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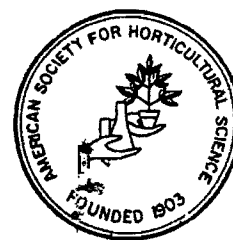
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CRITERIA FOR EVALUATING IMPORTANT FRUIT CHARACTERS IN MANGO (*Mangifera indica* L.) GERMPLASM

Robert J. Knight, Jr.

Subtropical Horticulture Research Station
Agricultural Research Service
U.S. Department of Agriculture
Miami, Florida 33158

ABSTRACT

Standardized criteria are needed to select seedlings of mango (*Mangifera indica* L.) that merit retention in a varietal improvement program, and to compare selections and cultivars evaluated. Such a slate lets seedlings and new or uncommon cultivars be compared with well-known standards. Preferences may vary in different regions, and performance of a given cultivar may vary; however, application of this system or clearly defined modifications of it can enhance the interchange of information and plant material worldwide among people working to improve mangos. Traits of importance are shape, size, colour, firmness, fiber content, disease resistance, flavor, and productivity. A tabular system for rating these characters like those already used for strawberry and blueberry was developed and is being used to advantage in a program of mango germplasm evaluation. Occasional defects such as fruit cracking, "jelly seed" or stem end breakdown are noted when necessary in a "Remarks" column. A "Score" column permits one or more checks to give an estimate of overall quality, and a tree slated for discard is also designated here by a special sign, "/x/".

RESUMEN

Se precisan criterios para seleccionar plantas de mango (*Mangifera indica* L.) de semillero que merecen retención en programas de mejoramiento, y para comparar selecciones y variedades ya evaluados. Tal sistema permite la comparación de plantas de semillero y nuevas variedades con variedades establecidas. Preferencias pueden variar de región a región, y el comportamiento de una variedad puede variar; sin embargo, la aplicación, de este sistema o una clara modificación de ello podría aumentar el intercambio de información y materia vegetal entre todos que trabajan para el mejoramiento del mango. Las características más importantes de la fruta son la forma, tamaño, color, firmeza, cantidad de fibra, resistencia a enfermedades, sabor, y productividad. Un sistema tabular para evaluar estas características fue desarrollado y utilizado con ventaja en un programa de evaluación de germoplasma del mango. Defectos de la fruta, tales como rajadura, pudrición interna, y pudrición por el tallo se notan en una columna para comentarios cuando sea necesario. Otra columna permite marcar una o más veces para indicar la calidad general, y la marca "/x/" se usa para indicar la eliminación de una variedad o selección.

The most effective fruit varietal improvement programs entail the efficient exchange of information and also of germplasm which is evaluated for performance under a wide range of conditions. Cooperative work involving the U.S. Department of Agriculture and various State and private organizations resulted in an array of new blueberry and strawberry cultivars superior to those in use earlier (2, 7).

Specific criteria vital to a cultivar's success need to be applied to any possible selection to determine its varietal potential. Unless a specific genotype can produce acceptable fruit that is resistant to disease and shipping stresses, in sufficient quantities to supply market needs, it has no potential as a new cultivar despite any other superior attributes it may have. A great deal of time and expense can be saved by rigorous use of a rating system that can early pick out those few seedlings in a population that have varietal potential and compare them realistically with existing cultivars. Widespread application of such a system can enable one cooperator intelligently to select the most outstanding individuals from the working collections of others for trial under his or her own conditions. Limitations on land, water and labor increase the value of a system that enables such informed use of plant germplasm.

Careful laboratory analyses can obtain the precise data needed before final decisions on varietal release are made. Before that time, however, rapid practical means adapted to use on large numbers of individuals in the field are needed if adequate evaluation of seedling populations and first selections is to be carried forward. The application of a subjective rating system first used and described by Morrow

et al. (6) affords such a means. Although each numerical rating is arrived at subjectively, the resulting figures can be analyzed objectively so that an idea of the character and potential usefulness of a given individual or group of individuals can be conveyed with a minimum of confusion to others familiar with the system. Long used by breeders of deciduous fruit, it has proved equally useful for evaluation of tropical and subtropical fruit in the Agricultural Research Service Clonal Repository at Miami — notably avocado, lychee and mango (*Mangifera indica* L.) (5). Because of wide current interest in mango improvement and the interest throughout the Caribbean Basin in producing fruit for North American markets, this system is now proposed in order to afford a uniform means of evaluating the performance and usefulness of specific mango cultivars and selections.

