several growers in the area. The charts that have been kept indicate to us the instruments are very reliable and accurate. We feel it is unrealistic to install permanent irrigation without instruments to measure moisture levels. Growers who have used them tell us they would compare irrigation without instruments to a doctor without a thermometer.

IV. Frost Protection Systems

Our ten meager years of working with frost protection in extreme southern Florida have taught us we have only scratched the surface in the use of water and sprinklers for this purpose. Uniformity and complete coverage of the perimeters of crops is of great importance. Harrison recommends .25 in/hour in our area and a spacing of 50'x50'. We did learn in 1962 that wind can reverse the heat transfer and super cool the crop. Sprinklers must rotate at least one r.p.m.

V. Fertilizer Injection

Fertilizer has been injected into sprinkler systems for at least 20 years in Florida. Most installations have been in nurseries and have been successful with the use of liquid fertilizer. Uniformity is of utmost importance and will be more important in the future when insecticides and other forms of chemicals begin to be used. Uniform velocity is important because sudden changes can cause materials in suspension to drop out and eventually block the lines. Inexpensive standard mix materials have been used exclusively for the last 18 months on a commercial basis with excellent results. We hope to report on this in the future.

Summary

The data presented here is from company records and pertains to fruit crops and multi-purpose design wherein uniformity is paramount. It is possible to apply this to many crops and areas but if irrigation is the only purpose of the sprinkler system the criteria are excessively strict. I feel it would be a serious mistake, however, to design and install a system today without preparing for other uses in the future. In years to come most agricultural chemicals will be applied by sprinklers.

Acknowledgments

Appreciation is expressed to Dr. Simon E. Malo for his assistance in editing and encouraging this effort.

LITERATURE CITED


GENETICS OF MANGO POLYEMBRYONY

THOMAS T. STURROCK
Department of Biological Sciences
Florida Atlantic University
Boca Raton

Following the presentation of a paper “Nu-cellar Embryos of the Mango” before this society last year (6), a question was posed from the floor during the discussion period. The writer was asked if there were any poly-embryonic mango varieties that were known to have grown from monoembryonic seeds. The example of Simmonds was given (Haden X Carabao grown by the late Edward Simmonds and named after him) (7). Later thoughts on the subject have raised some interesting questions concerning the genetics of mango polyembryony.

Mango breeding is a very slow process due to the long time required for a seedling to reach fruiting age. Therefore, it is experimentally impossible to retrace what actually occurred in the development of present varieties. An attempt is made in this paper to piece together what evidence is known regarding the lineage of selected varieties. It is on this evidence that these theoretical genetic conclusions are based.

Those mango varieties which are of Indian origin are chiefly monoembryonic (2). Many mango varieties of Indochinese origin have polyembryonic seeds. The crosses between those two races have resulted in some interesting genetic
peculiarities. Characteristics of the progeny of these crosses are now beginning to shed light on their genetics as described in the following examples:

**EXAMPLE No. 1: The Mulgoba—Haden line**

The historical introduction of Mulgoba to Florida by the United States Department of Agriculture is well documented. This monoembryonic variety is of Indian origin. Seeds taken from Mulgoba resulted in the well known monoembryonic Haden variety. The pollen parent of Haden is unknown. Since the fruit is greatly different from the usual Mulgoba seedlings, the assumption is that it resulted from a natural cross. The presence of fibers together with the color and flavor of Haden suggest that Turpentine, which was prevalent in the area of the parent Mulgoba tree, was the possible pollen parent of that cross. Turpentine is a polyembryonic variety which breeds true due to the formation of nucellar embryos.

Haden has become the “standard” of the Florida mango industry. Its many problems with unfruitfulness are legion. Hundreds of “Haden Seedlings” have been produced in South Florida with varying degrees of success. This brings us back to the original statement that Simmonds is a polyembryonic variety derived from a monoembryonic Haden seed.

