, type of blossoming, and a chart depicting the position of a tree. Copies of these passports were distributed among the local leshozes (forest management enterprises) to be used by them in their work.

5. Conclusions

The best Kyrgyz varieties and forms of walnut are as good as the existing foreign walnut varieties as far as the fruit quality is concerned. However, the mountain climate conditions of the walnut fruit forest belt with spring frosts, high precipitation during flowering period and the fact, that trees often have to endure drought at the beginning of the summer all have an impact on the formation of the walnut harvest. Some special varieties and forms of the walnut differ with regard to yielding capacity, depending on their degree of adjustment to the climatic conditions of the location.

1. The most promising walnut varieties (Uygur, Sharptop, Pioneer) and the selected new walnut forms (3A, 4A, 11A, 10A, 12A, 2A) have been recommended to the state-owned leshozes (forest management enterprises), as well as to the CFM (Collaborative Forest Management) tenants and private gardeners for the purpose of installation of the high-yield walnut cultures and plantations.
2. The walnut forests growing on large areas in southern Kyrgyzstan are characterized by great form diversity. This enables a continuous selection of more and more valuable new walnut forms. The walnut forms selected in the past and singled out as the best walnut varieties, as well as the new walnut forms selected in the recent years, are actually only a part of the best forms of walnut that grow in the natural and artificial walnut stands in the walnut-fruit forests zone.

Summary

The walnut (*Juglans regia* L.) is widely spread in the south of Kyrgyzstan. The cultivated form of this species is planted on farmlands, gardens, roadsides and parks. In the walnut-fruit forest belt where walnuts occur naturally, large cultivated areas are planted with walnut trees by the leshozes. Walnut fruits are harvested both from natural stands and cultivated areas. Weather conditions such as spring frosts, dryness during the summer months and other climatic calamities frequently affect the development of favorable yields. These phenomena are the reason for the varying total yield capacity in the range of few tons to three or four thousand tons per year. Most of the trees found in natural conditions are either low-yielding or not fruitful at all. On average, 100 to 130 kg of walnuts can be harvested per hectare. In order to receive high yields, it is necessary to cultivate in nurseries selected high-yielding walnut species. Selection of high-yielding walnut varieties is a continuous process that plays an essential role in increasing the productivity of the walnut fruit forest stands.

Zusammenfassung

Studie zu Varietäten und Vielfalt der Walnussbaumarten in Kyrgyzstan

Im Süden von Kyrgyzstan ist der Walnussbaum (*Juglans regia* L.) weit verbreitet. Kulturformen dieser Art werden auf Ackerland, in Gärten, an Strassenrändern und in Pärken angebaut. In der Zone, wo Walnussbäume wild bzw. von Natur aus vorkommen, sind grosse Flächen vom Forstdienst mit Nussbäumen bepflanzt worden. Walnüsse werden sowohl von den gepflanzten als auch den natürlich vorkommenden Bäumen geerntet. Witterungseinflüsse wie Frühlingsfröste, sommerliche Trockenheit und andere klimatische Widerwärtigkeiten betreffen häufig die Entwicklung einer guten Ernte. Deshalb fallen von Jahr zu Jahr unterschiedlich grosse Ernten an, und zwar im Bereich von wenigen Tonnen bis zu drei oder vier Tausend Tonnen jährlich. Der Ertrag der meisten Wildformen ist eher gering oder gleich null. Pro Hektare können im Durchschnitt 100 bis 130 kg Walnüsse geerntet werden. Um hohe Ernten zu erzielen, ist es notwendig, ausgelesene, ertragreiche Sorten in Baumschulen zu kultivieren. Die Selektion ertragreicher Sorten ist ein fortlaufender Prozess, der für eine höhere Produktivität der Walnussbaumbestände eine grosse Rolle spielt.

Übersetzung: MARGRIT IRNIGER

Résumé

Étude des variétés et de la diversité des noyers au Kyrgyzstan

Au sud du Kyrgyzstan, le noyer (*Juglans regia* L.) est largement répandu. Il est cultivé dans les champs, les jardins, le long des routes et dans les parcs. Le service forestier a planté cette essence à grande échelle dans l'aire de répartition naturelle du noyer. Les noix sont récoltées tant dans les plantations que dans les peuplements naturels. Les influences atmosphériques telles que les gels printaniers, la sécheresse estivale et d'autres calamités climatiques, affectent fréquemment les récoltes de noix. C'est pourquoi l'importance de la récolte annuelle globale fluctue de quelques tonnes à trois ou quatre mille tonnes. En conditions naturelles, le rendement de la plupart des noyers est faible, voire nul. La récolte moyenne atteint 100 à 130 kg de noix par hectare. Pour obtenir de meilleures récoltes, il s'avère nécessaire de cultiver en pépinière les variétés sélectionnées pour leur rendement élevé. La sélection est un processus continu qui joue un rôle essentiel dans l'accroissement de la productivité des peuplements de noyers.

Traduction: CLAUDE GASSMANN

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