An Evaluation System for Filberts (*Corylus avellana* L.)[1]

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A common evaluation system for filberts has been developed by research leaders of breeding programs in U. S., France, Italy, and Spain. The system incorporates important horticultural or economic traits and is independent of specific breeding objectives. To minimize the influence of site and season on certain traits, especially phenological traits, a standard set of well-known cultivars was established, against which all other clones are compared. Ratings are recorded numerically so the data can be readily computerized.

Breeding programs for improved filbert cultivars have been initiated during the past 9 years in Oregon (U. S. A.), Italy, France, and Spain. Until recently (5, 6), there had been no genetic studies published for this crop plant and only a few, very generalized accounts of breeding results had been reported (2, 3, 4). Because of the paucity of genetic information available, and the modest size of our individual programs, the research leaders of these 4 relatively new breeding programs considered it of mutual advantage to cooperate by exchanging results and materials. It was agreed that a common evaluation system was necessary for valid comparisons of results. The First International Congress for Almonds and Filberts, held Oct. 25-28, 1976, at Reus, Spain, afforded the opportunity to meet and discuss this subject. By pooling our evaluation experiences of the past several years, we were able to develop a system applicable to all programs. Our purpose was to establish rating scales for tree and nut traits that would be comparable at different locations and which would be independent of our differing breeding objectives. Further, the system should incorporate all horticulturally important traits, be complete enough for cultivars, and yet efficient for large numbers of seedlings in breeding populations. Ourecky and Reich's (1) numerical scoring system, while having merit for their specific objectives, is not universally applicable.

Traits which can be objectively measured, such as yield, weight of 10-nut sample, and % kernel, can be readily compared at different locations. Certain others such as phenological events, must be rated subjectively, and they are also markedly influenced by environmental factors. Not only do the calendar dates for leafing out, staminate and pistillate anthesis, and nut maturity vary in different seasons and at different sites, but also the period of time from earliest to the latest clone is variable. Furthermore, on a given filbert tree, all of these phenological events occur over an extended period. For example, catkins may be elongating and shedding pollen for several weeks. Pistillate flowers also may gradually emerge and appear to be at full anthesis for several weeks. Nuts may fall over a period of 2-4 weeks, or more. Despite these sources of variability, the relative timing of these events for different clones is generally constant enough so that a sequential arrangement, from the earliest to the latest can be established which will be valid for most seasons and most sites. Therefore, for each trait we have developed a sequential set of standard cultivars against which all other clones can be compared. This system also permits us to reduce the number of times needed to pass through the orchard for evaluations. Two to 4 observations (relatively early, mid, and late season) should be adequate to rate all plants, even though there may be up to 2 or 3 months between the earliest and the latest clones. On any given date, first the standards are evaluated and then all others are rated in relation to these. The extremities of the rating scales are based on the earliest and latest cultivars presently in our respective collections, which include all significant commerical cultivars and a wide array of genetic types. To accommodate new types transcending these standard cultivars, the scales are left open at either end. Obviously, the standard cultivars must be maintained in all plots where comparisons are to be made with other cultivars and with seedling trees from breeding programs.

Tree and nut traits with rating scales and standard cultivars, where applicable, are presented in Table 1. The number of categories for various subjective traits differs either because of our inability to discriminate accurately more classes, or because we did not feel it was important to establish as many classes for some as for others.

Branch density is evaluated on unpruned trees. Trunk diameter, measured at 25 cm from the ground, is an objective measure of total tree growth. In trees trained to a single trunk, this value, converted to cm^2 cross-sectional area, can be used to calculate yield efficiency [yield (g)/cross-sectional area of trunk (cm^2)] an important parameter for comparison of reproductive potential of different sized trees (7).

