Problems of Regeneration of Juniperuspolycarpos C. Koch in the Forests of Iran

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Introduction

Juniperus polycarpos C. Koch is an important tree on south slopes of the high mountains of Elburz and in the northern parts of Khorassan and Arassbaran of Iran. It is also distributed in some of the central mountains of that country. The natural forests of Juniperus polycarpos occur as open woods of scattered trees (Figs. 1 *and* 2). This species is important in soil protection, and it is very resistant to frost, growing in some areas where the minimum temperature reaches —35° C. Juniperus polycarpos is also relatively drought resistant. The open forests result from two main causes: serious lack of regeneration and excessive use by man and cattle. If preventive measures are not taken soon, these forests will disappear entirely. Most of the trees remaining in these forests today arise from suckers and collar shoots.

The absence of natural regenerqtion is the most important problem in these Juniperus forests. Much of this problem is due to the unusually high proportion of hollow seeds produced. In fact, the virtual absence of sound seed therefore prevents artificial regeneration of these forests. On the other hand, it will be possible to obtain sound seeds, and hence carry out artificial regeneration in these *Juniperus* forests, by using artificial pollination techniques.

Sexuality

J. polycarpos is generally dioecious, but sornetirnes it is pseudomonoecious. All of the female trees lack male cones (Fig. 3), but male trees sometimes bear a few female cones.

Fig. 1. — Typical form of Juniperus polycarpos, the most important tree on south slopes of the Elburz mountain range.

Fig. 2. — Degraded stand of Juniperus polycarpos on south slope in Elburz mountains.

Seeds

Based on dissections of many fruits, the number of seeds per cone was most frequently, 4 or 3, ranging from 2 to 7.

Seeds per Fruit Number	Fruits Percent
2	9
3	27
4	45
5	14
6	14
7	1

Pests

Fifty-eight percent of fruits were attacked by insects[1]) (butterflies). This was determined only by the exit holes on mature fruits; the larvae of these insects feed only on the fleshy parts of a fruit and are apparently harmless to the seeds themselves; no larvae were found in the cut seeds. Only Megastigmus occurred in the seeds, but did not cause extensive damage.

Problems *of* germination

Attempts to germinate seeds of Juniperus *polycarpos* are often unsuccessful. This is not surprising, because our first observations have shown that, except for perhaps one percent, the seeds are hollow. Hollow seeds may results from many causes, such as: insect attack; sterile pollen; sterile ovules; asynchronous maturation of male and female flowers; and unsuitable climatic conditions for fertilization (which could bring about incomplete pollination).

Insect attack, as previously considered, is probably not very important. Examination (cutting tests and x-ray) of

[1]) Talegan, near Karadj 1970, 71, 72.

Fig. 3. — Fruiting branch of *Juniperus polycarpos*.

seeds of attacked and unattacked fruits showed that, although the seeds were apparently sound, they were in fact all hollow. Sterile pollen or sterile ovules do not explain empty seeds, because artificial pollination leads to full seeds. It is very difficult to assess the importance of male-female flower timing. The female flowers appear in early spring. Often the ovules are exposed for 10 to 12 days, after which the cone scales close, precluding further pollen entrance. During this time it is not certain how long the ovules are receptive to pollen or vulnerable to fertilization. The male strobili have been formed since the previous summer but pollen release does not ordinarily occur until a few days after the female strobili become receptive. In general, the conditions of pollination are not as suitable as is observed among pines. Variation of climate during the past epochs may be considered. This factor can act in two main ways:

(1) temperature may change the duration of the naked state of ovules and opening of male cones, therefore causing some problems in high and low temperatures; (2) humidity and fog may change the condition of fertilization. Drops of moisture have been observed in early morning on the orifices of ovules. This moisture could facilitate the entrance of pollen. Perhaps the natural climatic conditions of these trees were more humid and temperate in past epochs. The actual climate of *Juniperus* forests on the south slopes of Elburz is cold subarid.

