

Mechanized Pollen Harvesting in Larch Seed Orchards

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In French seed orchards, artificial pollination is being developed for mass production of seed of hybrid larch (*Larix eurolepis* Henry). A mechanized pollen harvester is currently used to collect large quantities of pollen directly from grafts. A hinged Plexiglas® tank carried at the front of a tractor is shut around the tree and pollen is shocked out of the male strobili. Bursts of air cause semirigid plastic tubes inside the tank to whip the branches, releasing the pollen. Then the pollen is sucked into the filtration unit at the rear of the tractor. This harvester has been operating satisfactorily since 1988. In a good flowering year (1992), it collected on the average of 145 g (5.1 ounces) of pollen per hour, which represents the output of 10 male-catkin pickers. Moreover, this machine also proved quite efficient in a Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seed orchard. Tree Planters' Notes 44(4): 141-145;1993.

Hybrid larch (*Larix eurolepis* Henry), well known for its high growth potential (Bastien and Keller 1980), is insufficiently used in tree planting efforts in Europe because of a lack of seeds. To obtain adequate quantities of seeds, seed orchard managers must make special efforts.

Hybridization seed orchards of larch present specific problems because there is generally a poor match of flowering times between many of the clones of European larch (*Larix decidua* Mill.) and Japanese larch (*L. leptolepis* (Gord.)) used for the production of hybrid seed (Philipson 1990). In France, a 2- to 3-week phenological lag between the two species prevents effective wind pollination and compels the managers to use artificial hybridization. This requires successful completion of the following steps: (1) harvesting pollen of the Japanese larch clones used as male parents, (2) drying, processing, and storing this pollen, and (3) pollinating the European larch clone.

As far as pollen harvesting is concerned, the usual method consists of picking the male strobili manually from the grafts. However, this technique is time-consuming if one considers that the pollination of 1 ha (2.47 acres) of seed orchard requires the collection of several kilograms of pollen and, therefore, several hundred thousand strobili. To save time it is possible to cut flowering branches, but as larch bears its flowers on branches that are at least 2 years old, this prun-

ing results in the elimination of potentially flowering branches for future years and does not seem compatible with a sustained level of production. Besides, extraction of pollen from big volumes of branches is not easy.

Our solution is to collect the pollen directly from the grafts and to mechanize this operation in an attempt to reduce its cost (Philippe and Baldet 1992). Contrary to Jasumback (1991), who reported about a cyclone dust collector, we use a tractor-mounted harvester that has been operating satisfactorily since 1988. After a technical description of the machine, results from the five last harvesting campaigns will be reported.

Description of the Harvester

The pollen harvester, carried by a 75-horsepower agricultural tractor, operates according to the common concept of a dust collector. It consists of two main parts: (a) a tank designed to encompass the tree to be harvested and (b) a rear unit combining the components for suction, pollen filtration, and pneumatic energy production (figures 1 and 2).

The harvesting tank. The tank is hexagonal, because laboratory tests have proven that such a shape reduces the centrifugation phenomenon, in which pollen is lost because it sticks all around the lower part of the tank. The metallic frame, 2.5 m (8 feet) wide and 3 m (10 feet) high, is covered with transparent polycarbonate panels (Plexiglas®), 4 mm ($\frac{1}{6}$ inch) thick. This material gives the driver good visibility, and its me

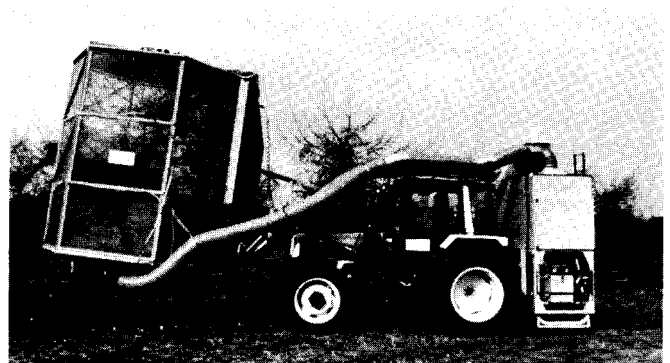


Figure 1—General view of the pollen harvester.

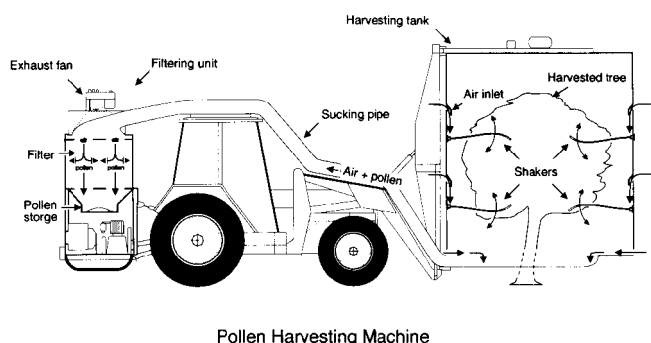


Figure 2—Functional diagram of the harvester.

chanical properties enhance the rigidity of the tank. The tank can be moved vertically—as high as 3 m (10 feet) from the ground—and forward and backward in order to fit the morphology of each graft. It is made of two identical halves that can be opened and shut by pneumatic jacks. Because of air compressibility, shutting the tank does not damage the shoots that may stick out of the tank.