Pollen germination and amount of pollen are generally evaluated only for clones of special interest, e.g., potential cultivars, parents in breeding programs, possible pollinizers, or those used in compatibility studies. Percentage germination is based on an average of 2 replicates of few hundred grains in a hanging drop with 20% sucrose in water. Cultures are incubated overnight at room temperature (about 20°C). Alternatively, pollen can be germinated on an agar plate (1.75% agar, 0.75 M sucrose, 0.1% boric acid). This method affords a more uniform distribution of pollen.

Husk length becomes important only if the husk restricts the nuts from falling free. Due to different cultural practices, complete free husking is necessary for European and American cultivars, whereas Turkish cultivars must retain their nuts in the husk.

Physiological maturity can be de-

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Table 1. Rating scales for tree and nut traits for filberts.

Trait	Rating scale	Standard cultivar
I. VEGETATIVE TRAITS		
Growth habit	1=very upright	Pinyolenc, Sant Pere
	2=upright	Segorbe, Daviana
	3=moderately upright–spreading	Barcelona, Negret, T.G.D.L.[z]
	4=spreading	Morell, Ribet
	5=very spreading	Imperial de Trebizonde
Branch density	1=too few branches	
	2=moderately open	Barcelona, Negret, T.G.D.L.
	3=too dense	Bergeri
Tree vigor	1=very weak	Imperial de Trebizonde, Pallaz
	2=moderately weak	Tonda Romana, Negret
	3=medium	T.G.D.L., Daviana
	4=vigorous	Barcelona, Ribet
	5=very vigorous	Segorbe
Trunk diam	(expressed in mm)	
Suckers	1=none	*Corylus colurna*
	2=few	Daviana, Cosford
	3=moderate amount	Segorbe
	4=many	Barcelona, Negret
	5=very many	Sant Pere, T.G.D.L, Ribet
Leafing out	1=earlier than Pallaz	
	2=very early	Pallaz, San Giovanni
	3=early	Tonda di Giffoni, T.G.D.L., Gironell
	4=early-medium	Barcelona, Sant Pere
	5-medium	Negret, Tonda Romano, Pauetet
	6=medium-late	Segorbe, Ribet
	7=late	Merveille de Bollwiller, Cosford, Duchilly
	8=very late	Nooksack
	9=later than Nooksack	
Big bud mite infestation	1=none	Ribet, Merveille de Bollwiller
	2=small amount	Barcelona, Grifoll
	3=moderate amount	Segorbe, Gironell
	4=much	Negret, T.G.D.L., Sant Pere
	5=very much	Daviana, Cosford
II. FLOWERING TRAITS		
Amount of pistillate flower clusters	(rated annually on a 1-6 scale)	
Time of pistillate anthesis	1=earlier than San Giovanni	
	2=very early	San Giovanni, Negret
	3=early	Tonda di Giffoni, Nocchione
	4=early-medium	Barcelona
	5=medium	T.G.D.L.
	6=medium-late	Segorbe
	7=late	Merveille de Bollwiller, Daviana, Duchilly
	8=very late	Bergeri
	9=later than Bergeri	
Amount of catkins	(rated annually on a 1-6 scale)	

[z]T.G.D.L. = Tonda Gentile Delle Langhe.

Table 1 (continued)

