SHORT COMMUNICATION

Influence of ecology factors on the walnut forests of Kyrgyzstan

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ABSTRACT

The article presents data on the importance of walnut-fruit forests in Kyrgyzstan, the protective and ecological role of natural walnut forests. It describes in detail the influence of abiotic factors and the ecology of walnut. In general, the climatic conditions of the walnut-fruit forest belt are favorable for the growth and development of walnut. However, a number of factors such as spring frosts, summer droughts, abnormally high temperatures in summer due to climate change negatively affect the condition and fruiting of walnut. Information is given on the ecological confinement of walnut and the types of walnut forests. Information is given on the influence of biotic and anthropogenic factors on natural walnut forests. Information is given on the influence of major pests and diseases on walnut forests. Due to pests and diseases of the forest, productivity decreases and the condition of walnut forests worsens. Effective biological measures to combat forest pests and diseases are needed. The solution to the issues of preserving natural walnut forests and their biodiversity is of great scientific and practical importance.

***Keywords**:* Abiotic and biotic factors, natural walnut forests, walnut,

INTRODUCTION

In the belt of walnut-fruit forests of Kyrgyzstan, the main forest-forming species is the walnut (*Juglans Regia* L.). Walnut fruits have high nutritional properties, and the wood is of particular value in the production of furniture and other products. Natural walnut forests growing on slopes of various exposures and steepness, perform soil-protecting functions and prevent erosion processes, play a water-protecting and water-regulating role. It is of great importance for the local population as a source of nuts. In the belt of walnut-fruit forests the great species and form diversity of tree and shrub species attracts many researchers and can serve as a gene pool of world significance (Gan *et al*., 1997). The current state of walnut forests is influenced by a number of factors, in particular anthropogenic factors and the influence of other biotic factors such as pests and forest diseases. Due to anthropogenic factors, there is a decrease in forest biodiversity. Besides, damage by pests and diseases worsens the sanitary condition of walnut forests, the productivity of forests and the quality of fruits decrease. Threats to biodiversity are associated with human anthropogenic activity and include habitat change, fragmentation of natural communities due to overuse, overharvesting, environmental pollution and climate change.

In addition to anthropogenic and other biotic factors, the condition of walnut forests is also affected by abiotic factors such as high summer temperatures, drought,

lack of moisture and low temperatures in winter and spring. Due to climate change, in some years there are abnormally high temperatures in summer and abnormally low temperatures in winter, which affect the growth, development and productivity of walnut and other wild trees. Therefore, a strategy to address the complex problem of preserving Kyrgyzstan's walnut forests will have to restore the ecological functioning and productivity of forests while meeting the socio-economic needs of the population dependent on these resources. Restoring walnut forests on non-forest and degraded lands could combine ecological and socio-economic objectives while reducing the pressure on natural walnut-fruit forests.

Influence of abiotic factors on walnut forests

Walnut growing in different microclimatic conditions of the walnut-fruit forest belt has its own ecological features. Walnut is demanding of light, moisture, warmth and richness of the soil. Due to their light requirements, walnut trees in dense plantings occupy the first tier and form narrow crowns (Fig. 1). In natural conditions on slopes of northern exposures in walnut forests, trees have a high trunk and narrow crowns, as they strive for sunlight and perform photosynthesis functions. Walnut trees growing in the wild, where they are illuminated from all sides, form a powerful crown and bear fruit well. The demand for light is confirmed by the condition of walnut crops created under the canopy of old forests, where they have low survival rates (Nikitinsky, 1970).

Walnut grows and develops well with sufficient soil moisture. This is confirmed by the best growth of walnut trees on northern and north-eastern slopes, since moisture is retained in the soil longer at these exposures than at southern ones. We saw that the demand for richness of walnut soils in the fact that they grow better on black-brown soils, which are very fertile. Individual trees and groups of trees can be found on exposed layers of red sandstone. Walnut trees do not tolerate heavy clay and poorly drained soils.

