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Outcrossing in a Diverse Peach Rootstock Seed Block

T. G. BECKMAN

Abstract

Over a 3 year period incidence of evident outcrosses (heterozygous redleaf) was recorded in open-pollinated seedlots of 'Nemared' and 'Rutgers Redleaf' collected in a rootstock repository. Since this block is made up predominantly of green-leaf cultivars this technique should detect most outcrossing events. Outcrossing averaged 6 percent. However, rootstock cultivar had a highly significant effect on the number of outcrossing events; in 'Nemared' such events occurred on average at more than three times the rate observed in 'Rutgers Redleaf.' In the absence of sufficient isolation to prevent undesirable outcrossing, rootstock cultivars need to have some readily identifiable 'marker' to reveal outcrosses so that they may be discarded.

Introduction

Knowledge of the extent of outcrossing in a plant species is an important factor in the understanding of its breeding behavior and subsequently to the development of a breeding strategy for crop improvement. Currently, the United States peach industry is based almost entirely on seedling-type peach rootstocks. Commercial seed blocks are rarely sufficiently isolated from other peach orchards to prevent the introduction of 'off-type' pollen by bees and other pollinating insects. Such outcrossing is likely to have a detrimental effect on commercial rootstock performance by interfering with the uniform

USDA-ARS, S.E. Fruit and Tree Nut Res. Lab., 21 Dunbar Road, Byron, GA 31008.

transmission of desirable parental traits to their seedling offspring.

Early estimates of outcrossing in peach ranged from <3 percent (6) to <5 percent (3) based on observations of off-types in open-pollinated progenies. More recently outcrossing in peach has been reported as ranging from ca. 15 to greater than 30 percent (1, 2, 4). Unfortunately, these more recent reports are flawed by either small progeny numbers or complicating factors such as extremely small numbers of detectable pollen donors in the block under study.

In our recent work studying seed germination and subsequent nursery growth and performance of a cross-section of seedling type peach rootstocks we have noted the presence of evident outcrosses in our homozygous red-leaf lines (heterozygotes are readily detectable by a marked reduction in the intensity of red pigmentation in the growing tip). Since the seed utilized is harvested from open-pollinated homozygous red-leaf peach rootstocks residing in a small repository of predominantly green-leaf rootstock cultivars, this approach should reliably detect virtually all outcrosses. The purpose of this paper is to report outcrossing rates detected in a large population of seedlings collected over a 3 year period under circumstances which allow the direct observation of events.

Materials and Methods

From 1993 through 1995 open-pollinated seed was harvested from the same trees of 'Nemared' and 'Rutgers Redleaf' in the Rootstock Repository at the Southeastern Fruit and Tree Nut Res. Lab., located at Byron, GA. In 1993 there were groups of 3 trees each of these 2 rootstock cultivars present in this block, but this number was reduced to 2 trees of each prior to spring 1994 bloom. In 1993, trees in this block ranged in age from 3 to 10 years. Most were 6 or more years of age. This block was rectangular in shape, ca. 73 x 210 m, with trees planted every 4.9 m in the row with rows ca. 6 m apart. Trees of 'Nemared' and 'Rutgers Redleaf' were located near the North and South ends, respectively. There were 243 trees scattered throughout the block that were judged to be potential pollinators (i.e. verified pollen producers and displaying an overlapping bloom period). Of these, 15 were heterozygous red-leaf and 10 were homozygous red-leaf. The remaining 218 were green-leaf. There are several other peach plantings within 0.5 km of this block that would be capable of serving as pollen donors but all were almost entirely composed of green-leaf cultivars. A sample of seed from each rootstock cultivar was collected each year and subdivided into 6 samples of 50 seed each. Samples were then randomly distributed (one each) to 6 commercial fruit tree nurseries. Just prior to budding the following spring, each seedlot was inspected and the total number of germinating seedlings and number of evidently outcrossed (i.e. heterozygous red-leaf) individuals noted.

Total number of seedlings observed of each rootstock cultivar and the number of heterozygous redleaf outcrosses observed were pooled over all 6 nurseries each year. Statistical analysis of rootstock cultivar effect was performed via Chi-Square (5).

Results and Discussion

Across both rootstocks, outcrossing averaged 6.5, 7.0 and 4.2 percent in seedlots

Table 1. Total number of seedlings inspected and number of outcross seedlings observed in 'Nemared' and 'Rutgers Redleaf' peach seedlots collected at the Byron, GA repository (1993-1995).

	1993		1994		1995		Combined	
Rootstock Cultivar	Total	Outcross	Total	Outcross	Total	Outcross	Total	Outcross
'Nemared'	212	27 (12.7%)	184	18 (9.8%)	157	8 (5.1%)	553	53 (9.6%)
'Rutgers Redleaf'	233	2 (0.9%)	216	10 (4.6%)	199	7 (3.5%)	648	19 (2.9%)
	P < .01[z]		P < .05		ns		P < .01	

[z]Probability of significance of difference in rootstock cultivar effect on ratio of outcrosses to selfs (calculated as total number of seedlings inspected minus number of outcrosses observed).

collected in 1993, 1994 and 1995, respectively, as shown in Table 1. Interestingly, the highest rates observed (1993 and 1994) coincided with the placement of 3-4 full-size bee hives ca. 100 meters from this orchard during the bloom season. Starting in 1995 we consolidated such hives at a central location ca. 1.5 km from this orchard in order to reduce handling and facilitate their maintenance by the commercial supplier.