As soon as it is closed, short blasts of compressed air (1 to 2 seconds each) are blown through 12 semirigid plastic tubes fastened on the lateral walls. Under the effect of air pressure of 8 to 10 Bars (120 to 150 pounds per square inch) these tubes whip the tree vigorously, so that it releases its pollen. Then, pollen in suspension within the tank is immediately sucked in through four holes (20 cm (8 inches) in diameter) located on the floor and forced by air to the filtration unit.

Larch pollen naturally carries a static charge and adheres strongly to any surface it comes into contact with. Therefore, the tank is equipped with four levels of inlet slots—total length = 30 m (98 feet), width = 3 mm ($\frac{1}{8}$ inch)—that are set along the horizontal parts of the metallic frame and fitted with deflectors that guide the outer air down along the walls and thus prevent pollen deposition.

Pollen transport toward the filtration unit. The pollen is pulled into two flexible pipes 250 mm (10 inches) in diameter. Their internal ringed surface generates microturbulences that prevent pollen deposition. Flow rate and average speed are 4,000 m³/hr and 35 km/hr (22 miles per hour), respectively.

Filtration. Considering the great volume of air that must be treated per unit of time and the fragility of pollen, the machine is provided with a large filtration surface. Its size has been calculated so that the air

flow speed does not exceed 10 cm/sec (4 inches per second) when it reaches the filtering material.

The filtration surface consists of 11 cylindrical filtration sleeves, 1 m² each, tightened vertically. The air flow enters each sleeve through the upper aperture, in a parallel direction to the filtration surface. This process helps minimize the risk of pollen injury, as well as the risk of siltation. Filtration sleeves are made of a tissue used in flour-milling for the sifting of different kinds of flour. The tissue has a mesh size of 35 μm, porosity of 35%, great dimensional stability because the warp and the weft threads are welded together, and anti-siltation properties because the tissue is made of single-stranded nylon provided with a very smooth surface.

After separation from the air flow, the pollen grains fall down to the bottom of the filtration sleeves. There stands a conical hopper ending in a drawer-like receptacle, made of transparent polycarbonate, where pollen is finally collected. Filtration sleeves, hopper, and receptacle are subject to the action of a pneumatic vibrator, which contributes to quick and complete pollen recovery.

Machine Output

Description of the seed orchard. The machine has been tested in a small experimental seed orchard consisting of alternating rows of European and Japanese larch. Grafts were planted in 1976, at 5-m (16-foot) intervals. In 1992, the average tree was 3 m (10 feet) high and 2.5 m (8 feet) wide. The most vigorous grafts have been pruned in order to fit the tank of the machine (figure 3).

Pollen harvesting concerns only Japanese larch. Respectively 70, 115, 127, 72, and 123 grafts were mechanically harvested in 1988, 1989, 1990, 1991, and 1992.

Results of the 1988-92 mechanized harvests. The mean amount of pollen harvested per graft from 1988 to 1992 was, respectively, 1, 4, 10, 3, and 14 g after sifting and drying at 5 to 7% moisture content (figure 4). These quantities may seem low for someone who is not accustomed to larch, but we must emphasize that larch species are poor pollen producers. Annual variations of pollen crop are mainly due to flowering intensity and, to a smaller extent, to climatic conditions during pollen shedding and increasing age of the orchard.

Though most of the crop is collected in the form of pollen, male catkins are also released when whipping the trees. In 1990 and 1992, pollen extracted from these strobili represented 20% of the total crop (figure 5).



Figure 3—Size of a vigorous Japanese larch graft after pruning.

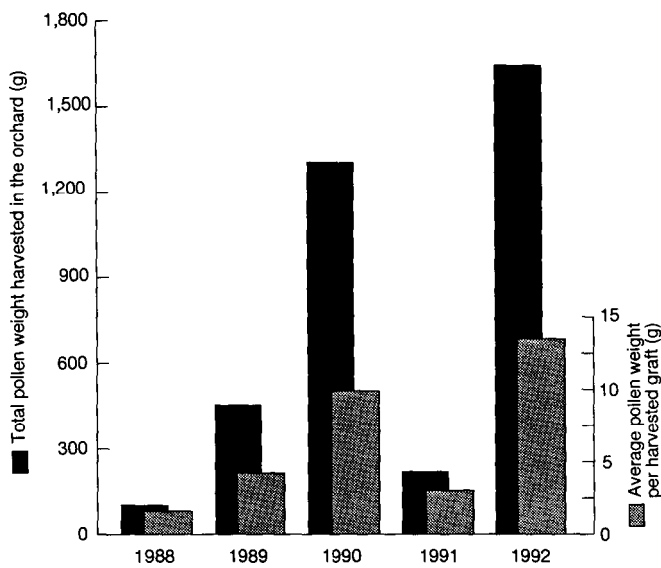


Figure 4—Amounts of pollen harvested mechanically from 1988 to 1992.