The name “Simmonds” was given to the previously designated “Haden X Carabao No. 1” seedling of Mr. Edward Simmonds by Wolfe and Lynch (7). Records at the U.S.D.A. Plant Introduction Garden in Miami do not indicate whether these Haden X Carabao crosses of Mr. Simmonds were hand pollinated or the results of open pollination of Haden flowers growing near Carabao flowers. Those who knew Mr. Simmonds and his work suggest that the latter is probably the case. Thus, we are assuming that Carabao is the pollen parent of Simmonds. Since Simmonds has some of the characteristics of Carabao not found in Haden—yellow color, sub-acid flavor, and anthracnose resistance—it is fairly safe to assume that Carabao was, in fact, the pollen parent and that Simmonds is the result of a Haden X Carabao cross and not the result of a Haden X Haden cross. Whatever the origin, Simmonds is a polyembryonic variety and developed from a monoembryonic seed.

For sake of argument, let us assume that the polyembryonic trait is a recessive character. An individual must then be homozygous for that character before it will be manifested. An individual which is heterozygous for the character will not develop the phenotypic trait but may pass it on to its offspring. This can be illustrated by the model presented in Fig. 1. Mulgoba is monoembryonic and by itself produces seedlings which are also monoembryonic. We can assume here that there are no recessive genes for polyembryony in this variety as it is of Indian origin. When Mulgoba (homozygous dominant monoembryonic) is crossed with an unknown pollen parent (perhaps Turpentine—homozygous recessive polyembryonic), the offspring (e.g., Haden) would be heterozygous monoembryonic. This heterozygous monoembryonic variety when selfed would produce an array of offspring which would be expected to produce one-quarter homozygous monoembryonic individuals, one-half heterozygous monoembryonic individuals, and one-quarter homozygous polyembryonic individuals. When this heterozygous monoembryonic individual (Haden) is crossed with a homozygous recessive polyembryonic pollen parent (Carabao), as illustrated in Fig. 2, the offspring would be expected to be one-half heterozygous monoembryonic and one-half homozygous polyembryonic. If this is the case, then Simmonds probably developed from such a cross.
EXAMPLE No. 2: The Edward line

Edward is another of the crosses supposedly made by the late Edward Simmonds which was assumed to be another of the Haden X Carabao crosses (5). Further observations of this variety suggest that it resembles Paheri more than it does Haden and is probably a Paheri X Carabao cross. Regardless of its parentage, it is a monoembryonic variety.

In 1962, David Sturrock reported before this society (3) on results of some Edward X Pico crosses (open pollination from adjacent inflorescences). At that time, the few seedlings from that cross which had produced fruit were all monoembryonic. Since that publication, a number of other seedlings have fruited. From the total of twenty-four individuals, five have been definitely confirmed to be polyembryonic. Several were discarded for various reasons before examination, and some did not survive long enough to bear fruit (4). The fact that any polyembryonic offspring were produced is significant.

Since these seeds were the result of open pollination, we cannot be sure that they are positively Edward X Pico crosses. They may be Edward X Edward (self pollinated) or the result of some other accidental cross. However, some of the seedlings exhibit enough of the shape, flavor, and color characteristics of Pico to assume that they resulted from an Edward X Pico cross.

Paheri (also known as Pirie, Rajpuri, and other names) is a monoembryonic variety of Indian origin. Let us assume that it is a homozygous monoembryonic variety, as there is little evidence of polyembryony among the Indian varieties. Carabao is a polyembryonic variety (and therefore, by our assumption, homozygous recessive). The assumed cross (Fig. 3) of these two varieties resulted in the production of Edward, which is a monoembryonic variety. If this assumed parentage is correct, Edward would then be heterozygous for the polyembryonic factor.

