



HOW CAN WE PROPAGATE THE *METASEQUOIA GLYPTOSTROBOIDES* HU ET CHENG?

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ABSTRACT

The Dawn Redwood can be propagated by seed sowing and by vegetative methods. For sowing are used imported seeds, because trees growing in Poland do not give productive seeds. Only the oldest specimen growing in Botanic Garden of Warsaw University, in years when very advantageous weather conditions occur, gives some seeds able to germination. Creation of unavailing seeds depends on many factors. Male flowers usually do not develop and pollination cannot be attained. There is also a lack of specimens in phase of senile growth in Poland. The oldest trees are a little over fifty years old. Very often plants able to propagation are growing separately, what hampers to cross pollination. In 1971 it was advanced hypothesis, that achieving of seeds in temperate climatic zone is impossible because of to short vegetation period for Dawn Redwood. Its vegetation period should have 134 days. It is then longer than by other coniferous trees losing its needles before winter. For example for Japanese Larch it is 115 days, and for Bald Cypress 96 days. Dawn Redwood can be propagate vegetative by hardwood or half-ripen cuttings. Works on this subject were started in England in 1948 and in United States of America. Mother plants were five months old seedlings propagated by seeds brought from China. Vegetative propagation methods are still improved.

Key words: Propagation by seeds, hardwood, softwood and half-ripen cuttings

PROPAGATION BY SEEDS

Seeds of Dawn Redwood should be collected from trees growing in groups, because for its proper creation, cross-pollination must occur [15]. Germination ability is noted on 90–95%, but seeds vitality is very short. After one year of storage germinates 30 till 60% of seeds, after two years 18–24% and after three years its vitality goes down to 1% or seeds are not germinating at all [25].

Seeds do not need any stratification period. Germination starts after 14 days from sowing time, and by seeds soaked in distilled water in temperature 30°C, for 24–48 hours, after 10–12 days [12]. Important factor determining germination is temperature. According to Kuser [16] only few seeds are germinating in temperature of 15°C after 13–22 days. In temperature of 20°C most of seeds germinates after 9 days, and after 13 days already 100%. Very

good notes we can achieve using changing temperatures, lower by night and higher during the day: 15/20°C – from 50 to 100%, 20/30°C – 100%, 20/35°C – 100% germinated seeds after 9–17 days from sowing.

High temperature and humidity of air and soil enforce occurring of soil coming diseases, especially seedlings base canker. By disinfection of soil or seed dressing with fungicides (ex. Penncozeb 80 WP or Previcur 607 SL) development of these pathogens can be reduced.

For sowing is used 1:1:1 mixture of peat moss, coarse-grained sand and perlite, humidity to about 80% of full water capacity. Seeds are sown to the soil by broadcast, quite regular, and covered with thin, 1–2 mm coat of coarse-grained sand. This is made in second half of April or in May in unheated glasshouse or foil tunnel. In heated rooms sowing can be made already in March. Seedlings will grow during vegetation period till 20–30 cm. Sown in May will reach 10–15 cm, and in June– only 3–5 cm.

Tree root system is strongly developed, but roots of young plants are fragile. Because of that replanting of seedlings to the soil putted in 5–6 cm in diameter pots, should be made when cotyledons are fully developed. It is not recommended to use bigger pots, because then root system is developing very intensively and a plant part over the ground level do not grows.

For growing should be used soil having big water and air capacity and rich in organic substances. Young plants should be fertilized in such a way to be well wooden before winter. In first and second year of growing seedlings should be wintered in no-frost conditions. Root system should be protected against frost with wooden dust or straw. Dawn Redwood propagated by seeds its full frost hardiness reaches not earlier than in third or fourth year of growing [12].

PROPAGATION BY STEM CUTTINGS

Dawn Redwood can be propagated by hardwood, half-ripen and softwood cuttings [13]. It allows us to get material genetically identical to the mother plant, what is essential in propagation of countless cultivars.

HARDWOOD CUTTINGS

Propagation of Dawn Redwood by stem cuttings, especially hardwood cuttings, is not much used. For cuttings we choose strong stems, having thickness of pencil or thicker. These are usually two year old stems and older. Minimal length of cutting should be about 20 cm. Term of its collecting are not precisely defined. Proper stems from mother plants are cut from autumn to early spring, always before vegetation starts. Cut on the base of cutting is made with sharp knife just under the pair of buds, because only in this place roots are created. [1, 25]. Cuttings are putted in sandy-peat moss soil in such a way to loose over the soil level only one pair of buds. Rooting occurs in summer months, and till vegetation period end, growth should achieve length of 20 cm [1, 25].