Walnut is a heat-loving species. The optimum temperature for its development is 26-30^0 C (Kolov, 1985). Resistance of adult walnut trees to low temperatures (-30-32 ^{0} C) and slightly lower is possible only during the period of deep dormancy, *i.e.*, the greatest readiness of the protective and adaptive system to withstand cold. In the autumn-winter period, walnut trees are characterized by varying winter hardiness. In early autumn, trees do not have sufficient resistance to low temperatures, as they have not yet completed hardening. By the end of autumn, the hardening of plants is complete, and they can withstand temperatures below -17 ^{0} C without damage. The critical temperature for stamen buds during the dormant period is an air temperature of -21.5^0 C, for apical buds, growth and pistillate growth buds the critical temperature is -22-23^{0}C. After leaving the dormant period, the resistance of trees, and especially the reproductive organs of the walnut, decreases as the activity of physiological and biochemical processes corresponding to this biological rhythm increases (Richter, 1985). A decrease in frost resistance of plants is observed in March, with a significant decrease in April and May. Walnut trees have the least frost resistance during the growth period. When the temperature drops from -1 to -3 ^{0} C, flowers die, and from -4 to -5 ^{0} C, tender spring shoots die. In natural walnut forests and in plantations there are late-flowering and early-flowering forms of walnut, which are distinguished by a shorter

growing season and are less affected by spring and autumn frosts. Depending on the biological characteristics of the walnut, the sum of active average daily positive temperatures preceding the beginning of the phenological phase of opening of bud scales, or the beginning of bud growth, ranges from 900 to 1200^0 C .

The influence of abiotic factors has both positive and negative character. Favorable climatic conditions of the walnut-fruit forest belt, especially not hot summer, relatively mild winter, sufficient amount of precipitation in winter and spring and accumulation of moisture in the soil have a favorable effect on the growth and development of walnut. However, a number of factors have a negative effect on the condition and fruiting of walnut, these are frequent spring frosts, many cases of severe winter frosts affecting the condition of vegetative and generative organs of trees, even shoots and branches of trees are damaged. In the zone of walnut-fruit forests in spring the air temperature often drops to -1-2 ^{0} C, and in some years the air temperature in the second and third ten days of April drops much lower. For example, in 1999, the air temperature dropped to -6.9 ^{0} C in April and these late spring frosts damaged not only young shoots, but also two-three-year-old branches of walnut. Cases of spring frosts occurred in 2003 and 2005, when in mid-April the air temperature dropped to -3, and the frost damaged the blossoming generative and vegetative buds on walnut trees. These late spring frosts are destructive for fruit trees, especially walnuts, the condition worsens and leads to the absence of a nut harvest.

Summer droughts also affect the growth and fruiting of walnuts. In recent years, the maximum air temperature in summer often rises to 40-43^0 C, which causes a lack of moisture in the soil and leads to premature yellowing and drying of leaves, and unsatisfactory fruiting of walnuts. According to long-term data from the Ak-Terek meteorological station (1750 m above sea level), in the belt of walnut-fruit forests, the average amount of precipitation per year is about 1100 mm. From the presented figure 2 it is clear that the distribution of precipitation has a pronounced seasonal character. The maximum amount of precipitation falls in the winter-spring period (November, March-April), and the minimum - in the summer-autumn (August-September).

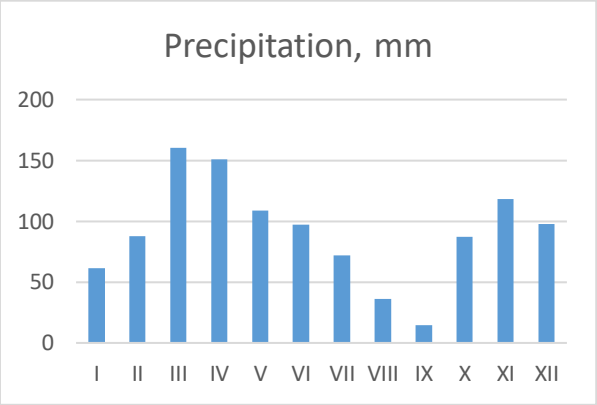

Fig. 2. Average monthly precipitation in the walnut-fruit forest belt (according to Ak-Terek weather station)

The small amount of precipitation in the hot months leads to a lack of moisture in the soil and unsatisfactory growth and fruiting of trees. In some years, there is insufficient precipitation or less than 1000 mm per year and because of this, less moisture accumulates in the soil, which is necessary for plants during the growing season.