If heterozygous Edward is self pollinated, it would theoretically produce an offspring population of one-quarter homozygous monoembryonic individuals, one-half heterozygous monoembryonic individuals, and one-quarter homozygous polyembryonic individuals (see Fig. 3). If heterozygous Edward is crossed with Pico (polyembryonic and therefore homozygous recessive for this characteristic), a theoretical offspring population of one-half heterozygous monoembryonic individuals and one-half homozygous polyembryonic individuals would result.
polyembryonic individuals would be produced (see Fig. 4).

The ratio of polyembryonic to monoembryonic offspring is, however, at least 5:19 (and possibly higher because of missing data) (4). This compares favorably with the 1:3 theoretical ratio for a self pollinated heterozygous parent (see Fig. 3). If we consider that the missing data might change this ratio, it might approach the 1:1 theoretical ratio of a heterozygous parent crossed with a homozygous recessive parent see Fig. 4). In either case, we can conclude from the results that Edward is heterozygous for the polyembryonic factor since it has passed this characteristic on to its offspring.

**Conclusions**

From the evidence and discussion, the following assumptions can be made:

1. The polyembryonic condition in mango is a recessive factor and is probably controlled by a single pair of genes.
2. The condition becomes phenotypic only if the individual receives genes for the character from both parents and is homozygous for the character.
3. An individual that contains only one of the recessive genes would be heterozygous and would not display the character.
4. The involvement of more than one pair of genes would result in a much more complicated array of phenotypes in the progeny.

**LITERATURE CITED**

4. , Personal communication.

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**EVALUATION OF LONGAN AND LYCHEE INTRODUCTIONS**

R. J. Knight, Jr., W. E. Manis, G. W. Kosel and C. A. White  
Crops Research Division  
Agricultural Research Service  
U. S. Department of Agriculture  
Miami  

**Abstract**

Over 75 percent of a seedling population of 163 longans (Euphoria longan Steud.), field-set in 1962 fruited in 1968 (Aug.-Sept.). Based upon yields of single trees at 7.5 x 15 foot spacing, projected per-acre production varied from 193.5 to 46,827 pounds. We observed marked seedling variation in individual fruits, cluster size, pulp:seed ratio, soluble solids content, and other horticultural characters. Equally variable was the potential of individual seedlings for production of marketable fresh fruit and for processing (canning, freezing). Upon thawing frozen longan fruit does not deteriorate as rapidly as frozen lychee nor does the longan skin impart...
an unpleasant flavor to the pulp as occurs with the lychee. The consistency of variation indicates that apogamy is non-existent in this population. The few lychee (Litchi chinensis Sonn.) seedlings that fruited, in a population of the same age as the observed longans, exhibited sufficient variation to encourage optimism for future selections.

**INTRODUCTION**

Some forms of the Longan (Euphoria longan Steud.) are esteemed for their food and medicinal values in the Orient, where the fruit is poetically termed the “Little brother of the Lychee” (1, 2). The tree has a reputation of growing well in much of Central and South Florida, as it thrives on a wider range of well-drained soil types than does the lychee (Litchi chinensis Sonn.). Despite its vigor and productivity in Florida, the longan has not been as highly valued as the lychee: Col. William R. Grove, Sr., some 17 years ago called it “a fine fruit in China but of which there are now no good representatives in Florida” (3). One Western observer familiar with fruits cultivated in Indochina considered a dwarf form of longan grown in the Mekong Valley area of Cambodia to be the finest of the Sapindaceous fruits. He did not indicate whether the dwarf form is a different species than D. longan, but this note is obvious interest to growers of subtropical fruits (4). Durian and longan orchards are said to account for the livelihoods of a small number of specialists in Cambodia who produce fruit that sells at extravagant prices (5). Longans produced in Dade County, Florida were marketed in local chain stores in September, 1968. Therefore the test of the consumer acceptability has already begun here.

The 1962 planting of longan seedlings at the U. S. Plant Introduction Station, Miami, Florida has developed well vegetatively and a few precocious individuals fruited in 1966 and 1967 but only this year, 1968, did a sufficient number fruit to justify evaluation for selection of superior individuals.