As a general rule, characters are rated on a scale of 1 to 10. (Fruit shape and yield, both special cases, are handled differently as discussed later.) A score of 1 indicates the least desirable, a score of 10 the most desirable rating for a particular character. A score of 5 or lower for any character except fruit shape is enough to bar that plant from consideration for introduction, although it may still be selected for use in breeding if it has other desired characters. Certain traits for which a given kind of fruit is rated may be critical in that fruit, such as fiber in the mango. Specific characters, however, are of general importance. These include fruit size, color, firmness, taste, disease resistance and productivity.

Characters for which mango germplasm is rated numerically are: fruit shape, size, firmness, color,

anthracnose disease resistance, taste, fiber content, and yield. A "Remarks" column also records any observation noted in one specific plant but not common enough to be regularly rated. Such remarked observations include a tendency to crack, to be soft near the seed ("jelly seed"), to show internal breakdown at the stem end, to exhibit aborted seeds under some conditions, or to be otherwise deficient. Total value is then summarized in a final column by assigning a 1 – to 4 – check rating of the plant as a whole, the greatest number of checks indicating the most valuable material, or assigning a rating of "/x/", "x-ing it off", if the plant is to be discarded. Character ratings, and how these are arrived at, are next discussed.

Shape

The numerical scale of 1 to 10 is not well adapted to describing mango fruit forms because the range of variation for this trait is narrower than such a range of figures would imply. Most fruit of a given mango cultivar consistently maintain a specific shape. Fruit shape in mango ranges among cultivars from one extreme of nearly spherical, assigned of value of 1, through a more-or-less kidney-shaped intermediate form, given a value of 3, to an elongate cylindrical, sausage or parenthesis shape assigned a value of 5. Variants on these generalized forms occur, such as the presence or absence of a beak at the fruit's distal end with or without a minute protuberance or nak above this, a sinus on the dorsal surface, or a depression at the peduncle's point of insertion. This last-named trait is a defect in a commercial cultivar because it affords rainwater a place to collect and promote fungal growth. Any obvious eccentricity of form can be entered under "Remarks". The 1 to 5 scale affords a useful method of quantifying form in seedling populations or of describing it briefly in a new selection or cultivar, but no numerical rating is discarded.

Size

Mango cultivars from parts of the world where the fruit is a traditional crop show a wide range of size. For example, cultivars commonly grown in India range from the small Dashehari, which averages 172g wt to Banganpalli, which weighs approximately 625g (3). Four other Indian cultivars, Chowsa, Langra, Pairi and Suvarnarekha all weigh less than 300g, while Neelum at 364g approximates the smallest North American size accepted (3). The North American consumer's idea of proper mango size probably was influenced by Haden, the first important commercial cultivar, which ranges from 460–685g. Commercially successful cultivars grown in Florida now range in size from Van Dyke (280–400g) through Tommy Atkins (460–658g) to Keitt (570–860g) (4, 1). A fruit smaller than Van Dyke would have difficulty finding acceptance, whereas Keitt, larger than some markets prefer, encompasses the maximum acceptable size. Accordingly Keitt's numerical rating for size is 10, that of Tommy Atkins is 9, and that of Van Dyke is 6 or 7, depending on which end of its normal range the fruit under scrutiny approaches. The numerical rating thus reflects a mango fruit's absolute size instead of the degree it conforms to market preferences.

Firmness

Adequate firmness is essential to the success of any mango cultivar grown in one region and shipped to distant markets, as it is with any other fruit so handled. This trait varies widely within and between seedling populations. It can easily be described by the subjective, 1 to 10 rating system once the user has had enough practice to learn the skill by handling fruit. Van Dyke, for one example, is among the firmest of the well-known cultivars. Carrie, on the other hand, has one of the least firm fruits of any named cultivar grown in Florida, and would be rejected for serious consideration as a commercial cultivar even if it were otherwise acceptable. Firmness is unquestionably related to the amount and type of fiber in the fruit's pulp; too little fiber makes a fruit too soft to withstand packing and shipping stresses.