Artificial pollination

Sound, full seeds have been obtained by artificial pollination. Male branches were cut and placed into plastic bags and then forced in water at 25 to 30⁰ C. Within 24 hours the cone scales opened and released their pollen. At this time the female flowers were appearing in natural forest where the mean daily temperature was approximately 8 to 10⁰ C. Pollen was applied by a sprayer to the end branches of female trees bearing many female flowers. It was important to apply the pollen in the early morning when moisture drops were present on the ovules. This was repeated on the same branches every three days until the female flowers began to close.

To prevent any damage by insects we covered these pollinated branches with a net. Mature seeds were not obtained until the autumn of the scond year. In this way we were able to obtain many seeds. The methods here discussed can be very useful and important in producing seedlings for afforestation.

Discussion and Conclusion

At the present time, artificial pollination seems to be the only way of producing sound seeds of *Juniperus polycarpos* in Iran. The following practices are recommended for carrying out artificial pollination:

1. Force male branches in water.
2. Use very fresh pollen, as soon as possible after it has been shed.
3. Carry out pollination in early morning while drops of moisture are present on the orifices of the ovules.
4. Choose female trees in fairly dense stands; the microclimate tends to be more moist there than in open stands.
5. Choose branches on the shaded north side of the crown.
6. Cover the pollinated branches with light netting to prevent insect attack and to catch the mature fruits.

The quantity of pollen required for artificial pollination depends upon the method of pollination, the number of female trees per hectare, the diameter of the crown of the female trees, the stability of the air, and other factors. Generally, a male branch 30 to 40 cm long will produce one to 2 grams of pollen. This is an adequate amount to pollinate the ovules on more than fifteen 30 to 40 cm female branches. A typical female branch of that size will contain 50 to 100 strobili.

It is hoped that the method of artificial pollination described here will be useful in producing the amount of sound seed needed for artificial regeneration of existing forests and for afforestation of non-forested areas. It is also hoped that this method will be useful in the production of trees for ornamental purposes.

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Abstract

Juniperus polycarpos covers about 1.2 million hectares in the high mountains of Iran. Little or no regeneration occurs in these forests; hence they may eventually disappear. Our research showed that almost no filled seeds are produced naturally. Artificial pollination, on the other hand, is effective in producing sound seeds. Damage by insects, especially *Megastigmus,* was not found to be an important factor causing empty seeds.

Keywords: Artificial pollination, Iran, Juniperus, seeds.

Zusammenfassung

Juniperus polycarpos kommt auf großen Flächen in hohen Gebirgslagen im Iran vor. Seine Regenerationsfähigkeit ist jedoch nur sehr gering, so daß er möglicherweise dort einmal ganz verschwindet. In der Natur produzierte Samen sind meist hohl. Bei künstlicher Bestäubung werden andererseits gesunde volle Samen erhalten. Mit solchen Methoden will man deshalb jetzt Jungpflanzen für Aufforstungszwecke anziehen.

Natural Hybridization between Pinus edulis and Pinus monophylla in the American Southwest[1])

By RONALD M. LANNER[2])

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Introduction

Pinus monophylla TORR. & FRÉM. is a semi-desert pine typical of the Great Basin but extending southwards into Baja California and southeastwards across Arizona into New Mexico. Its close relative, *P. edulis* ENGELM., is a widespread species of the Colorado Plateau and southern Rocky Mountains. Because they produce edible nuts known as *piñones* in Spanish, they are popularly called "pinyon pines". Outlying populations of these species are sympatric in several locations. Neither species deeply penetrates the range of the other, but the long interface provides an opportunity for gene flow between them.

The possibility that these species hybridize in nature has been briefly raised by several authors. COLE[3]) compared a population of *P. edulis* and one of *P. monophylla* with putative hybrids from central Utah. He showed leaf resin canal number to be intermediate in the presumed hybrids and postulated that hybridization had occurred along a Great Basin ecotone. The trees in COLE's hybrid ecotone were initially identified by the coexistence of 2-needle fascicles and 1-needle fascicles on the same shoots. He assumed the frequencies of these fascicle types to be about equal.