The lychee has long been of interest in Central and South Florida, and field evaluation of large seedling populations has been in progress at our station for the past 6 years (6). The first of these seedlings entered production in 1968. Although few fruited those that did indicated considerable variation among the seedlings.

**MATERIALS AND METHODS**

The sources of the plant material evaluated are listed in Table 1. We drew a sample of 80 longan seedlings to be thoroughly evaluated for fruit characters from the total fruiting population of 123 trees of P. I. 89409. Time and labor available did not permit us to handle more. The population, field-set in the summer of 1962, consisted entirely of open-pollinated seedlings of P. I. 89409, a longan introduced (under the name of ‘Black-ball’) from Canton, China in 1930.

We collected the entire crop of each longan seedling evaluated, and noted whether individual fruit clusters were “large”, “intermediate” or “small”, since cluster size bears directly upon ease of harvesting. The total crop of 79 trees was weighed in the field (one tree bore too small a crop to weigh). This was less of a task in these young trees than it would be for fully mature trees, and the weights provided an objective index of each tree's productivity. Fruit were not removed from all twigs after it was determined that the twigs comprise a negligible part of the fruit cluster's total weight; we expected that treating crops from all trees alike would subject all to the same comparison. For 73 trees we recorded the incidence of double fruit or “culls” (excluded from North American markets) which occur in longans as well as in lychees. Sample size of fruit examined for culls varied from 101 to 541 fruits; the mean was 304 fruits.

A 120-fruit sample from each longan seedling was separated into 4 replicates of 30 fruit each. These were then peeled and pitted in the laboratory, and hulls, pulp and seeds weighed separately on a top-loading Mettler (Model P-3) balance. In order to calculate the proportion each component contributed to total fruit weight, Duncan's multiple-range test compared both weights of the whole fruit and ratios of edible pulp to seed (fresh weights). Fruit samples were subjectively rated for flavor, using a 1 to 10 scale (the higher the number, the more acceptable the flavor), as previously done with mango seedlings (7). An Abbe refractometer was used on samples of the juice from 78 seedlings to determine total soluble solids, expressed as percent sucrose. Comparison of the information collected enables us to determine which seedlings merit selection and consideration for release as named varieties.

Only 10 out of several hundred lychee seed-
lings fruited in 1968, an insufficient number to warrant an evaluation at this time on the same scale as that given the longans. These fruit were collected and observed for color, surface texture, horticultural quality (flavor and pulp texture) and compared with that of the seed parent.

RESULTS AND DISCUSSION

LONGANS

Cluster size.—With a hand harvested crop relatively large fruit clusters are an advantage in reducing picking costs. The method of subjectively classifying the bunches as "large", "intermediate" or "small" was not entirely satisfactory in separating "small" and "intermediate", but there was little difficulty in picking out the "large" clusters. Of 76 trees for which cluster size was recorded, 13 (17.11 percent) were "large", 23 (30.26 percent) "intermediate", and 40 (52.63 percent) were "small". The method of observation needs further refinement before valid assertions can be made on inheritance of the character, but this year's work suggests that "large" cluster is genetically recessive.

Weight of Crop.—Our seedling fruit trees are grown at a spacing of 7.5x15 feet (a density of 387 trees per acre). With this system undesirable individuals, rejected on evaluation, are discarded before crowding becomes severe. Crops of fruit collected from the sample trees varied from 1/2 pound to 121; the average crop weight for the entire sample (79 trees) was 39.10 pounds per tree. Multiplying each of these values by 387, projections of per-acre production varied from 193 to 46,827 pounds, with an average of 15,166.53 pounds. Eight of the trees observed bore 80 pounds or more of fruit, and 4 trees 100 pounds or better. Individual mature longan trees would of course bear larger crops than these young seedlings, but they would need to be planted at a lower per acre density than the seedlings. Replicated plantings of clonal propagations of selected productive seedlings will determine their consistency and uncover any tendency toward alternate bearing. Weight of the whole fruit samples (30 fruit each) ranged from 110.90 to 468.20 grams, and the mean weight of individual fruit from 3.70 to 15.61 grams. Mean weight of the 30-fruit samples was 238.98 grams, and of individual fruit 7.97 grams. The Duncan's multiple-range test uncovered 35 classes which differed significantly at the .01 level of probability. There was overlapping among all but the top 2 classes: the samples of seedlings 6-5 and 7-17 weighed 468.20 and 467.00 grams respectively, and differed significantly at the .01 level from seedlings 5-8 (372.95 grams), 5-38 (369.85 grams), and 6-30 (362.00 grams) which did not differ among themselves at the .01 level, but did differ significantly, at that level, from the rest of the 80 seedling sample.