Colour

Preference for aspecific external appearance may vary more from one region or another worldwide than for many other traits. Certainly Carabao, grown in the Philippines and exported from there to Japan, bears fruit of a yellow color that would not be accepted on North American markets when more attractive fruit are available, nor would that of Alphonso, one of India's most popular cultivars. Market preference in North America dictates a bright-colored fruit, blushed with red or purple. This probably results from Haden's long predominance as the market standard there. Such a fruit invariably has a competitive advantage over less colorful fruit of the same season. Accordingly color is rated from 1 to 10 based on the fruit's appearance, which is directly related to the amount of the fruit surface covered by a blush, and the brilliance of the orange to red or purple coloration of the blush.

Anthracnose Disease Resistance

Several fungus diseases impact on Florida mangos in the course of the fruit's development but one, anthracnose caused by *Colletotrichum gloeosporioides* Penz., is far and away the most important. Mango scab, *Sphaceloma mangiferae* Bit. and Jenk., seriously mars the fruit of a few cultivars imported for experimental use, but it is not usually important on commercial cultivars or seedlings related to them. Susceptibility to scab definitely appears to be of genetic origin because some accessions regularly show it. Where this is observed, it should be noted under "Remarks", but scab is not common enough to justify rating every accession for it. Powdery mildew, *Oidium mangiferae* Berthet is unfortunately more common than scab in Florida, particularly in years when the flowering season finds warm sunny daytime weather followed by foggy, humid nights. Susceptibility to *Oidium* varies among mango cultivars both in Florida and Africa. Severely affected cultivars can lose most of the flowers to a blight caused by the fungus, and less affected ones may keep fruit that set but is infected. This can then mature with scars of depressions on its surface. Despite occasional severity, powdery mildew is not sufficiently frequent in Florida to justify rating all plants for it. Those observed to be severely affected need to have the fact remarked.

Anthrachnose caused by *Colletotrichum* fungus is the most important mango disease in Florida, and its control is critically important, necessitating an effective spray program (1). Mango cultivars vary in their field resistance to anthracnose disease, and some (Tommy Atkins and Keitt, for examples) appear to keep some resistance after harvest. This is reflected in their superior shelf life. Their commercial importance rests in part on their relative resistance to storage disease, however, no mango germplasm evaluated in Florida to date has shown immunity to anthracnose disease. All unsprayed fruit shows symptoms to a greater or lesser degree. Because high resistance can enhance the effectiveness of a well-conceived spray program in improving fruit quality and shelf life, all mango introductions are evaluated for resistance to anthracnose. A rating of 10 would indicate total freedom from infection, whereas a 1 rating is assigned to a fruit whose surface is entirely covered with anthracnose lesions. No mango introductions in the Miami repository are sprayed with fungicide during the season of flowering and fruiting, thus all can be compared for their relative resistance to anthracnose. Severity of infections can vary with the amount of early rainfall in a particular year, but relative differences among clones are reasonably consistent: those showing almost no infection in a "good" (dry) year continue to show less infection than more vulnerable cultivars in a "normal" or "bad" (wet) year.

Taste

Some mango seedling populations show remarkably wide variance in fruit flavor. Ratings of this attribute might be most influenced by personal preference. Undeniably it is more likely to be subjectively interpreted than most others. For this reason, it is important to keep in mind what would appeal to the widest audience and to avoid letting preference for a particular regional or local type influence one's choice. This does not suggest that monotony is a desirable goal. On the contrary, the taste specific to fine named mango cultivars needs to be kept as a criterion to avoid reducing all the selections made to a common level of blandness. In practice, rating mango seedlings and selections for taste is not difficult once experience is gained in the field. Furthermore, cultivars recognized as superior in one region are likely to be equally appreciated elsewhere. Certain well-known cultivars, such as Mulgoba, Edward, Keitt and the Cambodiana can be kept as standards with which to compare newly tested clones. In addition, certain unacceptable flavors that crop up in seedling populations are easily recognized. Metallic taste, excessive turpentine, excessive acid, and extremely bland, flavorless taste are examples of what is often encountered and discarded. Use of a taste panel made up of several knowledgeable individuals can reduce the subjectivity of this rating system.

