Discussion

Controlled atmosphere storage has been shown to be an effective alternative to 0°C air storage of kiwifruit (7, 8) to reduce flesh softening during storage. Our data indicate that these benefits can be achieved only if CA conditions are established within a few days of harvest. The reduction of flesh softening attained in this study in response to rapid establishment of CA is similar to those reported for 'Golden Delicious' (4, 5), 'McIntosh' (4, 10), and 'Cox's Orange Pippin' (9) apples. If delays exceed one week, then the softening process will have already been initiated and the benefits of CA will be reduced severely. This consequence must be considered when designing and operating commercial kiwifruit CA facilities. The size of each CA room should be related to the anticipated daily volume of fruit so that loading and atmosphere modification can be completed within 1 week from fruit harvest.

CA storage (2% O_2 + 5% CO_2) does not effect the performance of kiwifruit greatly when subsequently transferred to 0°C air storage, since the rate of kiwifruit softening at 0° in air seems relatively unaffected by prior CA storage. CA conditions, therefore, should be maintained until just prior to marketing to optimize the fruit's market life. Air-stored kiwifruit should perform equally as well as CA-stored kiwifruit of the same firmness during subsequent market handling.

Literature Cited

1. Claypool, L.L. and R.B. Fridley. 1966. Precision with a Pressure Tester. Western Fruit Grow. 20(7):18–19.
2. Eckert, J.W. and N.F. Sommer. 1967. Control of diseases of fruit and vegetables by postharvest treatments. Annu. Rev. Phytopath. 5:391–432.
3. Gatti, R. 1984. Susceptibility of kiwifruits to mechanical injury at harvest and during storage. MS Thesis, Univ. of California, Davis.
4. Lau, O.L. 1983. Storage responses of four apple cultivars to a "rapid CA" procedure in commercial controlled atmosphere facilities. J. Amer. Soc. Hort. Sci. 108(4):530–533.
5. Lau, O.L. and N.E. Looney. 1982. Improvement of fruit firmness and acidity in controlled-atmosphere-stored 'Golden Delicious' apples by a rapid O_2 reduction procedure. J. Amer. Soc. Hort. Sci. 107(4):531–534.
6. Lidster, P.D., H.J. Lightfoot, and K.B. McRae. 1983. Fruit quality and respiration of 'McIntosh' apples in response to ethylene, very low oxygen and carbon dioxide storage atmospheres. Scientia Hort. 20:71–83.
7. McDonald, B. and J.E. Harman. 1982. Controlled atmosphere storage of kiwifruit. I. Effect on fruit firmness and storage life. Scientia Hort. 17:113–123.
8. Mitchell, F.G., M.L. Arpaia, and G. Mayer. 1982. Modified-atmosphere storage of kiwifruits (*Actinidia chinensis*), p. 235–238. In: D.G. Richardson and M. Meheriuk (eds.). Proc. 3rd Natl. Controlled Atmosphere Res. Conf., Symposium Series No. 1, Oregon State Univ. School of Agr. Timber Press, Beaverton, Ore.
9. Sharples, P.O. and G.C. Munoz. 1974. The effects of delays in the period to cool and establish low oxygen concentrations on the quality of stored 'Cox's Orange Pippin' apples. J. Hort. Sci. 49:277–286.
10. Smock, R.M. and G.D. Blanpied. 1963. Some effects of temperature and rate of oxygen reduction on the quality of controlled atmosphere stored 'McIntosh' apples. Proc. Amer. Soc. Hort. Sci. 83:135–138.
11. Sommer, N.F., R.J. Fortlage, and D.C. Edwards. 1983. Minimizing postharvest diseases of kiwifruits. Calif. Agr. 37(1–2):16–18.

J. Amer. Soc. Hort. Sci. 109(6):770–773. 1984.

Construction of a Milled Pine Bark and Sand Potting Medium from Component Particles I. Bulk Density: A Tool for Predicting Component Volumes

F.A. Pokorny[1] and B.K. Henny[2]
Department of Horticulture, University of Georgia, Athens, GA 30602

Additional index words. soilless medium, laboratory analysis

Abstract. **Volume of loose media was determined accurately by a devised mechanical method and used for bulk density (BD) calculations. BD associated with increasing percentages of pine bark and/or sand potting media were plotted. Linear increase in BD associated with increasing percentage of sand in the medium was used to predict the percentage by volume of sand and/or bark in an unknown mixture of the two components. The technique should be useful in synthesis studies utilizing pine bark and sand as medium components.**

Bulk density (BD) is an important soil physical property which influences other physical and chemical properties. Measurement of soil BD requires either an undisturbed soil core or a soil clod. To obtain BD from an undisturbed soil core, a sample cylinder of known volume is inserted into the soil, a core is withdrawn, oven-dry weight is determined, and BD calculated (1). When an undisturbed soil clod is used for BD determination, the clod is coated with saran resin, which is permeable to water vapor but not to liquid water. Volume of the soil clod is determined by water displacement and BD calculated (2).