Trait	Rating scale	Standard cultivar
Time of staminate anthesis	1=earlier than T.G.D.L.	
	2=very early	T.G.D.L.
	3=early	Woodford
	4=medium-early	Barcelona, Segorbe, San Giovanni
	5=medium	Negret
	6=medium-late	Daviana, Cosford, Tonda Romana
	7=late	Merveille de Bollwiller, Morell, Duchilly
	8=very late	Nooksack, *Corylus contorta*
	9 = later than Nooksack	
Synchrony of staminate and pistillate flowers	1=very protogynous	Negret, San Giovanni
	2=protogynous	Tonda Romana
	3=homogamous	Merveille de Bollwiller, Morell
	4=protandrous	Barcelona, Duchilly
	5=very protandrous	T.G.D.L., Segorbe, Bergeri
Amount of pollen	1=none	
	2=very small amount	Ribet, Tonda Romana
	3=small amount	Negret
	4=moderate amount	Barcelona
	5=much	Merveille de Bollwiller
	6=very much	Segorbe, Daviana, Cosford
Pollen germination	(expressed as percentage)	
III. NUT AND KERNEL TRAITS		
Estimated number of nuts/cluster	1=mostly singles	Daviana, Pinyolenc, Tonda Bianca
	2=mostly 1's & 2's	Merveille de Bollwiller, Cosford
	3=mostly 2's & 3's	Barcelona, T.G.D.L., Negret
	4=mostly 3's & 4's	Gironell, Nocchione, Segorbe
	5=mostly 4-6's	Tombul
	6=many with 7+	
Free husking at maturity	1=less than 5% fall in husk	Sant Pere, T.G.D.L.
	2=5-20% fall in husk	Negret, Barcelona
	3=20-50% fall in husk	Segorbe
	4=50-85% fall in husk	Morell
	5=85-100% fall in husk	Tombul, Duchilly
Estimated yield	(rated annually on a 1-6 scale)	
Yield	(weight in g)	
Yield efficiency	weight of crop (g)/x section area of trunk (cm^2)	
Nut maturity	1=earlier than Sant Pere	
	2=very early	Sant Pere
	3=early	T.G.D.L.
	4=early-medium	San Giovanni, Gironell
	5=medium	Daviana, Tonda Romana, Nocchione
	6=medium-late	Barcelona
	7=late	Merveille de Bollwiller, Negret
	8=very late	Nonpareil
	9=later than Nonpareil	

Table 1 (continued)

Trait	Rating scale	Standard cultivar
10-nut volume	(expressed in cc)	
10-kernel volume	(expressed in cc)	
Percent kernel by volume	10-kernel volume/10-nut volume	
10-nut weight	(expressed in g)	
10-kernel weight	(expressed in g)	
Percent kernel by weight	10-kernel weight/10-nut weight	
Shell attractiveness	1=very attractive	Daviana, Morell
	2=moderately attractive	Barcelona, Negret
	3=unacceptable	Tonda Bianca, Grifoll
Shell shape	(see Fig. 1 for 10 categories)	
Shell striping	1=insignificant or no stripes	Negret, Segorbe, Morell
	2=moderate stripes	Barcelona, Cosford, T.G.D.L.
	3=pronounced stripes	Campanica, Closca Molla
Shell pubescence	1=slight or none	T.G.D.L., Daviana, Morell
	2=moderate amount	Barcelona, Negret
	3=heavy	Duchilly, Grifoll
Miscellaneous shell traits	1=pinched apex	
	2=small dot scars on shell	
	3=irregular scars on shell	
	4=dark stain on basal scar	Mortarella
	5=basal scar humped up	
	6=deep groves	Tonda di Giffoni
	7=protruding apical tip	Tonda Romana
	8=split sutures	Tombul
	9=many shriveled, defective nuts, etc.	
Kernel attractiveness	1=very attractive	Sant Pere, Ribet, Pinyolenc, Tombul, Tonda Romana
	2=moderately attractive	Negret, T.G.D.L.
	3=mediocre	Barcelona, Gironell
	4=unattractive	Cosford
	5=very unattractive	Princess Royal

Table 1 (continued)

