TECHNICAL SESSIONS
Wednesday Morning, December 5, 1973

The twenty-third annual meeting of the Eastern Region of the International Plant Propagators' Society convened at 8:35 a.m. in the Saddlebrook-Washington Rooms of the Chicago Marriott Hotel, Chicago, Illinois. President H.B. Tukey, Jr., was moderator for the opening session.

PRESIDENT TUKEY: Good morning. We will now begin the 23rd annual meeting of the Eastern Region of the International Plant Propagators' Society. We have a very large attendance at this meeting with about 350 registered so far. We also have a very fine program for you, which was put together by your Vice-President, Dave Paterson.

With us this morning we have Mr. Rene Koch, who is Chief Horticulturist for the Chicago Park District who brings us greetings from the Mayor's office.

MR. KOCH: This is the windy city, but I am not going to be a windy speaker. On behalf of the Mayor of Chicago who could not make it today because he is working on the city budget and also on behalf of Edmond Kelley, the Superintendent of the Park District, I welcome you to Chicago.

PRESIDENT TUKEY: The following telegram as been received from Mayor Daley, "I know that your Society contributes greatly to gardening and this ultimately benefits homeowners and our parks. I want to extend warmest greetings to everyone attending your convention and I hope it is a great success. Sincerely, Richard J. Daley, Mayor."

At this time we will move into our program. I feel it is appropriate that being in the State of Illinois we start off with a representative of the University of Illinois, Dr. Jack Gartner, who will tell us about the use of hardwood bark in container production.

THE USE OF HARDWOOD BARK AS A GROWTH MEDIUM

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Growers of ornamental crops in the Southeast and the West Coast of the United States have used bark as a soil amendment or as a growth medium in container growing. In the Southeast the southern pine species are used and on the West Coast the

Douglas-fir, redwood, and western red cedar, are predominant trees harvested for lumber and pulp. Growers in the Northeast and Midwest have only recently utilized bark as a soil amendment. In this area the trees harvested are hardwood species such as oak, hickory, maple, walnut, and ash. In the past there was considerable speculation that bark and sawdust of hardwood species was toxic and growers were afraid to use these materials as soil amendments.

Recently, new laws were enacted and producers of bark wastes could no longer dump or burn these residues. Therefore, they were interested in finding other ways of disposing of them. Growers of ornamental crops have become more interested in artificial growth media and are switching to container growing as labor and land prices increase. Sphagnum peat and sand have been standard soil amendments in the past and growers have been looking for substitutes since the cost of sphagnum peat is steadily increasing.

In 1966, Bosley (3) reported success in growing rhododendrons in well-aged bark of hardwood species. This stimulated the interest of Midwest growers in the use of hardwood barks as a growth medium. No information on the use of hardwood bark as a growth medium was found in the literature. Lunt and Clark (5), Allison (1) and Bolin (2) all reported success in using softwood species as a soil amendment for container growing. The only problem they encountered was a suppression in growth from the lack of nitrogen.

In 1967, work was started at the University of Illinois on the use of hardwood bark as a growth medium. Since more than one research project is being discussed, the different problems encountered are presented as separate topics.

PHYSICAL PROPERTIES OF BARK

The paper industry is the largest supplier of hardwood bark in the Midwest. They utilize mixed species and this was used for the initial experiments.

At first we were concerned about particle size. When the hardwood bark is hammermilled to pass through a 12.8 mm screen, 0.7% are larger than 6.4 mm, 12.9% between 3.2 and 6.4 mm, 17.6% between 1.6 and 3.2 mm, 17.6% between 0.8 and 1.6 mm, 9.7% between 0.5 and 0.8 mm, and 26.5% smaller than 0.5 mm. Plants were grown in the various particle sizes; in particle sizes less than 0.8 mm, poor growth resulted due, in part, to poor aeration. When grown in particle sizes above 6.4 mm, poor results were obtained due to rapid drying and low moisture. Experiments were then established to determine the percent of particle sizes needed. The percentages of particle sizes were varied as to the percent below 0.8 mm and the percent above 3.2 mm. Good results were obtained when there was between 20 and 40% particles below 0.8 mm. Satisfactory growth was obtained when 10 to 20% of the particle sizes were above 6.4 mm. When hammermilling the bark to have tha majority of particle sizes fall below 12.7 mm, they fall well within this range.

Bark is hard to wet if it is allowed to dry out; water it thoroughly the first two or three waterings. If it does dry out, it may be necessary to add a wetting agent to wet it.

NITROGEN UTILIZATION

Nitrogen depletion occurred in our first experiments, which followed the recommendations of Lunt (5), who developed procedures for growing in fir and pine bark. We were unable to overcome the nitrogen deficiency using a commercial fertilizer with a 12-12-12 analysis without running into problems of high soluble salts.