Combined over all three years, rootstock cultivar had a highly significant effect on the number of outcrossing events ($P < .01$); in 'Nemared' such events occurred on average at more than three times the rate observed in 'Rutgers Redleaf.' Although both cultivars possess pink, showy flowers, this difference may be due in part to the relative attractiveness of these two rootstock cultivars to bees. In addition to estimating full bloom dates for each of the rootstock cultivars in our Repository we also subjectively rate bloom density. In spring of 1994 and 1995 'Nemared' was visually rated as having 'high' flower density (i.e. averaging ca. 1 flower per node on well-exposed fruiting wood) while in 1993 it was rated as 'medium' (averaging ca. 1 flower per 2 nodes). In contrast, 'Rutgers Redleaf' was rated in all 3 years as having 'medium' bloom density.

An alternative explanation may be the relative "accessibility" of these two rootstock cultivars to pollinators. 'Nemared' is located on the end of the block closest to woody areas and other peach blocks on the station, while 'Rutgers Redleaf' is located near the opposite end of the block near a perimeter fence beyond which lie open fields and housing developments. It has been our observation that wild bees entering this block invariably do so from the North indicating that their hives are most likely located in nearby woods which are closer to 'Nemared' than 'Rutgers Redleaf.' However, the observation that the differences in outcrossing rates between 'Nemared' and 'Rutgers Redleaf' were largest in the years that commercial hives were placed nearby (ca. equidistant between 'Nemared' and 'Rutgers Redleaf') would suggest that attractiveness rather than proximity may be a more important factor.

Clearly, the unharvested trees of 'Nemared,' 'Rutgers Redleaf' (and other heterozygous red-leaf and homozygous red-leaf cultivars located in this block) could also have cross-pollinated the seed source trees, yet remain undetected. To a first approximation the number of such events can be estimated by noting the number of red-leaf seedlings appearing in open-pollinated seedlots of green-leaf cultivars in this block. Five green-leaf cultivars scattered throughout this block were also part of our nursery performance study. During the three years of the trial a total population of 2758 seedlings from these green-leaf cultivars were inspected in which a total of 9 heterozygous red-leaf seedlings were found, a 0.3 percent cross rate.

After adding the estimated 0.3 percent undetectable outcrossing to other red-leaf rootstock cultivars present in this orchard block we obtain estimates of outcrossing ranging from ca. 1 to 13 percent, with an overall average of 6 percent. These are within the range reported in most earlier (but smaller) studies, but considerably lower than those reported by Miller et al. (4). This study suggests that the scion cultivar is an important factor in determining the extent of outcrossing. Cultivar attractiveness to bees, coordination of bloom with potential pollen donors, physical location relative to source of pollinators, pollinator number, weather, etc. no doubt all play a role.

The practical impact of this report is important. The degree of uniformity in the performance of seedling rootstocks, unlike that of clonally propagated rootstocks and scion varieties, is presumably dependent upon genetic homogeneity (minimal segregation) abetted by minimization of outcrossing. The inheritance of many important traits (such as tree vigor, cold hardiness, lesion nematode resistance, and peach tree short life tolerance, to name a few) in commercial peach seedling rootstock lines is either unknown or incompletely understood. If one cannot provide suitable isolation (distance, low attractiveness to potential pollen vectors, etc.) to prevent undesirable outcrossing, then the rootstock cultivar needs to have some readily identifiable 'marker' to reveal outcrosses in the seedling row so that they may be discarded before the budding operation. At the present time the use of homozygous red-leaf rootstock lines may be the most practical option since the most likely unwanted pollen donors will be nearby commercial peach blocks which will invariably be green-leaf. The resulting heterozygous red-leaf outcrosses can be reliably identified in a careful inspection prior to budding.

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Variation in Drupelet Number and Weight in Pacific Northwest Red Raspberries

PATRICK P. MOORE[1]

Abstract

Fruit weight, drupelet number, drupelet weight and seed weight were measured for five fruit per plot for raspberries in plantings established at Puyallup, Wash. Primary fruit were harvested in the first and second harvest seasons for raspberries in three plantings established in 1990, 1991 and 1992. For pooled data from the 124 plots sampled in this study, mean fruit weight fruit and drupelet weight increased from the first to the second season, while there was no increase in drupelet number. The planting established in 1992 did not follow the same pattern as the pooled data. In the 1992 planting the drupelet number increased, but drupelet weight did not increase from the first to the second harvest season. This may be the result of weather conditions at the time of fruit initiation or fruit development.

The weight of a red raspberry (*Rubus idaeus* L.) fruit is dependent on the number and weight of drupelets. In addition to determining the weight of the fruit, the number and weight of drupelets affect the appearance and may impact fruit firmness (4, 5). Understanding the variation in these components of fruit weight is important when attempting to breed for these characters.

In a previous study (2), the number and weight of drupelets were determined for 124 raspberry genotypes grown in research plots at Washington State University Puyallup Research and Extension Center. There was significant variation among clones in the number and weight of drupelets. The number of drupelets per fruit varied from 38 to 145 and the weight of drupelets ranged from 18 to 76 mg. However, the study only sampled fruit from a single fruiting season. Drupelet number and weight could be affected by the weather conditions during flower initiation, fruit development or age of planting. Evaluation of raspberry harvest data from

[1]Washington State University Puyallup Research and Extension Center, Puyallup, WA 98371
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