Fiber Content

The first mangos grown in Florida were unimproved seedlings brought in from the Caribbean. The pulp of most contained abundant coarse fiber that tended to stick in the teeth and reduce the consumer's enjoyment of the fruit's eating quality. Improved germplasm imported later from India, the Phillipines and Vietnam showed that the fruit's fiber content need not be objectionable. Evaluation of seedling

populations from parents of good quality showed that coarse, objectionable fiber is not the rule in such material (5). In evaluating fiber, two qualities need to be kept in mind: the fiber's, relative abundance and its fineness or coarseness. Abundant fine fiber, of a texture unobjectionable to the consumer, is a necessity to protect the interior of a commercial cultivar from bruising and internal collapse during handling and shipping. Thus, a "fiberless" mango is not the goal of any well-conceived improvement program. Both Keitt and Van Dyke cultivars, with an abundance of short, fine textured fiber, approach the ideal. Fruit of Tommy Atkins is more fibrous, but this attribute is unquestionably important for its shipping and storage abilities..

Yield.

It may be questioned how much can be learned of the potential prolificacy of a mature cultivar through observation of its initial cropping as a young seedling. Furthermore, many mango clones are notorious for alternate bearing. For this very reason, as much knowledge as possible about a potential variety's production needs to be gained from the start of the evaluation period. Observation of different seedling populations over a period of years suggests that their early yields actually portend subsequent cropping behavior. This vitally important trait obviously must continue under observation throughout the period of evaluation of a mango selection, before it can be named and released. There is no substitute for recorded kilograms and numbers-of-fruit data from replicated plantings to give a complete picture of a selection's potential vis-a-vis existing cultivars. However, because of the ease of applying the 1 to 10 rating system -- modified by the additional use of 0 -- as a field estimate of production, it deserves wide-scale use from the beginning of field observations. The ratings from 0 through 10 codify actual production compared to what it would be if a tree of a particular size were carrying a full crop, i.e. as much fruit as it could be expected to mature normally. Thus a tree with no fruit at all is scored 0; trees carrying a small number of fruit up to a crop about 10% of a full crop are scored 1; trees with greater crops up to 20% of normal are scored 2; and so on up the line, with a tree carrying 90% of a full crop scored 9 and one with a full crop scored 10.

Application of the Rating System

Ratings derived through use of the system described here have been given mango seedlings and cultivars in the Miami germplasm collection over a period of years, based on their observed performance here. (Modifications of the same system have also been applied to avacados, longans [*Euphoria longan* (Lour.) Steud.], and lychees [*Litchi chinensis* Sonn.]). More data are available on some accessions than others, depending on the length of time specific trees have been in the collection and the amount of attention devoted to them. Table 1 lists ratings of the most important Florida commercial mango cultivars and other local and foreign accessions. For 2 cultivars, Boribo and Gouveia, adequate yield performance information has not been accumulated, therefore no rating is given. As more data are collected,

some ratings may change from those presented here, particularly the yield ratings, but Table 1 reports the information presently available.

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Table 1 Ratings assigned mango accessions in the USDA collection at Miami

Clone	Shape ^z	Size ^y	Firmness	Color	Anthrac-nose	Fiber	Taste	Yield	Score ^x
Alphonso	3	5	7	2	3	7	9	1 ^w	/x/
Boribo	3	8	8	4	7	9	5	—	/x/
Carabao	5	6	7	3	5	9	8	6 ^w	/x/
Carrie	3	7	3	4	7	9	7	6	/x/
Gouveia	3	8	8	7	6	8	6	—√	
Haden	3	9	8	8	5	7	7	3 ^w	/x/
Kensington	3	8	7	7	7	8	7	6	√
Keitt	4	10	9	6	8	9	8	8	√√√
Langra	2	6	8	3	5	8	8	3 ^w	/x/
M-13269	3	8	9	5	7	7	7	8	/x/
Ono	4	7	5	6	7	7	7	6	/x/
Pope	3	9	5	7	2	8	8	1	/x/
Ruby	5	5	10	8	8	8	8	5 ^w	/x/
Tommy Atkins	3	9	9	9	9	6	6	7	√√√
Tyler	1	9	9	3	4	9	4	6	/x/
Van Dyke	3	7	10	9	7	8	7	6	√√√
Winters (M-20222)	4	7	7	8	7	7	7	7	√

^z Ratings of 1 (round) to 5 (long) indicate fruit's shape, not its desirability.

^y Ratings below 6 justify discard; those above 7 show size only, not merit.

^x 1 or more checks indicates overall value; /x/ lacks commercial acceptability.

^w Tends markedly towards alternate bearing.