Received for publication 1 Dec. 1983. Supported by State and Hatch funds allocated to the Georgia Experiment Stations. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

[1]Professor.

[2]Former Graduate Student, Tavares, FL 32778.

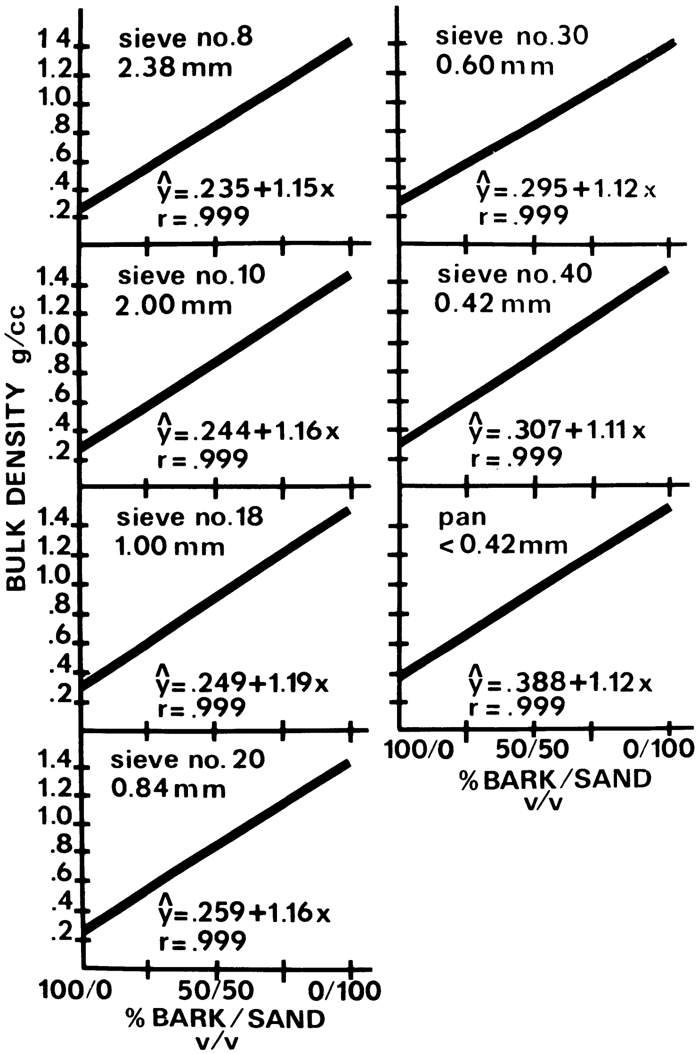

Fig. 1. Linearity of standard bulk density curves determined for predicting percentage pine bark/sand on an air- and oven-dried basis.

Methodology varies for volume determination used in BD calculations of artificial potting media. DeBoodt and DeWaele (4) used a ring sampling technique similar to that described by Baver (1) for BD determination of undisturbed field soil. This technique compacts organic media and is not always feasible for use in pots or with plants grown at close spacing. Swartz and Kardos (10), using aluminum cylinders of known volume, mechanically compacted loose, moist, golf green soil samples comprised of soil, sand, and peat and calculated BD from the depth of the soil in the sample cylinder after compaction. Joiner and Conover (6) and Richards et al. (8) determined BD by marking potting medium level in the container, measuring soil volume and oven-dry weight, and calculating BD. Mazur et al. (7) determined BD of hardwood bark potting media by filling cylinders with 1240 cm^3 of medium, weighing the cylinders, and calculating BD.

The objectives of this study were: 1) to devise and develop a mechanical method for settling loose samples of potting medium and/or components uniformly, and, 2) to establish standard curves based on BD for different particle size fractions of pine bark and sand media, and their use in predicting percentage by volume of pine bark and/or sand particles of a designated particle size in an unknown volume mixture of the 2 components.