Another factor is soil conditions. Walnut grows well on fertile black-brown soils, on slopes with northern exposures, where there is a sufficient humus layer. On other soils, brown and gray soils, where there is less humus and less moisture is retained, there is poor growth and development of walnut trees. On heavy and stony soils, trees need regular watering until late autumn and often become unstable to winter frosts. A decrease in the biodiversity of trees and shrubs in nut plantations leads to a change in the soil structure and the accumulation of moisture in the soil, which has a detrimental effect on the condition of the trees and a decrease in the ecological role of forests.

In early spring, wet snowfalls often cause snowbreaks of trees in old-growth walnut stands, branches and trunks break, and severe winter frosts cause frost cracks (Nurmanbaev, 2008). In snowy years in February and March, snow avalanches are observed on steep slopes, which causes snowdrifts of trees. In the valleys of mountain rivers in spring and summer, mudflows often wash away the banks along with tree and shrub vegetation.

The ecological confinement of walnut allowed researchers to divide natural walnut plantations into different types. Thus, according to previous studies, walnut forests are divided into 14 types (Niktitinsky, 1970). Among all types of walnut forests, the most productive nut plantations are the short-stemmed hazel of gentle slopes. These types of walnut forests have good soil conditions, slopes of northern exposure.

According to research on forest typology (Griza, Venglovsky *et al*., 2008), walnut forests, depending on the different combinations of accompanying species and location, growing conditions, are represented by several types: six clearly distinct types have been identified and their names are presented below.

1. Walnut with short-stemmed grass – type 1
2. Walnut with extra moisture – type 2
3. Walnut with spruce-fir – type 3
4. Walnut with hawthorn – type 4
5. Walnut with maple-apple – type 5
6. Park type walnut forest – type 6

Walnut forests are distributed within the altitude range from 1100 to 2000 (2200) m above sea level and occupy mainly gentle and steep slopes of northern orientation. The distribution of walnut forests up and down the absolute altitude is limited by climatic conditions. The upper limit of natural growth is limited by low air temperatures, the lower limit by insufficient moisture.

At the lower boundary of its growth (1100-1200 м), walnut plantations have an island distribution character and grow in areas with additional moisture. Associated species are usually hawthorn, hackberry, apple; of the shrubs - species of rose hips, honeysuckle, cotoneaster. In the middle part of the belt (1400- 1800 м), walnut forests are dense, highly productive, both pure and mixed. At the upper limit of its distribution (1800- 2000 м), walnut grows with maple, hawthorn, in the shrub layer - Sogdian cherry plum, species of honeysuckle, etc.

Researchers noted that the main object of economic use for obtaining fruits should be short-stemmed hazels of gentle and steep slopes, short-stemmed with additional moisture. In the plantations of these forests, all efforts should be directed at forming well-developed crowns of trees, which will allow obtaining high yields of fruits in the future. Maple-apple, spruce-fir, poplar-ash hazels should be used mainly as protective plantations (Nikitinsky, 1970). However, at present there is widespread use of walnut forests by local populations and all types of walnut plantations are used for economic purposes.

Therefore, taking into account, the forest types and their ecological confinement, it is necessary to take into account the fruit productivity of nut plantations. For example, according to research, the productivity of the short-stemmed walnut on gentle slopes is 174 kg per 1 ha, and the short-stemmed walnut on steep slopes is 4-3 kg per 1 ha (Vinogradov, 1970). According to research on forest typology, the yield of walnut forests has been presented in Fig. 3.

Figure 3 shows that satisfactory yields are observed in Type 1 of gentle slopes and in the Type 2 with additional moisture. In the remaining plantations mixed with spruce, hawthorn, maple and apple, the yield is comparatively low.

