so narrow that the ovary is exposed. Fruits do not abscise or enlarge. Staminate inflorescences are progressively stunted towards the stem tip, maturation of flowers is delayed and the few that open are small and bear no pollen.

Some plants recover spontaneously from YSL by resumption of normal growth but symptomatic leaves remain on the plant for many weeks. Recovered plants may develop the disease again at a later date.

During the past 2 years YSL has appeared in June during hot, rainy periods especially where short periods of flooding occurs after heavy rains. It has occurred in plants growing on raised beds covered with plastic mulch as well as plantings on level land. Plants have recovered during dry periods and YSL has recurred during subsequent wet periods. It has not developed or recurred during late fall and winter but some affected plants have displayed symptoms throughout this period.

Experimental Reproduction of Yellow Strap Leaf

Examination of affected papayas in the field revealed no signs or symptoms of a pathogenic disease either above or below ground. Since symptoms of YSL and circumstances of its occurrence are similar to those described for YSL of chrysanthemum an experiment was designed to test the hypothesis that the two diseases have a similar cause.

Soil was obtained from near the roots of papayas affected by YSL. Part of this was used without treatment and part was used to “inoculate” potting soil. Half of these soils were pasteurized with aerated steam at 170°C for 1.5 hr. These soils together with untreated potting soil were placed in 8” plastic pots and two 6” papaya seedlings were transplanted into each pot. “Wet” soil was provided by placing the pots in 9” pie pans which were filled with water twice daily. When full water stood about 25 mm above the base of the pot. Plants in “dry” soil were provided with good drainage and watered by hand as needed to maintain active growth. These treatments are summarized in Table 1. Each treatment was replicated 4 times. The experiment was started on July 18, 1978. Initial symptoms of YSL were evident 7 days later and severe symptoms 15 days later. YSL developed in untreated YSL-soil and in the mixture of YSL and potting soil but only when these soils were wet. YSL did not develop in pasteurized YSL-soil or in any dry soil treatment (Table 1).

The experiment was repeated in 1979 with identical results except that YSL developed 13 days after the moisture regimens were begun.

Discussion

The results of experiments to reproduce YSL indicate that the cause of the papaya disease is very similar to the cause of YSL of chrysanthemum. Symptoms of the diseases are similar, both occur in the field and are reproduced experimentally in very similar situations. This evidence strongly supports the hypothesis that YSL of papayas and chrysanthemum have a common etiology.

Literature Cited

Species and Cultivars

Spondias borbonica Baker comes originally from Mauritius and Reunion. It makes a tall tree with large pinnate leaves and has very deeply furrowed bark. It is similar in appearance to S. mombin. Although the tree has been growing here for many years the fruit and flowers have not been seen.

Spondias cytherea Sonn. (syn. S. ducis Parkinson) is called the ambarella, vi, or Otaheite apple. It is native to Polynesia. The species forms a medium sized tree (12 to 15 m tall) with smooth bark and large pinnate leaves to 40 cm long. The flowers are born terminally in spring and fruits ripen in the fall and early winter. The fruit is 6 to 8 cm long and 5 or 6 cm in diameter. The skin or pericarp is yellow when mature and somewhat leathery. The edible flesh (mesocarp) is yellowish in color and about 1 cm thick. The stone or woody endocarp has projections or spines that stick out into the flesh and complicate the use of the fruit. Seeds are produced in five small cavities in the stone. Often only one or two of the seeds will be developed. Although there is some variation among the seedlings, some being sweeter and with a thicker flesh than others, none has been propagated or named here.

Spondias mombin L. (syn. S. lutea L.) is called the yellow mombin, hog plum or jobo. It appears to be native from southern Mexico and the Caribbean south into northern South America. The species makes a medium sized tree (12 to 15 m) and has a rough bark somewhat like S. borbonica. The flowers are borne in large terminal panicles. The leaflets of the large pinnate leaves are more pointed than S. borbonica and a little more rounded at the base. The fruit is yellow in color but not as large as S. cytherea. It has a smooth stone. The fruit is not well liked anywhere and is inferior to S. purpurea which it resembles. Very few fruits seem to set on the few trees which are found in collections in South Florida.

Spondias purpurea L. F. Kurz (Syn. S. mangifera Willd.) has been grown for some years at the University of Florida Agricultural Research and Education Center (AREC) at Homestead. The trees are somewhat like those of S. cytherea but smaller and the individual leaflets are larger and rounder. The fruit is similar in appearance to S. cytherea but smaller with a smooth stone and is strongly resinous, acid, and bitter in flavor. Unless much superior cultivars can be found it has little merit for cultivation in our area.

Spondias tuberosa Arruda in Koster is known as the imbu in Brazil where it is native. It is reputed to be the best of the genus for its quality of fruit and has been introduced into Florida several times but it has not survived here to produce fruit. The leaves are smaller and there are fewer pinnate than with the other species.