Materials and Methods

One-hundred-ml plastic graduated cylinders (base diameter 5.5 cm) were placed in 5 front clamps along each of 2 arms of a Burrell wrist-action shaker. Bases of the graduated cylinders hung inside anchored wooden boxes 12 cm W × 48 cm L × 12 cm H. Distance between the clamp of the wrist-action shaker and cylinder top was 2 cm. Cylinders were positioned with spouts facing the same direction and with a straight side of the hexagonal base parallel to the front wall of the wooden box. Cylinders were fastened to dowels so that their bases uniformly struck front and back walls of the wooden box when the wrist-action shaker was operating at an angle lever position between 4 and 6. As medium or component samples were poured into each cylinder, a rod was inserted and moved vertically to prevent particle bridging.

Expt. 1. Bulk volumes of milled pine bark and sand were air-dried at a minimum of 30°C. Ten 20-g samples of pine bark and ten 130-g samples of sand were subjected to shaking times of 5, 10, 15, 20, 25, and 30 min. Volumes after shaking were determined. The experiment was conducted in a randomized complete block design with 10 replications. Data were analyzed by ANOVA, and treatments were delineated by regression analysis.

Expt. 2. Sample volume determination of loose potting medium components, the values of which are used in BD calculations, can vary considerably. In this test, mechanical compaction of loose samples was compared with methods used by Smith (9), which requires filling a container of known volume with

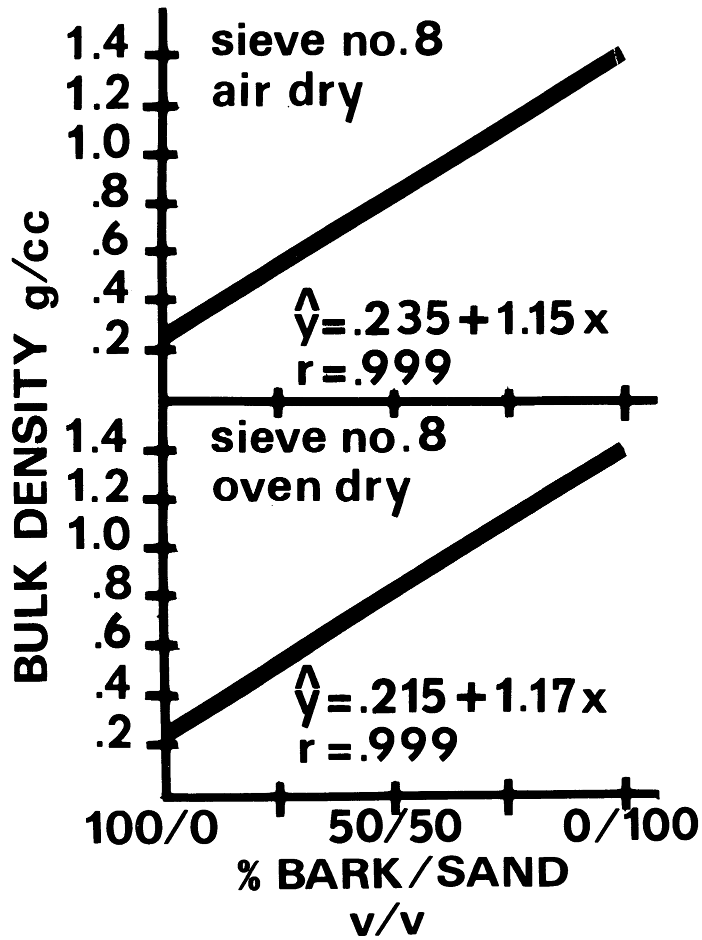

Fig. 2. Standard bulk density curves (air-dried basis) developed for each of 7 particle size ranges for predicting percentage pine bark/sand in an unknown mixture.

Table 1. Volume (ml) and bulk density (BD) of milled pine bark (20 g; calculated vol. 80 ml) and sand (130 g; calculated vol. 90 ml) as influenced by duration of mechanical shaking.

Shaking duration	Mean vol (ml)	$S\bar{x}$	Mean BD (g/cc)	$S\bar{x}$
Milled pine bark				
5 min	81.8*	2.87	0.245*	0.0086
10 min	81.2	2.67	0.246	0.0079
15 min	80.6	2.58	0.248	0.0079
20 min	79.7	2.43	0.251	0.0076
25 min	78.9	2.65	0.254	0.0087
30 min	78.3	2.49	0.256	0.0100
Sand				
5 min	92.1*	2.33	1.412*	0.036
10 min	91.3	1.73	1.424	0.027
15 min	90.8	1.33	1.428	0.021
20 min	90.0	0.82	1.445	0.013
25 min	89.4	1.56	1.452	0.026
30 min	89.1	1.33	1.459	0.024

*Linear response significant at 1% level.