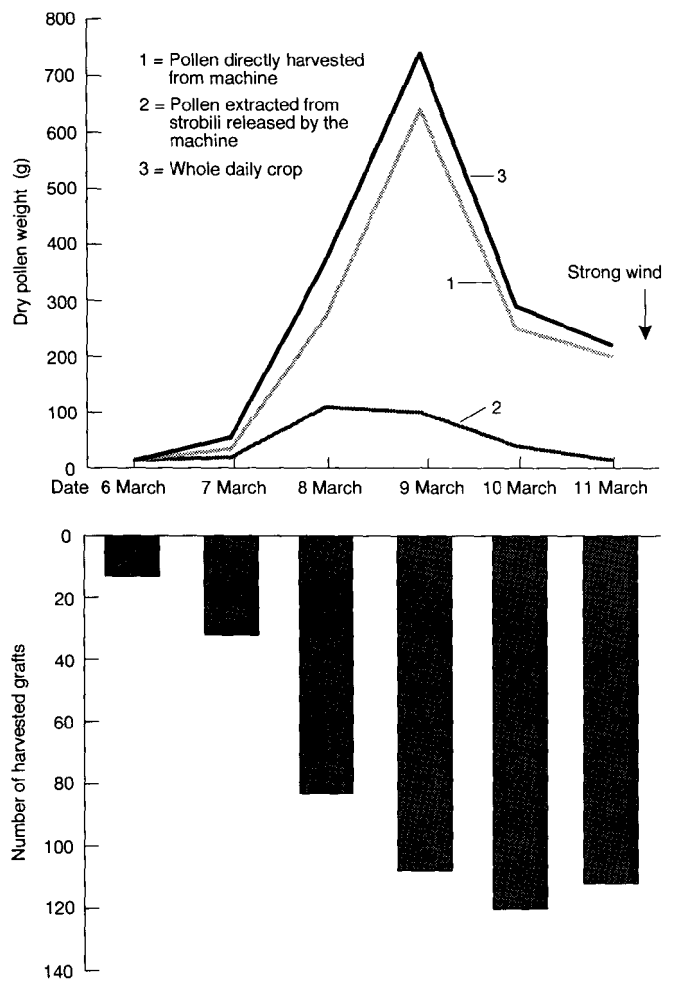


Figure 5—Amounts of pollen and numbers of grafts harvested mechanically each day in 1992.

Part of the pollen potential actually collected. The pollen potential was determined in 1992 (a very good flowering year) in three steps:

1. Assessment, from the ground, of the number of male strobili present on all the grafts to be harvested mechanically, i.e., 123 grafts (from 54 clones, 1 to 7 ramets per clone). The average production was estimated as 3,300 strobili per graft (minimum = 1,000 strobili; maximum = 15,000 strobili).
2. Estimation of the accuracy of field assessment by picking manually all the strobili on a sample of 10 grafts (from 7 clones) and determining the actual number of strobili produced by each of these grafts. It appeared that the field assessment re-

sults underestimated by 30% the actual number of male flowers. Therefore, the actual potential of the 123 grafts harvested mechanically was estimated to be 4,700 strobili per graft.

- Measurement of the pollen production per strobilus on the 10 sampled grafts. It averaged 7 mg per strobilus (minimum = 5.8 mg; maximum = 10.1 mg).

Finally, we concluded that the pollen potential of the grafts harvested mechanically in 1992 averaged 33 g (1.2 ounces) per graft (7 mg/strobili x 4,700 strobili/graft). This indicates that the mean amount of pollen harvested per graft (14 g, or .5 ounces) represents 40 to 45% of the potential, the rest being shed in the wind.

Working time. On a seed orchard scale, pollen harvesting is generally completed in about 1 week. In 1992 for instance, it lasted 6 days and 95% of the crop was collected in 4 days, from March 8 to March 11 (figure 5). Each graft is harvested 4 to 5 times (once or twice a day) to reduce pollen losses due to the wind. Data collected on 40 grafts during the peak of pollen shedding in 1992 indicate that each pass requires 1.5 min on the average (90 sec on March 8 and 9, 60 seconds on March 10). This time includes travel between trees, tank positioning, and actual pollen harvesting (figure 6).