Monteuuis et al. [19] were collecting 6cm length cuttings in January from specially conducted mother plants of different clones, growing in pots. Rooting was occurring in high humidity conditions, in small foil tunnels. Temperature inside of foil tunnels was staying on the level of 20°C, and temperature of soil (vegetative heating) on 23°C. As soil it was used mixture of sand, peat moss and grodane (v:v:v 1:1:1). Period of rhizogenesis took 3 months. On the first days of April rooted cuttings were replanted to the soil filled pots. Percent of rooting was different, was depending on the clone and was 10–70. During vegetation period plants were growing to the height of 40 cm.

Research on defined propagation method were conducted also by Eleršek et al. [8]. Stems were collected on 7th March from twenty-nine year old mother tree. To the date of 4th April they were storing them in the fridge in temperature of 4°C. They were making cuttings on length of 10–21 cm. They were treating them with Seradix B No 1, 2 or 3. Cuttings prepared in such a way were putted in the soil containing 50% of peat- moss, 25% of sand and 25% of perlite. Rooting of cuttings was occurring in the glasshouse. Control cuttings (not treated with stimulator) rooted in only 25, and treated with Seradix B No 1 – in 63, Seradix B No 2 – 48, and Seradix B No 3 in 50 %.

Obdržálek and Pinc [20] recommend taking cuttings between February and March and making an incise on the base of the stems. For hormones addition they recommend water solution of IBA (50 mg·dm⁻³) or 2% preparation in form of powder. Macdonald [18] use 0.8% IBA in form of powder. According to this author cuttings 15 cm length should be made from strong, not too thin stems. Temperature in period of rhizogenesis should be at 21°C. Pokorný [21] informs, that it is ineffective way, because allows us to achieve only 30–40% of rooted cuttings. Other mind is Connor [5]. He achieved about 90% of rooted cuttings already after four months from putting them in the soil. He was using more complicated method of cuttings preparation. He was collecting them between December and January. Cut on pieces length of 10 cm. Disinfected them firstly in chlorine water (15 ppm of chlorine), and then in solution of preparation Consan (200 ppm). After this treatments he was putting cuttings in plastic bag for 30 days in

temperature of 45°F (< 10°C). After this period he disinfected cuttings again in chlorine water and preparation Consan. Then cutting bases were soaked in IBA solution in concentration of 3000 ppm. Such prepared cuttings were putted in the soil being mixture of coarse-grain perlite (90%) and peat moss (10%). Plastic pots were disinfected earlier too. Temperature of surroundings was on the level of about 72°F (21–22°C). Rooted cuttings were replanted after 5.5 months.

HALF-RIPEN AND SOFTWOOD CUTTINGS

First tries of Dawn Redwood propagation by half-ripen cuttings were made on 16th July 1948 in Botanic Garden in Edinburgh. Cuttings length on 10 cm were collected from mother plants propagated by seeds received on 5th January 1948 from China. They were putted in the soil in inspect, in temperature of 18.5°C. First roots were observed on 6th August, so after 3 weeks from date of cutting collecting. Rooted cuttings were moved to warmer inspects, where better root system forming was observed. On this basis was created conclusion, that better for this species would be temperature of 24°C [2]. However Kuser [16] thinks, that to high temperature do not help in radicant. Creech [6] wrote about results of research on vegetative propagation of *Metasequoia glyptostroboides* by softwood cuttings, made in the United States of America. Mother plants were five months old seedlings propagated from first seeds brought from China. Cuttings were collected in August and putted in humid sand. Roots were appearing after three weeks, and after next two weeks cuttings were planted from sand to more fertile soil.

Zan [25] recommends taking of cuttings from half of June. However, he suggests that the most proper term for conditions occurring in Poland is first decade of July. He do not recommends later terms, because cuttings cannot create full worthy buds before winter rest. According to this author cuttings should have length of 10–12 cm and show tendency to branching. They should be shaded in aim to avoid withering. It is recommended to put them just directly in the pots having in diameter 8 cm, filled with peat moss or mixture of peat moss and sand. In places where rooting is made, machines for fog creation should be used. Cuttings should be left at the place where they were rooted until the spring of next year. On the spring we can start transplantation of rooted cuttings.