Three slow-release forms of nitrogen were selected: urea formaldahyde (38% N), magnesium ammonium phosphate (7% N) and Osmocote, a plastic coated balanced fertilizer (18-6-12). Osmocote gave the best results, equivalent to or better than that obtained with the standard mix of equal volumes of soil, peat and perlite as reported by Gartner, *et al.* (4)

Five N sources, i.e. urea, ammonium sulfate, ammonium nitrate, calcium nitrate, and sodium nitrate were studied. Ammonium nitrate was consistently the best source of nitrogen, as found by Gartner, *et al.* (4)

We are now attempting to determine why a balanced N source has to be used; perhaps it is a lack of nitrifying bacteria or a pH factor may be involved. When an ammonical source of N is used the pH of the medium decreases and when a nitrate source is used it increases. We find that it takes about 2% N in the form of ammonium nitrate to satisfy the decomposition of bark or 2 lbs/cu yd. With softwoods, an ammonical source of nitrogen can be used without difficulty.

pH FACTOR

As recommended by Lunt (4), we incorporated lime at the rate of 10 lbs/cu yd and the results were poor. Soil analysis revealed high pH values; the more bark in the mix the higher the pH (5). When 2/3 bark by volume was used, the pH ran as high as 8.5. We then studied the use of lime with bark using 1, 10, 20 and 40 lbs/cu yd. As indicated in Table 1, the greater the lime amendments, the higher the pH and the poorer the growth.

Table 1. Influence of lime level on pH* of various media at start of experiment and the highest pH measured.

	Lime Added lbs/cu yd							
	0		10		20		40	
	pH		pH		pH		pH	
Medium	Start	High	Start	High	Start	High	Start	High
Soil/peat:perlite	4.3	6.4	5.2	6.5	5.8	7.0	6.2	7.2
Soil:bark:perlite	5.0	7.2	5.8	7.5	6.2	7.5	6.0	7.8
Soil:bark	4.9	7.8	6.0	7.8	6.0	8.0	6.4	8.0

*pH read by Beckman Model B pH meter in saturated media paste.

If the bark was kept moist with distilled water the pH increased from 5.2 to 6.2 after 30 days. Spectrographic analysis of the bark showed calcium averaging 4.0% on a dry weight basis. It was found that calcium and magnesium were not needed, as there were sufficient amounts in the bark for good plant growth as reported by Klett, *et al.* (5). Analysis has shown the bark to have sufficient micronutrients for growth and we have had no deficiency problems.

PHYTOTOXIC PROPERTIES OF BARK

Our early studies did not indicate any phytotoxic properties of the bark. In the experiments on particle sizes, however, we seemed to have some plant inhibition. When bark leachate was used to water seedlings, germination and growth was suppressed. This bark had been harvested in mid-winter, which was the only difference from previous bark utilized.

It was found that by composting moist for a period of 30 days we could overcome the inhibition. Experiments were then designed to determine if all species contained this inhibitory action and if the time of year the bark was harvested was a critical factor.

In greenhouse experiments an apparatus developed by Koeppe and Bell (7) to determine phytotoxic properties was utilized. Rooted cuttings of chrysanthemum were grown in crocks of quartz sand connected to a crock filled with bark. A complete nutrient solution was circulated through the system daily. The nutrient solution was monitored every 3 days, keeping it at a pH of 6.0-6.5 and constant in nutrients.

Bioassays of aqueous bark extract using oat coleoptiles (9) and a cucumber seedling germination test were also used to study the inhibition.

The following species were tested for phytotoxicity: sycamore, white oak, red oak, ash, maple, cottonwood and walnut. Samples of bark from each species were taken from three trees of each species within 5 days of being harvested. This was done at three seasons of the year: summer, fall and winter. All samples were ground, air dried, and quick frozen to prevent any microbial activity.

The degree of inhibition varied among species and the season of the year (Table 2). Sycamore had the least inhibition and ash, maple, cottonwood and walnut the greatest. Most inhibition occurred with bark harvested in the winter months and the least in the summer. If the bark was aged for 30 days, being kept moist with distilled water and turning daily to insure good aeration, the inhibition was overcome (Table 3). In the greenhouse experiment, the different species required different amounts of nitrogen to maintain the proper level and different amounts of H^+ to maintain the pH as shown in Table 4.

Table 2. Mean elongation of oat, cucumber, and chrysanthemum for different seasons using various hardwood barks.