Fruit characters.—There is a positive relationship of individual longan fruit weight to weight of the tree's entire crop. In these young longans, at any rate, a large crop does not necessarily mean small fruit. On the contrary, large fruit seem important in determining that weight of the total crop will be large.

The percentage of total fresh fruit weight made up of the edible aril or "pulp" varied from 46 to over 70. Forty two of the 80 seedlings observed contained, by weight, more than 60 percent edible pulp. Two trees bore fruit with over 70 percent edible pulp. These marked differences were easily observed in the fruit given the taste test, and formed an important basis for fruit evaluation. Expressed as the ratio of edible pulp to seed (fresh weight), values ranged from a high of 7.045 (seedling 6-22) to a low of 1.555. The mean of all pulp:seed ratios was 3.209. Fourteen seedlings contained at least 4 times as much edible pulp as seed, by weight. Duncan's multiple-range test revealed 35 classes differing significantly from one another at the .01 level, as resulted for whole-fruit weights. With pulp:seed ratio, however, there was overlapping among all but the topmost class, made up of seedling 6-22 alone, which had a significantly greater ratio of pulp to seed (7.045) than all others.

Total soluble solids (T.S.S., expressed as percent sucrose) varied from 15.19 to 24.42, with a mean value of 19.58. No relation between T.S.S. and individual fruit weight was observed, nor did we find an obvious one between T.S.S. and total weight of a tree's crop. There was a close relationship between T.S.S. and the subjective ratings for flavor, but there were occasional exceptions. The lowest T.S.S. in the class given an 8 flavor rating—highly acceptable—was just under 18; but one tree given a 5 rating—objectionable—had a T.S.S. reading of 20.00, and the poorest flavor rating given, 4, was given to a fruit having a T.S.S. reading of 20. The fruit given the highest subjective flavor rating,
9, had a T.S.S. reading of 22.0, and the lowest T.S.S. reading, 15.19, occurred in a fruit given a 5 rating for flavor. Thus it is apparent that a high total soluble solids content is directly related to palatability, but other factors affecting flavor may also be involved.

In the North American lychee market double fruits are discriminated against as “culls”, and therefore the extent of their occurrence in seedlings is of interest. In the sample observed, 5 trees produced less than 5 percent of these “culls”, and 28 trees produced less than 10 percent “culls”. The mean incidence was 10.83 percent. Thirty-five trees (over 40 percent of the sample) yielded more than 10 percent but less than 20 percent double fruit, and 15 trees yielded 20 percent or more double fruit. Therefore, if the 1968 season was typical, the percentage of normal fruit produced by a given seedling is of importance in the overall evaluation.

A few fruit from several seedlings were held for a few days in the freezer. Brought out of cold storage, they did not break down or “go to mush” as do lychee fruits when so handled. Furthermore no unpleasant taste was absorbed from the peel by the pulp, in contrast to this objectionable characteristic occurring in lychee fruit. Longans have been canned for many years (2) in the Far East, and the fruit’s quality is reported to be unharmed by processing (1). A few laboratory samples of the pulp of our seedlings were taken by colleagues, stewed and held in glass jars under refrigeration. The products were considered highly acceptable either to be consumed alone or as an ice cream topping. Adding a small quantity of lime juice kept the boiled pulp a light color similar to its fresh state, but overshadowed the delicate longan flavor. The pulp cooked alone, turned a not-unpleasant yellowish brown color and had a

Table 1. Sources, survival and fruiting of longan and lychee seedlings.