Flowering Behavior

The flowers of our species of Spondias are considered to be polygamous, that is male, female and bisexual flowers occur on the same tree. The flowers of Spondias cytherea, S. mombin, and S. tuberosa that I have observed have all been perfect with anthers that appear normal and five good stigmas. Spondias purpurea on the other hand seems to be dioecious in our collection. According to Jorge Leon (2) the flowers of S. purpurea have small stamens at the base of the sessile ovary but no fertile pollen is produced. Therefore no seed is produced by this species and it is always propagated vegetatively. My observations of the cultivars agree with this but we have at least one tree that was grown from seed and which has produced only male flowers. The male flowers have longer filaments and no ovary. I do not know whether this tree produces fertile pollen but it would seem that good pollen must be produced in the area of Costa Rica where the seed for this tree came from unless it developed by parthenogenesis. It would seem that male trees occur in the area where this species is native but where it is only grown as cultivars as an introduced species the male trees would not occur. There is also the possibility that manifestation of sex by individual trees may change from year to year.

Another curious thing about the flowers of S. purpurea is the number of cells in the ovary. This may vary from three to twelve with the styles protruding irregularly from the ovary. In developing each cell of the ovary may make a lump or knob on the fruit. If there are enough cells they may all coalesce at maturity and produce a regular shaped fruit. The number of cells in the ovary may govern the size of the fruit and fruit of various sizes and shapes can be produced by a single tree. Fortunately there are many characters other than
fruit size and shape that can be used to distinguish cultivars. These include color of the flower which may be yellow or red and seems to correlate with the color of the mature fruit.

Propagation

All species can be propagated from seed but *S. purpurea* can be propagated this way only on the rare occasions when a fruit with a good seed is obtained. The flesh is cleaned from the stone and then the stone is planted whole. More than one plant may develop from this stone because there is a potential of five seeds in each fruit. Germination may take place in one to several months. If more than one seed germinates from the same stone it is sometimes possible to separate these when the plants are several inches tall.

Vigorous growing tip cuttings about 20 cm long were taken in late June and early July from trees of *Spondias cytherea*, *S. mombin* and *S. purpurea*. These were planted in a mixture of peat and perlite and placed in intermittent mist. Roots were produced on cuttings of all three of these species in 4 to 6 weeks. The cuttings were then transplanted and grew off nicely.

*Spondias purpurea* and *S. mombin* are commonly used in the tropics as living fence posts. For this purpose large cuttings 8 to 10 cm or more in diameter and several meters long are stuck in holes in the ground where the posts are wanted and they quickly take root and become living fence posts. This is probably the most common method of propagating these species. Ruehle (4) states that the amberella, *S. cytherea*, can also be propagated by this means as well as by air layering but I have not seen it done.

*Spondias tuberosa* was successfully grafted by side veneer graft, onto *S. purpurea* at AREC Homestead. The graft grew to flowering stage and appeared to be healthy but it was eventually lost by being inadvertently pruned off. According to Popenoe (3) it was also inarched onto *S. cytherea* at one time in Florida. Probably the other species can be grafted too, but no useful purpose would be served.

Cold Hardiness

All species tried seem to be very sensitive to cold. They have been successful only in the warmest locations of South Florida and the Florida Keys. *Spondias cytherea* seems to be a little harder than the others. During the freeze of January 1977 at the Montgomery Foundation the temperature of 10 or 12 cm were frozen nearly to the ground. They subsequently sprouted from the ground line and have made fair trees again producing some fruit the following year. A small tree of *S. cytherea* was frozen back to wood about 2 cm in diameter and a large tree of *S. mombin* was frozen back to wood 5 or 6 cm in diameter. This gives an indication of the sensitivity of these trees to cold. From a comparative standpoint they appear to be a little more sensitive to cold than the mango.

Soils and Other Cultural Requirements

The species of *Spondias* seem to grow equally well on rocky limestone soils or acid sand. They do require good drainage however. The soil requirements of *S. tuberosa* are still not understood. The tree did not seem to thrive on its own roots at AREC Homestead but some factor other than soil may have been involved.

One of the requirements that all of the species seem to have is the need for nearly full sunlight in order to grow and fruit. A shaded tree will produce little or no fruit. The trees are drought tolerant and seem to need no supplemental irrigation. They go dormant in late winter. *S. purpurea* will lose its leaves for several months and the other species may lose their leaves for a shorter period. The trees do not seem to need a rich soil and thrive without much added fertilizer. They grow more vigorously, however, with a regular fertilizer program. No schedules have been worked out however. There are very few insect problems with these fruits and they seem to be little bothered by caribbean fruit fly under our conditions.

The Future

For those who enjoy an interesting fruit, the better cultivars of *S. purpurea* can be recommended for dooryard cultivation in the warmer areas of South Florida. It is difficult to know whether better cultivars of this species exist in cultivation because no thorough exploration has been done for them in the areas where they are native. Some improvements may be possible by breeding if the male trees turn out to have fertile pollen. Surely *S. tuberosa* will eventually be successfully introduced and some superior cultivar of *S. cytherea* propagated so that this species too may become more popular.

Literature Cited