	Fall			Winter			Summer		
Treatment	*Oat mm	Cucumber mm	'Mum cm	*Oat mm	Cucumber mm	'Mum cm	*Oat mm	Cucumber mm	'Mum cm
10^{-6} M IAA	8.01			7.20			7.67		
Water	3.84	52.25	20.5	3.83	51.51	22.0	4.47	49.76	17.0
Sycamore	4.38	55.70	20.9	4.66	51.27	16.8	5.03	37.60	18.6
White oak	4.32	51.44	18.4	2.59	35.40	11.8	2.87	45.45	12.0
Red oak	3.74	45.13	20.0	3.04	33.55	10.8	3.40	39.73	12.0
Ash	3.40	41.45	18.8	2.62	30.85	12.8	3.67	17.76	15.9
Silver maple	3.09	45.18	16.0	2.11	26.86	9.1	4.00	26.63	16.3
Cottonwood	2.86	57.20	——	3.42	39.43	——	4.10	38.00	——
Black walnut	1.34	35.88	16.8	2.06	16.99	12.5	3.20	28.21	11.1
LSD .05	.80	3.50	6.3	.45	4.79	6.3	.37	6.15	6.3

*Treatment for oats included addition of IAA to each bark extract.

Table 3. Mean elongation of oat and cucumber using fresh and 30-day aged hardwood barks.

	*Oat		Cucumber	
Treatment	Fresh mm	Aged mm	Fresh mm	Aged mm
10^{-6} M IAA	8.20	7.97		
Water	5.37	4.54	45.78	45.78
Sycamore	5.34	6.66	32.59	49.56
Ash	3.80	5.96	31.55	55.00
Red oak	3.78	6.24	20.61	53.05
Black walnut	3.20	4.21	20.09	56.05
Silver maple	2.62	6.46	8.66	45.88
White oak	2.54	4.01	24.25	49.74
LSD .05	.58		4.34	

*Treatment for oats included addition of IAA to each bark extract.

Table 4. Meq. of H^+ added to maintain a pH from 6.0 to 6.5 and meq. of $-NO_3$ added to maintain solution at 15mM after 20 days.

	H +	$-NO_3$
Sand	30	45
Silver maple	60	280
Black walnut	250	270
Red oak	280	600
Ash	360	450
Cottonwood	445	480
Sycamore	515	625

Using paper chromatography, ten compounds having various degrees of inhibition in the bioassays were isolated. Work on the identification of these inhibitors is continuing. Experiments were designed to see if rate of decomposition had any effect on the inhibitors or their breakdown. the evolution of CO_2 from decomposing bark was measured by an incubation unit designed by Stotzky, *et al.* (10). A greater CO_2 production would mean greater decomposition and consequently a higher need for nitrogen. Fresh winter barks from sycamore, hackberry, cottonwood, and silver maple were incubated for 30 days. Hackberry and silver maple released twice as much CO_2 as did sycamore and cottonwood (Table 5) indicating that the latter two barks might not require as much nitrogen.

Table 5. Total amount of carbon released from decomposing bark over a 30-day period.

Bark	Carbon (mg)
Silver maple	258
Hackberry	223
Cottonwood	146
Sycamore	145

To check this, chrysanthemums were grown in the four freshly harvested barks. On the basis of height and dry weight measurements, chrysanthemums grown in sycamore and cottonwood bark were better than those grown in hackberry and silver maple bark. We also found that the plants grown in silver maple and hackberry, particularly silver maple, were slower in rooting than those grown in cottonwood and sycamore bark. Plants grown in maple bark had a very poor root structure until 4 weeks after the cuttings were potted. After this period of time, an adequate root structure was evident. Further studies with fresh bark, and bark composted for 30 days, showed the inhibition was almost eliminated after 30 days of composting (Table 6).

Table 6. Effect of species and age of bark on dry weight of chrysanthemums grown in 2/3 bark and 1/3 sand.

Species	Dry Weight (g)	
	Fresh	Aged (30-day)
Silver maple	20.0	31.7
Hackberry	16.8	27.5
Sycamore	27.5	41.8
Cottonwood	33.7	33.1

LSD .05-7.1

RATES OF BARK USED AND AMENDMENTS

Initially we substituted the ground bark for peat in our standard mix of 1/3 soil, 1/3 peat and 1/3 perlite by volume. Now we are utilizing 2/3 bark and 1/3 soil or sand, by volume. In our experiments we found no difference between soil and sand. The sand we use is a coarse masonary sand; most growers prefer using sand as it is readily obtained and is uniform from place to place.

Due to inhibitors, we have found that it is essential to stockpile the bark mix for a minimum of 6 weeks. During this stockpiling procedure it is essential to keep the mix moist — at least 60 to 90% moisture.