<table>
<thead>
<tr>
<th>Inventory number and seed parent</th>
<th>Field-set in 1962</th>
<th>6-year field survival</th>
<th>Survivors fructing, 1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.I. 89409, 'Black-ball' longan</td>
<td>175</td>
<td>163</td>
<td>123</td>
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<tr>
<td></td>
<td></td>
<td>93.14</td>
<td>75.46</td>
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<td>M-17886, 'Chom Poo Nuch' longan</td>
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<td></td>
<td></td>
<td>100.00</td>
<td>0.00</td>
</tr>
<tr>
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<td>8</td>
<td>0</td>
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<tr>
<td></td>
<td></td>
<td>100.00</td>
<td>0.00</td>
</tr>
<tr>
<td>M-8516A, lychee</td>
<td>683</td>
<td>403</td>
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<td></td>
<td>59.00</td>
<td>2.23</td>
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<td>M-17599, 'Wirt No. 1', lychee</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>29.13</td>
<td>4.35</td>
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</table>
flavor enjoyed by most who tried it. These few tentative trials suggest that the longan should be seriously considered for processing in Florida and other warm parts of the world.

Longan selections, made this fall from the evaluated seedlings, will be propagated for additional testing in our program to obtain improved varieties.

**LYCHEES**

Survival data (Table 1) indicate that lychee seedlings have been less successful in our well-drained calcareous soils than have the longans. Percentages mean little between the lychee populations, but a comparison with the longan seedlings is illustrative: 75.46 percent of 163 longan seedlings (P. I. 89409) field-set in 1962 were already fruiting by summer 1968, while one lychee fruited of the population of 23 surviving seedlings of M. 17599, Wirt No. 1, and 9 plants (2.23 percent) fruited in another population of 403 living seedlings (m-8516A). The few seedlings which fruited exhibited enough variation in fruit characters (color, surface texture, and horticultural quality) to suggest interesting possibilities for selection when appreciable numbers begin production.

**CONCLUSION**

The past summer's observations on longans indicated that the extent of seedling variation is great enough in the young trees—derived from open-pollination of P. I. 89409—to enable us to select individuals horticulturally superior to the parent plant. If the selections made this year continue to exhibit the desired qualities, then introduction of the most outstanding ones as named varieties will be justified. The marked variability in the population observed indicates that apomixis is either non-existent or of very rare occurrence in this line of longans.

The small number of lychee seedlings that have fruited to date, and their comparatively small crops, have precluded extensive observations, but it is already evident that sister seedlings resultant from open-pollination do vary markedly among themselves. As more young lychees begin to fruit, more intensified evaluation, similar to that already undertaken on the longans, will be initiated.

**LITERATURE CITED**


**TROPICAL FRUIT TREE AND OTHER EXOTIC FOLIAGE AS HUMAN FOOD**

**Julia F. Morton, Director, Morton Collectanea, University of Miami, Coral Gables**

To most of us, the terms “green vegetable” and “vegetable greens” convey an image of the leafy products of herbaceous plants commonly cultivated as annual garden or field crops. It has recently been made quite obvious to me that, in terms of world food sources, this is a rather limited view. Though I have long known that the leaves of certain trees and other woody plants are edible, have been resorted to in emergency, or, like those of the European bay (Laurus nobilis L.) and the Asiatic curry (Murraya koenigii Spreng.), commercially dried and utilized as spice, I did not fully realize that, for large populations in tropical countries, eating fresh tree leaves as vegetables is not a matter of casual nibbling but is truly a way of life.

This past spring, while engaged in a field survey in the Philippines and Southeast Asia, in