CRITCHFIELD and LITTLE (1966) stated cautiously that the species "may occasionally intergrade". MIROV (1967) speculated that these pinyon pine species "possibly intercross", and urged controlled breeding experiments to settle the question. MANSFIELD-JONES[4]) studied morphological variation in pinyon pines in southwest Utah in an attempt to correlate species distribution with environmental parameters. He referred to intermediate trees as "intergrades" but did not postulate a hybrid origin for them. One feature of the intergrades was the simultaneous occurrence of 1-needle and 2-needle fascicles on the same shoots.

Two recent reports from this laboratory (LANNER 1971; LANNER and HUTCHISON 1972) have discussed the distribution of putative hybrid pinyon populations in parts of Utah, but evidence of hybridity has been deferred to this paper. The objective of this study was to define the extent of natural hybridization between *P. edulis* and *P. monophylla*.

The Study

Major emphasis has been placed on geographic variation in the frequency of monophylly, i. e. the single needles that characterize *P. monophylla*. These single needles had been thought to develop following the abortion of one of a pair of needle primordia (DOAK 1935), but recent work shows that only one needle primordium is formed (GABILO and MOGENSEN 1973). Because of its extreme rarity elsewhere in the approximately 100 species of *Pinus*, monophylly is regarded here as the result of a mutation of unique value as a genetic marker. It is assumed that this mutant form has had a single origin during the evolution of the pinyon pines.[5]) For this reason, the single-needle pines of central Arizona, long considered to be *P. monophylla* but recently described as a variety of *P. edulis* by LITTLE (1968), are included here within *P. monophylla*.

Single-needle fascicles are found in F_1 progeny of the artificial cross *P. monophylla* × *P. edulis*, produced at the Institute of Forest Genetics, Placerville, California. Sixth-year shoots of three such hybrids were kindly supplied by Dr. W. B. CRITCHFIELD. Foliage of 10 shoots had 49.7 percent 1-needle and 50.3 percent 2-needle fascicles. Sample size was small (233 fascicles), and the shoots had variable frequencies of 1-needle fascicles. By contrast, foliage from 5 wind-pollinated seedlings of each of the 2 maternal parents was purely 1-needled (571 fascicles examined); and shoots of the 3 *P. edulis* parents contributing to the pollen mixture had only 1 monophyllous fascicle of the 688 examined. These findings demonstrate the heritable nature of monophylly.

A second valuable leaf character is the number of leaf resin canals. This quantitative character has not been widely used in studies of natural hybridization, perhaps because closely related species usually have similar numbers of leaf resin canals. But whereas *P. edulis* has a very stable and low number of resin canals, *P. monophylla* shows

[1]) Research supported under the McIntire-Stennis Cooperative Forestry Research Program and published with the approval of the director of the Utah Agricultural Experiment Station as journal paper 1767.

[2]) Associate Professor of Forest Science, Utah State University, Logan, Utah, 84322.

[3]) COLE, FRANKLIN R. 1965. The pharmacognosy of Utah pinyon pines. Ph. D. Thesis, University of Utah.

[4]) MANSFIELD-JONES, G., Jr. 1967. Environmental sorting of sympatric pinyon species in southwestern Utah. Ph. D. Thesis, Duke University.

[5]) MCCORMICK and ANDRESEN (1963) reported 5 percent of 1-needle fascicles in *P. cembroides* ZUCC., Mexican pinyon, in the Chiricahua Mts., but no mention is made of a requirement that needles be cylindrical to avoid counting fascicles that have shed all but 1 needle. I have examined a much larger sample of Mexican pinyon fascicles from several southeastern Arizona locations without finding any bona fide 1-needle fascicles.