From our experiments we have derived the following formula which several commercial growers are utilizing in Illinois for production of their crops.

To each cu yd of mix, when utilizing 2/3 bark and 1/3 sand, you must add 6 lbs. of ammonium nitrate, 5 lbs. of superphosphate, 1 lb. of elemental sulphur and 1 lb. of iron sulfate. This should then be mixed in a drum or rotary mixer to obtain a thorough mix. After mixing, it should be stockpiled moist for a minimum of 6 weeks. After stockpiling, it is ready for use. The amount of nitrogen recommended is only for offsetting the decomposition and it is, therefore, still essential to fertilize at every watering, using a complete nutrient solution of a 20-20-20 analysis, utilizing a 250 ppm of N. This may vary according to the crop, depending on its nutrient requirements.

Advantages of Bark:

1. Bark is fairly economical and readily available.
2. Bark has an excellent waterholding capacity.
3. It provides a well-drained and well-aerated medium that is difficult to overwater.

4. The plants are able to obtain water readily from the bark; bark mixes do not seem to dry out rapidly.
5. Bark contains all minor elements essential to plant growth.
6. It is light in weight and easy to handle.
7. Preliminary experiments indicate a reduction in nematode population when using bark.
8. Ion exchange capacity exceeds that of peat and increases with age.

Precautions

1. Lime cannot be added. The pH rises as the bark ages; bark contains 3½ to 4% calcium by dry weight.
2. Nitrogen must be added. Ammonium nitrate is the best source and should be added at the rate of 6 lbs. per cubic yd. Avoid using urea and straight ammonium sources.
3. A thorough mix must be obtained by using a rotary-type mixer.
4. The bark must be stockpiled for 6 weeks prior to use.

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PRESIDENT TUKEY: We do have time for a few questions.

BILL CURTIS: It is my understanding that on the West Coast when bark is stockpiled with Osmocote we have problems with root burn.

JACK GARTNER: Yes, you can get too much fertilizer release under those conditions. We are not recommending Osmocote anymore; we now recommend ammonium nitrate stockpiling for about 60 days. The pile should not be too large and should preferably be turned at least once during this time. We have noticed some heating during stockpiling with temperatures of 140^0 to 150^0 F during the first 10 days but this gradually goes down.

JIM WELLS: You're putting in 6 lbs. of ammonium nitrate to overcome nitrogen deficiency, what is your fertilization program thereafter?

JACK GARTNER: This depends upon the crop but usually runs about 200 ppm N using a balanced source such as 20-20-20 or 20-10-5, applied with each watering. With high N crops we may go up to 250 or 300 ppm N.

VOICE: Would there be an advantage to dissolving the fertilizer and applying it to the bark to have it absorbed into the product, much like a Pro-mix, or is this what you are accomplishing by stockpiling?

JACK GARTNER: I believe you might get into trouble with non-uniform distribution by dissolving and adding the fertilizer to the bark, though I understand some growers in Ohio are doing it this way. I have not tried this method yet, but as long as you get uniform distribution through the bark it should work.

BRYSON JAMES: Did you measure your nitrogen levels before and after composting, to arrive at the 6 lb. rate?

JACK GARTNER: We established this on an empirical basis at first, actually getting our best results at 9 lb. but there is some danger of burn, so we settled on the 6 lb. rate. In addition, two laboratory procedures — rate of bark decomposition and the circulatory system — both gave nitrogen values of around 2% actual N.

RICHARD BOSLEY: I want to commend you on what you have done. I do wish to comment on how the N gets distributed through the bark by our method which uses urea as the N source. The bark is composted in layers using 3 to 4 lb. of urea per cu yd. This is covered with polyethylene and almost immediately the bacteria begin coverting the urea to ammonia gas and this is how the N is distributed through the pile. I suspect this also does a good job of killing any pathogens which might be present. At warm temperatures, the reaction is usually complete in 48 or so hours; this can be determined by raising the poly and if you smell ammonia it is not complete.

JACK GARTNER: You then add dolomitic limestone afterwards don't you?

RICHARD BOSELY: Yes, after composting we add any other ingredients, e.g. sand, peat, etc., with which we may wish to ammend the medium.

JACK GARTNER: The point I wish to make is that we went to ammonium nitrate to avoid the drop in pH we got when we used urea or the increase we got when we used only nitrate. Ammonium nitrate avoids a pH shift which has to be corrected after composting. Our two methods are probably giving the same result.

PRESIDENT TUKEY: Thank you Jack, you have certainly gotten us off to a good start. Our next speaker is from the Cooperative Extension Service in Ohio and Fred Buscher will be talking about determining air-filled pore spaces in container media.