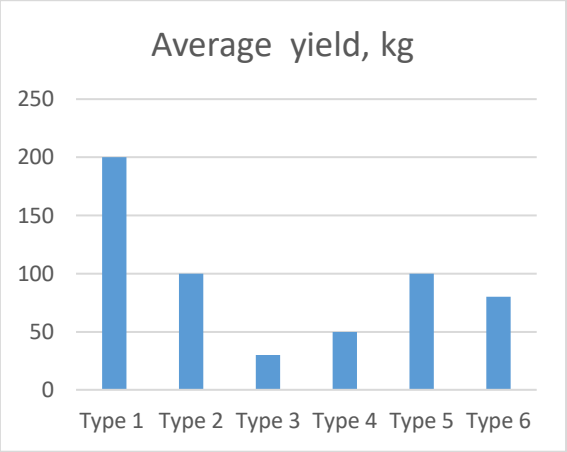

Fig. 3: yield of walnut in different types

It should be noted that the yield fluctuates greatly due to the weather conditions of the year and when determining fruit productivity it is necessary to take into account long-term yield data.

Biotic factors affecting walnut forests

Biotic factors include damage to walnuts by pests and diseases. Walnuts are often damaged by gypsy moths, walnut moths, aphids and other pests. Among the diseases, walnuts are affected by fungal diseases - marsonia , bristly- haired tinder fungus and others. Fungal diseases dramatically reduce the quality of wood. Certain types of stem rot, especially when affecting the sapwood of living trees, lead to their weakening and drying out. Mass development of rot in plantations gradually worsens their sanitary condition. The rate of spread of rot depends on the physical and technical properties of the wood and, mainly, on the biological characteristics of the pathogen, the location of fruiting bodies on the trunk and the number of infection penetration sites. Forest growth conditions also greatly affect the development and spread of fungal pathogens. Climatic factors affect the growth, development, reproduction and spread of fungi. The latter are very demanding of environmental conditions and are usually confined to a certain set of environmental factors.

The main reason for walnut damage by stem rot is mechanical damage to the bark. Intensive temperature increases in the area of walnut-fruit forests in early spring contribute to sunburn of the bark and deterioration of the physiological condition of the tree. Bark damage often occurs at an early age, since the walnut has very thin and delicate bark at this time.

Marssoniasis of walnut (*Marssonina juglandis.* Magn or brown spot): The disease affects leaves, green shoots and fruits. In early or mid-May, small round spots of brown or light brown (later grayish) color with a wide brown border appear on young leaves. The spots often merge. Affected leaves fall off prematurely. Small, sunken, reddish-brown spots form on the ovaries. In damaged areas, the tissue lags in growth, the fruits dry out, crack and often fall off prematurely. Sometimes they rot, the kernel spoils (turns black, dries out) and becomes inedible. Green, non-woody shoots are affected, especially in the nursery.

Bacteriosis of walnut (Xanthomonas juglandis): It affects all varieties of walnut. The disease manifests itself in the form of various kinds of spots on leaves, branches, fruits and inflorescences. On leaves, the spots are small, reddish-brown, often angular. Similar spots are on young branches and fruits. On fruits, the spots gradually increase in size and become brown; later they become depressed and turn black. On young fruits, while the nut shell has not hardened, bacteria can penetrate the kernel, causing rotting. In ripe fruits, the kernel is not damaged. In places of damage, a liquid is released in which bacteria accumulate in large quantities. The pathogen overwinters mainly in the kidneys. The most severe damage Bacterial disease occurs in years with damp and warm springs.

Codling moth (*Sarrothripus muscle* Ersch.). It belongs to the family (Cymbidae). It is widespread in Central Asia and has a great negative economic

significance. The damage to fruits by it reaches 40-50%, and in some areas 80% and more. Nuts damaged by the caterpillars of the first generation fall off completely, the caterpillars of the second generation feed on the pericarp. The fruits have dark spots on the pericarp. To combat the walnut codling moth, use the method of cleaning the peeling bark of trees, removing dried branches.

Gypsy moth (Lymantria dispar L.): The gypsy moth is characterized by pronounced sexual dimorphism: the male and female are very different in appearance. The male has a wingspan of up to 45 mm, with a thin abdomen and feathery antennae; the wings are dark gray or brownish -gray with intermittent dark transverse stripes. The female is almost twice as large as the male (wingspan up to 75 mm) and is lighter in color, with thread-like antennae and a thick abdomen. Life cycle: In the nut-fruit forests of southern Kyrgyzstan and throughout its vast range, the gypsy moth has a one-year generation (Ashimov, 2010). One of the biological control measures against the gypsy moth is the use of the drug Virinensh.