Currently in American nurseries there are made cuttings length on 8 to 20 cm. There are collected typically softwood stems but also a little wooden stems, with delicate bronzing bark. They use soil composed from 50% of perlite and 50% of vermiculite. For rhizogenesis process stimulation they use popular preparations like ex. Root Tone. Cuttings are putted in multiplates, which are staying in the places with high surrounding humidity [10].

Monteuuis et al. [19] conducted research on Dawn Redwood propagation by different types of cuttings. They researched also additive of exogenous substances stimulating rooting, different ingredients of the soil, and also influence of cut of cuttings base on effectiveness of rooting and root system quality. Cuttings were collected from mother plantings growing in unheated glasshouse, from two growing systems. In first system plants were growing in pots filled with soil composed from 7 parts of composted pine bark and 3 parts of peat moss. Cut of those plants was made in January on about few centimetres over the ground. On the start of vegetation period, mother plants were fertilized with multicomponent fertilizer containing N:P:K 20:20:20. Then, in period of growth leaf fertilization method was used. It was made with fertilizer enriched in nitrogen (N:P:K 28:14:14). In second growing system, called cascade system, cuttings of “n” generation were collected from plants desired for productive plantations (generations „n” – 1). They were grown also in the glasshouse for 10 months in dawn watered ‘Melfert Standard’ polls.

Monteuuis et al. [19] did not found any differences in percent of rooted cuttings collected from mother plantings, from two growing systems. From mother plantings they were collecting different lengths cuttings and as the proper one they have chosen 10 cm length. They showed, that cuttings having only two buds are too weak and for propagation of Dawn Redwood should be collected cuttings with four or more buds. The right term of cutting collection they indicated in June. Transplantation of rooted young plants for further growing they recommended to make after two months or on the spring next year. They have also founded, that place of cutting collection and type of stem used for propagation has important influence on percent of rooting and on renewal of growth of plants after wintering. Cuttings collected from mid-part of the stem were rooting better than from the top part. Also permanent stems showed better abilities for rhizogenesis than falling ones (adequately 90 to 20%). Cuttings rooted from permanent stems, transplanted on the same vegetation season, were renewing growth on the next year only in 45 and transplanted on the spring in 90%. Cuttings from falling stems, though they were showing rhizogenesis abilities, in the next season were not growing.

In research influence of exogenous stimulating substances on roots creation was taken into consideration too. It was showed positive influence of Rhizopon AA, containing 0.5% of IBA, on cuttings rooting effectiveness (76.8%). Using of other substances (0.5% IAA – Rhizopon A and 0.1% NAA Rhizopon B) had no influence on percent of rooted cuttings in comparison with control (adequately 51.5, 59.0 and 59.1%).

In achieved results authors [19] showed important influence of soil type on rhizogenesis process. The smallest quantity of cuttings (38.6%) rooted in 1:1 mixture of melted pine bark and perlite. In the soil containing 2 parts of

peat moss and 1 part of perlite 50% of rooted cuttings were achieved. The best results (77.1%) were achieved using 1:3 mixture of peat moss and perlite.

Incise of cuttings on their base enlarged percentage of rooted cuttings from 36 to 54%. However, authors indicated, that in place of incision roots were not created. Root system of new plants was weaker than not incised plants.

Dawn redwood cuttings started to form secondary roots two weeks after they were transferred into the substrate. Initially groups of cells initiating the process of rhizogenesis, the so-called primordia, differentiated from the cambium. From these cells radicles were generated with a formed apical meristem covered with a calyptra. In the course of root growth the phloem was ruptured followed by the rupture of the phelloderm and phellem, covered by the epidermis. Dawn redwood produced secondary roots from tissues located in the vicinity of the pericycle [14].

DISCUSSION

Dawn Redwood is introduced species, which achieved second step of acclimatization [11]. Young plants may be frost tender, but with age are becoming fully hardy. Seeds should be imported from China and sown directly after their receiving. Fresh seeds are germinating very well, though loose very fast their germination ability. Germination starts after 3–4 weeks from sowing in humid soil (own observation).

For popularization of this species, way of its propagation should be simplified. Smaller technical difficulties makes vegetative propagation than seeds sowing. Because of that, an aim of this work was to elaborate propagation of Dawn Redwood by half-ripen cuttings. Further growing in pots was elaborated too.