Trait	Rating scale	Standard cultivar
Kernel uniformity	1=very uniform	
	2=moderately uniform	
	3=not at all uniform	
Kernel fibre	1=none	Ribet, Pinyolenc, Daviana
	2=small amount	Negret, Segorbe
	3=moderate amount	T.G.D.L., Barcelona
	4=much	Cosford
Kernel shrinkage	1=relatively none	Negret, Tombul, T.G.D.L.
	2=small amount	Barcelona, Daviana
	3=moderate amount	Cosford
	4=severe	Princess Royal
Flavor	1=very good	
	2=acceptable	
	3=unacceptable	
Pellicle removal	1=all removed	Tombul
	2=almost all (90-99%)	T.G.D.L., Negret
	3=much removed (75-90%)	Sant Pere
	4=moderate amount (50-75%)	Barcelona, Ribet
	5=moderate-small amount (25-50%)	Tonda Romana, Morell
	6=small amount (5-25%)	Cosford, Grifoll
	7=none removed	Duchilly
Miscellaneous kernel traits	1=wrinkled pellicle	
	2=deep suture	Tonda di Giffoni
	3=parts of pellicle fall off	
	4=black tips	Gironell
	5=rotten kernels	
	6=many only partially developed	
	7=many blanks	Corello
	8=brown spots in cavity, etc.	
Percent Blanks	(Refer text)	

fined as the time when the nut abscises from the husk. In closed husk types, nuts are harvested at this stage, that is, when they become loose within the husk. However, in free husking types, nuts are not harvested until the husk dries sufficiently to allow 95-100% of the nuts to fall, which is considerably later than physiological maturity. Because of these different harvest criteria, it is difficult to make reliable comparisons for nut maturity in the contrasting types. Thus, our set of standards includes only free husking clones. Maturity of closed husk clones must be evaluated by different criteria.

A sample of 10 typical nuts for each clone has been found to be sufficiently reliable for volume and weight determinations. Volume, measured as displacement of water in a graduate cylinder, is the preferred parameter for nut and kernel size. Percent kernel by volume indicates the amount of fill, which generally decreases with increasing nut size. Nut weight reflects both size and shell thickness. Because shells are heavier than kernels, nuts of the same size having thick shells weigh more than those with thin shells. Percent kernel by weight is influenced by both shell thickness and amount of shrinkage. Thin-shelled, well-filled, small nuts have the highest percent kernel by weight.

Shell shapes are given in Fig. 1. The length/width ratio for sperical, round-compressed, and spheroidal-trilobate is about 1; for ovate, oval, and oval-compressed it is about 1.2; and for all long nuts about 1.3 or more. Miscellaneous shell and kernel traits include various irregular characteristics that occasionally appear in certain clones. These categories are open-ended because additional traits will no doubt be found.

Kernel fibre refers to the dried, woody-like fragments of the ovary wall which sometimes adhere to the seed coat, or pellicle. Kernels with much fibre are less appealing and less palatable, unless blanched. Although flavor does vary considerably, it is not possible for a single evaluator to discriminate several categories of flavor. An attempt is made, however, to identify and eliminate those with noticeable undesirable off-flavors. In order to evaluate the ease of pellicle removal, a sample of 100 kernels from previously dried nuts is placed at 115°C for 20 min. Blank nuts are arbitrarily defined as all nuts without kernels or whose kernels are less than half size. Three samples of 100 nuts each are used to calculate blank percentages.

The traits considered in this paper include only those which can be evaluated at all sites. Certain others, which are not universal, such as cold hardiness, susceptibility to various diseases (*Phyllactinia* sp., *Xanthomonas corylina* Dawson, *Sphacelona* sp., etc.) and pests (*Balaninus nucum* L., *Melissopus latiferreanus* Walsh., etc.) may be additional