In the Kyrgyz Republic, in works on forest pests, including the gypsy moth, only K.E. Romanenko (according to Ashimov, 2010) has a list of parasites and predators trophically associated with it. A total of 11 species were noted, including the wasps – *Anastatus disparis* Rusch., *Telenomus phalaenarum* Mayr, *Brachimeria intermedia* (Nees), *Dibrachus cavus* Walk., *Pimpla instigator* F., *P. turionellae* L.; *Dermestes lardarius* L., *Malachius bipustulatus* L., *Calosoma sycophanta* L., *Exorista flies larvarum* L. and *Pseudosarcophaga affinity* Fall . The available information is limited to brief data on the biology of parasites and predators, without specifying the degree of infection and destruction of the host at different stages of its development. There is no information on the biology and ecology of most entomophagy, their distribution and numbers in different habitats.

Aphids are a typical common pest that feed on the juice of walnut leaves and buds. Because of this diet, aphids weaken plants and minimize yields. They harm seedlings the most. But they can also have an extremely negative effect on an adult tree, attacking in whole colonies, especially if it has rained. If we do not quickly eliminate aphids, we can lose a significant part of the harvest. We can determine whether a walnut is damaged by aphids by visually inspecting the plant. Such pests look like small, round bodies on leaves and shoots, especially on the back. They can be yellow, light green or black. The presence of aphids is also indicated by a viscous surface of the green mass (insects produce a specific liquid), a change in its usual shape and twisting.

Influence of anthropogenic factors

The condition of walnut forests is also greatly influenced by anthropogenic factors. Currently, the rapid increase in population, expanding the anthropogenic territory due to the growth of settlements in these relict forests, thereby increases the pressure on the forests. And children widespread grazing of livestock due to lack of pastures, haymaking is carried out in the forest (under the forest canopy), high demand for firewood leads to the gradual cutting down of the undergrowth, i.e. shrubs and associated second-tier trees. Research results show that natural regeneration of walnut is very low, young trees do not find enough space for vegetation. These unique forests will have a future if the people living there comply with the standards of their use and protection, and if the political limits of conditions open up a long-term development perspective for the regions.

Various ways of using the forest - collecting nuts and berries, forest pastures, firewood, haymaking and many others - are

integral components of local land use systems. Moreover, these forests are of great importance due to their natural and ecological functions, such as the function of protecting the soil from erosion or the natural water balance. Research has shown that walnut-fruit forests and their products perform a variety of functions for different population groups at different levels. Subsistence concerns and urgent economic interests are currently causing irreversible damage to the forest. For this reason, it is urgently necessary to develop criteria for the restoration, protection and use of unique forests. In doing so, such requirements must be met that are consistent with concern for forest protection. And forms of forest use that are harmful to the forest must be effectively prevented or at least alternatives to them must be identified.

According to forest fund accounting data for 2015 (Anon., 2015), the area of mature and over mature walnut forests is more than 60%, which indicates an increase in old-growth trees in the forest and a deterioration in the condition of natural walnut stands. Effective methods and mechanisms are needed to restore and preserve walnut forests. Failure to comply with and the absence of sanitary and health measures and the difficulties of their implementation in mountainous conditions contribute to the spread of stem and other pests. To a large extent, this is facilitated by the prohibition of sanitary felling and the failure to carry out complex forestry felling of forest care. According to researchers, currently the walnut-fruit forests still have a good chance of receiving the status of a territory recognized by UNESCO as a world heritage site, but if the forest continues to suffer losses, then in a few years or decades these changes will be lost (http://nabu.kg).

SUGGESTIONS

- Taking into account the current state, the prevalence of over mature walnut forests and the lack of natural regeneration of walnut in many areas, it is necessary to pay attention to forest restoration activities and improving the efficiency of silvi-cultural work in the walnut-fruit forest belt.
- When planning forest restoration activities, the ecology of walnut and the ecological confinement of walnut forests should be taken into account.
- The use of more effective biological methods of combating walnut diseases and pests will help preserve the natural environment and obtain organic products that meet international standards.
- Needed to analyze the current state and determine the fruit productivity of walnut forests and plantations in different types and environmental conditions and the impact of climate change.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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