Vegetative methods of propagation are used in horticultural production in aim of faster and easier getting of daughter specimens and then, when generative propagation, from some reasons, is impossible. The essence of vegetative propagation consists in reproduction of plants using parts collected from them, such as: stems, leaves or roots [9]. The most important its feature is ability of direct transfer of genetic characteristics from mother plants to their progeny, what cannot be achieved while propagation by seeds. We can receive from one specimen genetically identical progeny, called clone or type [4]. This process is possible thanks to high plants regeneration ability, it means to remake losing plant parts. It concerns especially to quite easy roots formation by stems pieces. This natural and primordial plants ability is used by human in horticultural practice for propagation of cultivated forms by cuttings [23].

Dawn Redwood can be propagated by two vegetative methods: by hardwood cuttings (collected in winter or early spring) and in summer time by half-ripen cuttings [11]. Better results are achieved by half-ripen cuttings propagation [19]. They became an object of research in this work. According to Zan [24] half-ripen cuttings should be collected in mid-June. Hryniewicz-Sudnik et al. [11] reports, that in polish conditions the most suitable term for rooting is first half of July. On the base of earlier reported literature, data term of Dawn Redwood propagation by half-ripen cuttings in conducted experiment was settled on second decade of July.

Effectiveness of rooting of Dawn Redwood half-ripen cuttings depends on their morphological features. This hypothesis has been proved by French scientists team under management of Monteuis [19]. Except of hardwood cuttings they researched a few types of half-ripen and softwood cuttings collected from falling and durable stems. In first group were selected branched and not branched cuttings, with a part of last year wood, so called heel and without it and cuttings made from middle stems (such stems which created no buds on the top, but their morphological structure was the same as ripen stems). To the second group were selected nodal and internodal cuttings collected from main stems. All were 8–10 cm long. Larger number of roots and percent of rooting was achieved from cuttings collected from durable stems. It was almost 90%. Half of rooted cuttings created more than 5 roots. Quite considerable was also part of cuttings with four and three roots. They characterized also the highest percent of growth recovering after winter. Global efficiency in percent of growth in the next year according to the initial count of cuttings was on the level of 75%. On the base of research results was confirmed, that rooting efficiency cannot be enlarged by using heel cuttings.

In conducted own research cuttings were collected only from durable stems: one- and two nodal and apical ones. After statistical analysis of achieved results significant influence of type of cuttings on percent of rooting was not confirmed. However, influence of type of cutting on length of created roots was observed. The best were apical cuttings. By these the longest roots were achieved but with significantly different length. The most equalized length of roots was noted by one nodal cuttings. Such a regularity was observed too: the longest were cutting, the longest roots they created. Taking into consideration only individual and summary roots length, the best should be chosen apical cuttings. Influence of type of cutting on quantity of roots was not synonymous. In research synthesis, statistically the best values had apical cuttings. Only a little worst were two nodal cuttings.

Important aspect of vegetative propagation is creation of striking roots. On the cuttings, primordiums of striking roots are created usually on their base. They can be localized in the nodes, internodes, spiracles and callus tissue developing on the basal part of cutting, too. Root differentiation from callus is occurring by woody plants, which's

cuttings are rooting very hard [7]. Buraczyk and Zakrzewski [4] are reporting, that on the cuttings roots are initiated from callus very rarely. Wound tissue is characterized by intensive development and uses most of food reserves aggregated in cutting, what can have unfavourable influence on root growth.

From information coming from Creech [6] and Białobok [2] publications and from own observation follows, that rooting of Dawn Redwood takes place after expiration of three weeks from putting of cuttings in the soil. Striking roots were growing only from pericycle. It proves, that Dawn Redwood belongs to easy rooting species.

The most important substances regulating process of rhizogenesis are plant hormones from auxins group [3]. Their positive influence on striking roots initiation was known already in the thirties of 20th century [17]. They are counted to so called growth regulators, it means “organic compounds, which in small quantities, excluding trophic working, induce, reduce or in other way affect to processes of growth and development of plants”. Here are belonging endogenous compounds– made by plant, and synthetic compounds too [26].

In conducted research as one of factors was used substance stimulating processes of rhizogenesis. Preparation Seradix B No 1 mixed with Captan Dispersed 50 in volume ratio 1:1 was used. Fungicide additive was protecting cuttings against fungi diseases and taking role of cofactor of active substance – 0.2% IBA. Monteuis et al. [19] showed positive influence of 0.5% IBA (Rhizopon AA) on percent of rooted cuttings. Using of other active substances (0.5% IAA – Rhizopon A and 0.1% NAA – Rhizopon B) had no influence on enlarge of effectiveness of rooting according to control. In own researches much better results were achieved while using growth substance. Using of 0.2% IBA enlarged quantity of rooted cuttings even on 14.5%.