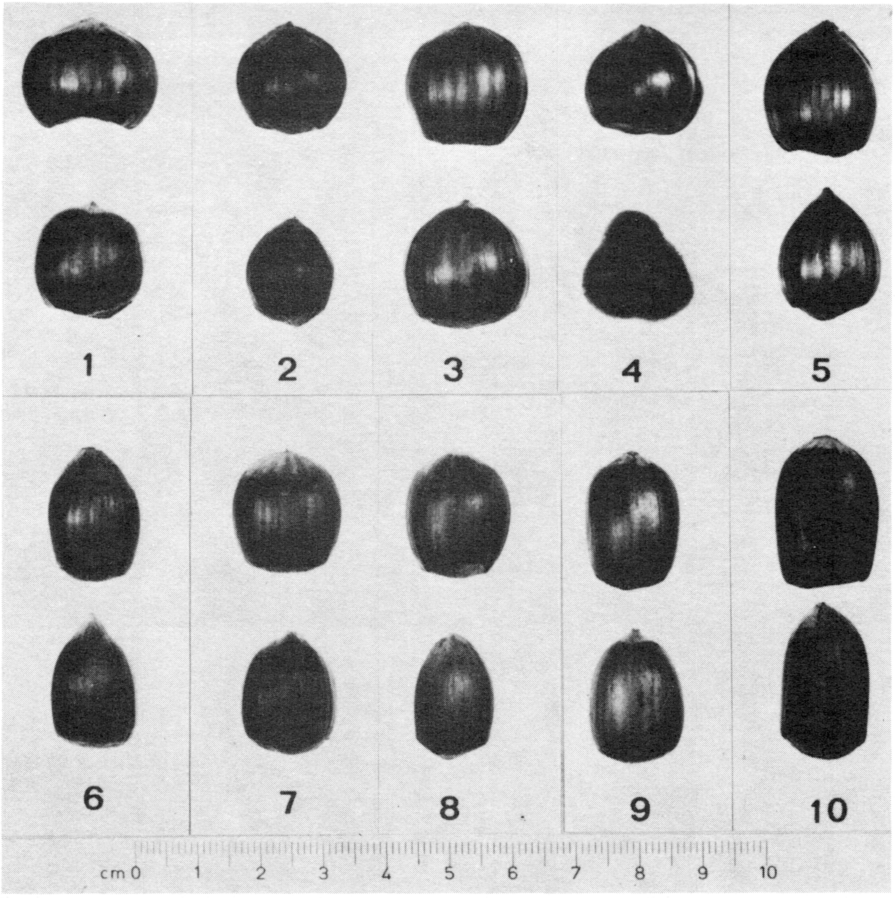

Fig. 1. Filbert nuts shapes. 1 = oblate, 2 = round-compressed, 3 = spheroidal, 4 = spheroidal-trilobate, 5 = ovate, 6 = long ovate, 7 = oval, 8 = oval-compressed, 9 = long round in x.s., 10 = long-compressed. Upper nuts are ventral views, lower are lateral views (except no. 4, where lower nut is apical view).

evaluation items in specific areas.

As the breeding programs proceed and numbers of hybrid seedlings vastly increase, computerization of the data becomes highly desirable, if not essential, for efficient analyses. Our evaluation system was designed with this in mind with all items being expressed in numerical values. An appropriate computer program will greatly expedite analyses of the inheritance of traits, determination of correlations or linkage between traits, and identification of selections having specific combinations of desirable traits to use as parents.

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Productivity and Mechanization of the Tatura Trellis Orchard[1]

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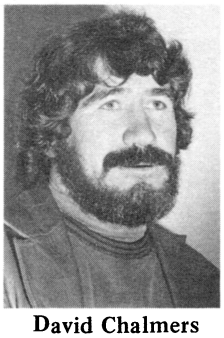
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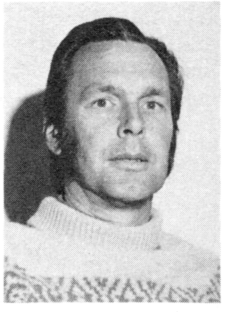
Leo van Heek

High yield and low cost of production are the important ingredients of profitable fruit growing. The Tatura Trellis aims to optimize yield by using orchard design and management principles that are based on understanding and overcoming the plant physiological shortcomings of existing orchards. It aims to reduce the cost of production by eliminating labor in the simplest and therefore the cheapest way.

The following, briefly, were the physiological and management inputs we considered necessary for optimum yield:

- A tree design, that fills the allotted space (quickly), resulting in optimum land use.
- An uniform and controlled distribution of leaves and fruit to

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