Use of Tyvek Housewrap for Pollination Bags in Breeding Hazelnut (*Corylus avellana* L.)

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Some controlled pollinations in our hazelnut breeding program require covering a large branch with a bag to exclude foreign pollen from the receptive female flowers. Tyvek housewrap (Du Pont, Wilmington, Del.) has been the most durable and adaptable of the materials we have used to make pollination bags. This paper describes the properties of Tyvek housewrap that make it suitable for pollination bags and how we use it.

Hazelnuts are monoecious, amentiferous, and wind-pollinated and are obligate outcrossers due to sporophytic self-incompatibility (Thompson, 1979). Pistillate flowers can be isolated from foreign pollen in either of two ways. For crosses where a large number of seed is desired, a small tree (≤ 2.3 m high) is emasculated and caged with a wooden framework that is covered with a white polyethylene film secured to the frame with nailed wooden laths. When a lesser number of female flowers is needed or when a tree is too large to cage, individual emasculated limbs are covered with pollen-proof bags that are tied shut around the limb with plastic flagging tape (Fig. 1). In the Willamette Valley in western Oregon, hazelnut cultivars and species bloom from late November until late March. Thus, pollination bags must maintain their integrity through 4 months of wind, rain, sun, and occasionally snow.

Over 25 years, we have tried Kraft paper, white polyethylene plastic, and vellum (high rag content) paper as pollination bag material, but each has shortcomings. White polyethylene traps moisture inside the bag, promoting development of an unidentified white mold and degradation of the female flowers. Kraft

paper and vellum bags often develop holes before the end of the pollen shedding season, even when they are covered with an additional cloth bag, as is our practice. According to the manufacturer's literature, Tyvek is water resistant yet transmits water vapor (Du Pont, 1986). In our experience, Tyvek is not wetted by rainwater and neither does condensation occur within the bag nor do flowers mold. Tyvek has also been more resistant to tearing and punctures than the other materials we have tried.

Tyvek housewrap is a 155- μ m-thick film of spunbonded, nondirectionally oriented, high-density polyethylene fibers; individual fibers are 0.5 to 10 μ m in diameter (Du Pont, 1986). It is designed as an air infiltration barrier for house construction and is applied beneath the exterior siding. Microscopic spaces between the fibers create gas permeability, but

Fig. 1. A Tyvek bag covering an emasculated limb on a hazelnut tree in preparation for making a controlled pollination. The bagged limb on the left side is covered with a cloth bag to reduce the weakening effects of wind buffeting on the Tyvek bag.

because of the random, overlapping orientation of the fibers, the spaces are small enough to make Tyvek water resistant. One weakness of Tyvek is that holes can form if sharp twig ends repeatedly abrade the bag. This problem is mitigated by minimizing the number of stiff shoot ends that contact the bag. Tyvek housewrap is available from building material suppliers in widths of 0.91 m or 2.74 m.

We determined Tyvek's impermeability to pollen by rubbing hazelnut pollen on one surface of a piece of Tyvek, then examining the opposite surface under $\times 100$ magnification. No pollen was observed to have penetrated the material in three tests; thus, we feel assured that Tyvek is pollen-proof. The average diameter of hazelnut pollen ranges from 25 to 30 μ m (Trotter, 1947). In addition, percent cluster set upon self-pollination of Tyvek-bagged flowers is 0% to 8% (Mehlenbacher and Smith, 1991). If the bags were not pollen-proof, considerably higher set would have been observed.

We manufacture our pollination bags by cutting the Tyvek to size (2.43×0.55 m), folding the sheet in half, double-folding the cut edges along two sides, and stapling every 10 to 15 cm. The bags are $\approx 1.2 \times 0.55$ m, and the materials cost about \$1.50 per bag. A bagged branch of this size bears 10 to 200+ female flowers, depending on cultivar. We cover the Tyvek bag with a polyester muslin bag to reduce the effects of wind buffeting against the bag. The more the Tyvek is moved about and pushed on by wind, the more the bag loses its initial crispness and shape. This results in the bag rubbing against the flowers within, which degrades the stigmatic surfaces and makes them useless for pollinations. Another Tyvek bag can also be used as an outer bag. A second bag would probably not be necessary if the flowers need protection for 1 month or less. Bags that are not excessively pliable and that do not have abrasion holes are reused the next season. In this manner, we are able to use $\approx 90\%$ of the bags for two seasons. Tyvek bags may be useful with other wind-pollinated crops. Tyvek can be easily fashioned into any size bag needed, which is one of the most useful features of this material.

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