Often in literature different authors recommend incision of basal part of cutting by cutting out of a piece of a narrow strap of bark exposing cambium. This operation has in aim better cuttings rooting, having not influence on their wholesomeness. Positive influence of incisions on cuttings rooting lies in that, that cuttings are taking water and growth substances easier. On better rooting of cuttings wounded on the base can have influence also creation of so called wound hormones [3]. In experiment of Monteuis et al. [19] was made 1 cm longitudinal incision of cuttings on the base of last internode. Positive influence of this operation on percent of cuttings rooting was observed. For hardwood cuttings an operation of incision enlarged percent of rooted cuttings from 24.2 to 40.3 and for half-ripen from 36 to 54. However, there was often noted, that striking roots were not created in zone of incision.

From own observations results, that incision of cuttings had negative influence on percent of rooting, especially the one nodal ones. Also two nodal cuttings reacted negative on this operation. Only apical cuttings reacted positive, but this tendency was very poorly marked. An operation of incision had no influence on roots length by one nodal and apical cuttings. Only two nodal cuttings were creating longer roots. Incision of cuttings base had different influence on quantity of created roots. Poor influence of operation on rooting process, together with enlargement of work consumption, decides on that, that it is not recommended while Dawn Redwood propagation.

Monteuis and his research team [19] were determining influence of type of soil on percent of rooted cuttings. The best results (77.1%) they achieved using mixture of peat moss and perlite (1:3). In mixture of peat moss and perlite in volume ratio 2:1, 50% of rooted cuttings was achieved. In mixture of melted pine bark and perlite (1:1) they achieved only 38.6% of rooted cuttings.

In own research for rooting of Dawn Redwood was used soil characterized by good air-water volume, light and permeable. It was mixture of peat moss and perlite in volume ration 1:1. Thanks to this soil achievement of almost 100% of rooted cuttings was possible.

Monteuis et al. [19] were replanting plants directly after root formation. They noted, that roots are very delicate and sensitive on unfavourable environment conditions, especially on water stress and intensive operation of sunbeams. Too excessive shading enforces development of fungus *Botrytis cinerea*. It is good to make suitable microclimate in closed chambers. After 2–3 weeks from planting of Dawn Redwood, when roots will grow through the soil, plants can be hardened. In such conditions they can initiate growth before winter. Cuttings replanted too late, though acclimatization, will not initiate growth on the spring. In France 90% of cuttings planted in October has not initiated growth. Similar situation can take place, when plants are propagated by cuttings made from falling stems. Zan [25] warns against planting in autumn. Recommends leaving of rooted cuttings until spring or putting them while propagation directly into 8 cm in diameter pots.

Further Dawn Redwood growing should be compatible to its environment requirements. Mineral-humus, very fertile and not too heavy soil should be used. It should be humid all the time and evenly. This species requires sunny positions. Plants about 1 meter high can be admitted to be fully hardy on frost [11]. Zan [25] shows, that about 30% of cuttings is growing quite shrubby. In aim to stop it, one of parallel apical stems should be removed. Stems competing with leading stem, can be used to make half-ripen or hardwood cuttings. This operation should be done in second year of growing.

CONCLUSION

Dawn Redwood may be propagated by sowing of seeds or by vegetative methods. Imported seeds are used in sowing, since trees growing in Poland do not yield fertile seeds. Only the oldest tree growing in the Botanical Garden of the Warsaw University, in the years of especially advantageous weather conditions yields scarce seeds capable of germination (Dolatowski – oral communication). The formation of sterile seeds is dependent on several factors. Male flowers frequently do not develop and pollination does not take place [11]. Moreover, there are few trees in the senile growth in Poland. The oldest trees are slightly over fifty years old. Frequently plants capable of reproduction grow singly, which makes cross-pollination difficult [19]. Moreover, Stephan [22] hypothesized that obtaining seeds in the moderate climatic zone is impossible due to the short vegetation season of dawn redwood. Its vegetation season should be 134 days. It is longer than that of coniferous plants shedding needles in winter. For example for Japanese Larch it is 115, while for Bald Cypress – 96 days.

Dawn Redwood may be propagated by vegetative methods using hardwood or half-ripen cuttings. Studies on this method were initiated in 1948 in England [2] and in The United States [6]. Maternal plants were 5-month old seedlings obtained from seeds imported from China. Methods of vegetative propagation are being constantly improved.

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