Table 2. Volume (ml) and bulk density (BD) of 20-g loose samples of oven-dried milled pine bark as influenced by 3 methods of compaction.

Method of compaction	Mean vol (ml)	$S\bar{x}$	Mean BD (g/cc)	$S\bar{x}$
Manual tap				
3 times	59.4[z]	5.20	0.34[z]	0.03
40 times	53.5	3.40	0.38	0.02
Mechanical tap				
20 min	54.2	1.98	0.37	0.01

[z]Orthogonal comparisons: Manual tap 3 times vs. others — significant 1%(*) level. Manually tap 40 times vs. mechanical tap — not significant.

Table 3. Bulk density (BD) of pine bark and sand component particles.

Medium component	BD (g/cc)	NBS sieve no. 8	10	18	20	30	40	Pan
Bark	air-dried	0.23	0.24	0.25	0.26	0.29	0.31	0.39
	oven-dried (g/cc)	0.21	0.22	0.23	0.24	0.27	0.30	0.37
Sand	air-dried	1.37	1.40	1.43	1.40	1.41	1.41	1.50
	oven-dried (g/cc)	1.37	1.40	1.43	1.40	1.41	1.41	1.50

an excess of loose medium, tapping the bottom of the container 3 times on a hard surface and removing the excess; and by Brown and Pokorny (3) and Gugino et al. (5), which requires placing loose material in a graduated cylinder and tapping the cylinder base 40 times to settle the medium.

Twenty-gram samples of oven-dried milled pine bark were placed loosely in a graduated cylinder and compacted by each of the 3 methods described. After compaction, volume of a sample was determined and BD calculated. The experiment was conducted in a randomized complete block design with 10 replications. Treatment effects were delineated by orthogonal comparisons.

Expt. 3. Air-dried milled pine bark and sand particles were collected separately after a 20-min shaking period on a Ro-Tap shaker using U.S. Standard sieves with openings of 4.76, 2.38, 2.00, 1.00, 0.84, 0.60, 0.42, and less than 0.42 mm (mesh numbers 4, 8, 10, 18, 20, 30, 40, and receiver pan, respectively). BD, on both an air- and oven-dried basis, was calculated for each particle size fraction of bark and sand, using the mechanical technique described. Each particle size fraction of pine bark, with the exception of the 4.76 mm fraction, was mixed on a volume basis with the same particle size fraction of sand in proportions of 0%, 5%, 10%,. . . 90%, 95%, 100% bark to sand. Air-dried BD of each medium component was used to calculate component weight to yield a 100 cc volume upon mixing. BD of each mixture for the 7 particle size fractions was determined on an air- and oven-dried basis, and standard curves were developed. A randomized complete block design with 10 replications was used, and data were analyzed by ANOVA. Linear regression was calculated to determine if a predictable relationship existed between percentage by volume analysis of the mixtures and BD.

Three bark and sand mixtures (v/v), the volume ratios different for each of the 7 particle size fractions, were prepared by another investigator. These samples, their volume ratios unknown to us, were weighed, their volumes determined, and BD calculated. By identifying BD on the standard curves for the 7 particle size fractions, volume percentage of bark and sand in each mixture was predicted. The experiment was conducted as a randomized complete block design with 5 replications. Accuracy of prediction was determined by standard error of the estimate S_y.

Results and Discussion

Volumes of milled pine bark and sand medium components decreased and BD increased as shaking time was increased from 5 to 30 min. Lowest standard error for volume estimation and BD with pine bark and sand was obtained with the 20-min shaking duration (Table 1).

Volume and BD of loose pine bark samples was significantly greater when compacted 3 times manually in comparison with compacting manually by striking a cylinder 40 times at its base or by tapping the cylinder mechanically (Table 2). There was no significant difference in sample volume for BD between manually striking the cylinder 40 times or tapping mechanically for 20 min. Mechanical compaction of loose milled pine bark or sand samples reduced sample volume variation. Additionally, mechanical compaction allowed for handling 20 samples simultaneously.