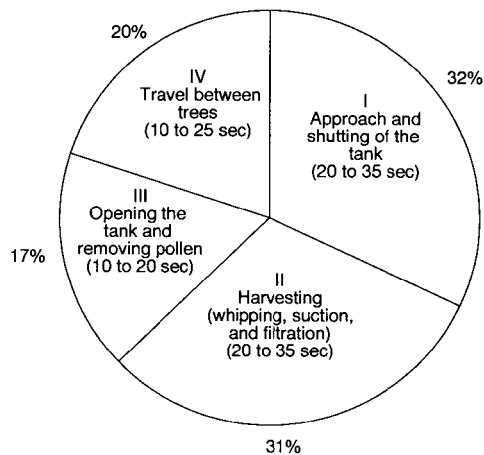


Figure 6—Breakdown of the running times of the pollen harvester.

Driving the machine requires only one operator, and no ground person is needed to position the harvesting tank. Still, the help of an additional worker who identifies and points out beforehand the grafts ready for harvesting proves useful.

Comparison of mechanized and manual pollen collection. In 1992, 10 grafts were harvested manually by picking male catkins to compare yields obtained by manual and mechanical techniques. Results confirm that flower picking is time-consuming: one worker collected on the average 2,000 catkins per hour—close to 14 g (.5 ounces) of pollen after extraction—whereas the machine harvested 145 g (5.1 ounces) of pollen during the same time.

Moreover, manual collection of all the strobili on a seed orchard scale seems unrealistic because it would demand too many pickers. In 1992 for instance, each hectare would have required 17 workers on the average (hypothesis: 400 grafts/ha, 4,700 strobili/graft, 2,000 strobili picked/worker/hr, and duration of harvesting 1 week). In addition, as strobili must be picked up as near as possible from the pollination time to avoid risk of collecting immature pollen, the actual number of workers should be much more important at the peak of pollination.

Pollen quality. In vitro viability assays (conductivity and germination) indicate that pollen quality is good. Moreover, mechanically harvested pollen has been routinely used in pollination for 3 years and it has resulted in normal seed yields. These results confirm our opinion that mechanical harvesting is not harmful to the pollen.

Discussion

The pollen harvester provided the evidence of its capacity to collect quickly large quantities of pollen with only one operator. Furthermore, the fact that the machine harvests mainly pollen, like the cyclone dust collector, and few strobili (figure 5), offers two additional advantages over male-flower picking: (1) costs related to pollen extraction from the strobili are greatly reduced and (2) risks of collecting immature pollen may be less important.

However, some restrictions inherent in this technique must be pointed out:

Its success depends on the atmospheric conditions prevailing during pollen shedding. Rainy weather

prevents harvesting because most of the pollen grains will stick to rain drops in the tank, the sucking pipes, and the filters. This is a problem that is common to many pollen collection techniques.

- Pollen losses due to the wind represent a significant part of the orchard production, as noted above. In this respect, it would be interesting to compare in a larch seed orchard the cyclone collector and our harvester, taking into consideration both pollen quantity and quality.
- It is obvious that the size of the grafts must be compatible with the tank size. Periodic pruning is, thus, imperative. Though we have no data about the effect of pruning on pollen production, height and width control may be considered as a serious disadvantage because small trees (3 to 4 m (10 to 13 feet) high) have a lower flowering potential than unpruned trees. However, the economical feasibility of harvesting adult trees by climbing has to be considered too. In that respect, the cyclone collector seems advantageous because it allows the operators to reach 7 to 8 m (25 feet) into a tree's crown (Jasumback 1991).
- Spacings must be adapted for easy driving of the machine inside the orchard. Positioning represents indeed 50% of total working time in our 400 grafts/ha seed orchard, which appears too dense. Cost effectiveness of the harvester would be improved with spacings of 8 m (26 feet) between rows and 6 m (20 feet) within the row.

Nevertheless, these restrictions are of no importance in the case of indoor seed orchards designed to produce pollen from small potted grafts sheltered from wind and rain. It is obvious that the technique described in this paper would be particularly suited to this kind of orchard, provided that the plants can be moved to the harvester without losing their pollen.

Moreover, the harvester also proved its efficiency in a 30-year-old clonal seed-orchard of Douglas-fir—*Pseudotsuga menziesii* (Mirb.) Franco—located in Les Barres Research Centre (center of France). Though the harvester has not been designed for big trees, it could be used to collect pollen on 12-m-high (40-foot-high) grafts by treating separately branches from the lower whorls. Under such conditions, 600 g (21.9 ounces) of pollen have been harvested in half an hour. Thus, this machine makes possible large-scale pollen collection in Douglas-fir seed orchards.

For more information, contact the authors at CEMAGREF Nogent-sur-Vernisson, France.

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