BD of both pine bark and sand, either air-dried or oven-dried, increased as particle size decreased (Table 3). Oven-drying of milled pine bark resulted in a slight decrease in weight, but this decrease did not occur with sand. Linearity of standard curves determined on an air- and oven-dried basis was not affected by the slight decrease in BD of the milled pine bark on oven-drying (Fig. 1). Since an additional 24 hr per sample was required for oven-drying, standard curves constructed on the basis of air-dried BD were used to identify components of a bark and sand mix.

BD increased linearly with increasing percentage of sand in the bark and sand mix for all particle size fractions (Fig. 2). Linear regression was highly significant accounting for 99.8% of the response. Since there was a high correlation between BD and percentage by volume of sand in the mixture, standard curves should be precise indicators of the percentage of bark and sand in any mixture retained on a given sieve.

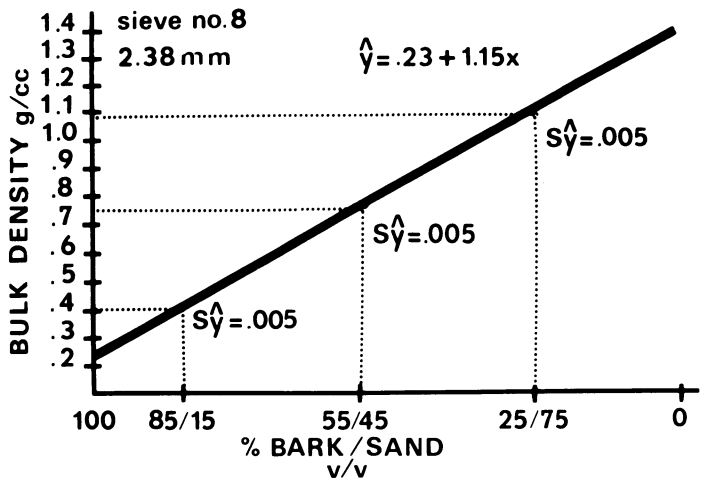

Fig. 3. Identification of unknown volume mixtures of pine bark/sand using standard bulk density curves.

From combined analysis of the 7 standards (Fig. 2), a single equation was developed to predict BD values as follows: $\hat{Y} = a + bX$, where $\hat{Y}$ = bulk density, $a = [0.181 + 0.179 (\frac{1}{1 + S})]$, S = mesh size in mm, b = 1.146, and X = percentage sand. Linear regression for the combined equation was highly significant, accounting for 99.7% of the variation.

Percentage by volume bark and sand in the unknown samples was identified correctly from standard curves (Fig. 3). The largest standard error of the estimate was 0.007. Accurate identification of unknown bark and sand mixtures, with low error of prediction, supports, in part, the hypothesis that standard BD curves can be used to identify the volume of individual components in bark and sand mixtures.

Literature Cited

1. Baver, L.D. 1956. Soil physics. Wiley, New York.
2. Brasher, B.R., D.P. Franzmeier, V. Valassis, and S.E. Davidson. 1966. Use of saran resin to coat natural soil clods for bulk density and water penetration measurements. Soil Sci. 101:108.
3. Brown, E.F. and F.A. Pokorny. 1975. Physical and chemical properties of media composed of milled pine bark and sand. J. Amer. Soc. Hort. Sci. 100(2):119–121.
4. DeBoodt, M. and N. DeWaele. 1968. Study on the physical properties of artificial soils and the growth of ornamental plants. Pedologie 18(3):275–300.
5. Gugino, J.L., F.A. Pokorny, and F.F. Hendrix, Jr. 1973. Population dynamics of *Pythium irregulare* Buis. in container-plant production as influenced by physical structure of media. Plant & Soil 39(3):591–602.
6. Joiner, J.N. and C.A. Conover. 1965. Characteristics affecting desirability of various media components for production of container-grown plants. Soil Crop Sci. Soc. Fla. Proc. 25:320–328.
7. Mazur, A.R., T.D. Hughes, J.B. Gartner. 1975. Physical properties of hardwood bark growth media. HortScience 10(1):30–33.
8. Richards, S.J., J.E. Warneke, A.W. Marsh, and F.L. Abjibury. 1964. Physical properities of soil mixes. Soil Sci. 98:129–132.
9. Smith, R.C. 1970. Characterization of media for container-grown nursery stock. MS Thesis, Univ. of Georgia, Athens.
10. Swartz, W.E. and L.T. Kardos. 1963. Effects of compaction on physical properties of sand-soil-peat mixes at various moisture contents. Agron. J. 55:7–10.