Performance of Biodegradable Nursery Containers©

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INTRODUCTION

Consumer demand for environmentally conscious products and business practices is on the rise (Behe et al., 2013) and consumers are willing to pay more for eco-friendly products, such as plants grown in biodegradable containers. Biodegradable containers or biocontainers are made from plant-based materials and degrade quickly in the environment. Two recent online surveys found that consumers are willing to pay $0.23 to $0.29 (Yue et al., 2010) and $0.61 to $0.82 (Hall et al., 2010) more for plants grown in biocontainers. Besides the market opportunities, nursery growers are interested in biocontainers due to their environmental conscience and interest to reduce transplanting costs. Plantable biocontainers can reduce transplanting time by 17% relative to traditional plastic containers that must be removed when planted (Nambuthiri and Ingram, 2014). In response to industry's interest in biocontainers, a broad range of products are commercially available (Table 1) and others are in development (Evans and Hensley, 2004; Helgeson et al., 2010; Schrader et al., 2013).

Despite consumer interest in biocontainers, the nursery sector has been slow to adopt them. In 2009, less than 25% of greenhouse and nursery growers in the USA used biocontainers and fewer than 15% planned to adopt them in the next 1 to 3 years (Dennis et al., 2010). There are a variety of reasons why growers are reluctant to use biocontainers, which includes premature breakdown and higher cost. This paper summarizes the findings of recent research that compares the performance of a variety of biocontainers to traditional petroleum-based plastic containers. This information will assist growers to select an appropriate biocontainer to meet their needs.

Table 1. The different biocontainers that were used in the studies cited in this paper.

Types of biocontainers	Product names	Manufacturer
Bioplastic	SoilWrap® sleeves	Ball Horticultural Co.
	TerraShell™ (OP_{47})	Summit Plastics Company
Coconut fiber	Coir pots	Myers Industries Inc.
		Dillen Products
Manure	CowPots™	CowPot Co.
Paper	Ellepots	Ellegaard A/S
	Fiber grow products	Myers Industries Inc.
Peat	Jiffy pots®	Jiffy®
Rice hull	NetPot™ and rice pots	Summit Plastics Company
Rice straw	Straw Pot™	Ivy Acres
Wood fiber	Fertil pots	Fertil USA
	Moulded fiber pots	Western Pulp Products

COMPARING THE PERFORMANCE OF BIOCONTAINERS WITH TRADITIONAL PLASTIC CONTAINERS

Strength and Compatibility with Automation

A few studies have measured the strength of biocontainers (Beeks and Evans, 2013b; Evans et al., 2010; Koeser et al., 2013a). In general, the strength of water-permeable biocontainers drops significantly after a few weeks in production (Beeks and Evans, 2013b; Evans et al., 2010). Beeks and Evans (2013b) measured the strength of nine biocontainers after 15 weeks of production of *Cyclamen persicum* 'Rainier Purple' using subirrigation. At the end of the trial, the tensile strengths of peat, manure, wood fiber, and rice straw containers were significantly less than plastic containers. In fact, the peat and manure containers broke during production. Similar findings were reported by Evans et al. (2010). They concluded that bioplastic, coconut fiber, rice hull, rice straw, and paper containers had adequate strength (i.e., at least 2 kg wet vertical and punch strength), while wood fiber, manure, and peat containers did not.

Koeser et al. (2013a) tested how seven biocontainers held up to mechanical filling with a gravity-fed potting machine and shipping the biocontainers in shuttle trays placed on rolling carts in a box truck. All of the biocontainers performed well in the mechanical filling trial. Container damage never exceeded 1.5% and there was no difference in the proportion of biocontainers successfully filled. However, it was noted the manure, peat and rice straw containers were slower to fill because they were difficult to separate. In the shipping trial, 27 and 35% of the manure and peat containers, respectively, sustained damage. The paper and wood fiber containers sustained no damage during shipping and outperformed the bioplastic (8.3% damage), coconut fiber (8.3%), plastic (1.7% damage), and rice straw (6.7%) containers. Based on these findings, growers should be cautious when using manure, peat and, to a lesser degree, wood fiber containers due to their relative fragility.

Plant Growth

Biocontainers must not compromise plant growth or quality to be accepted by industry. Several recent studies have evaluated plant growth in biocontainers. Lopez and Camberato (2011) measured the quality and marketability of *Euphorbia pulcherrima* grown in six biocontainers. After 14 weeks of growth, they concluded that plant quality was not negatively impacted by any of the containers. Kuehny et al. (2011) conducted an extensive study on the growth of three bedding plants in eight biocontainers at three trial sites. Although there was variation in plant growth between the containers types, Kuehny et al. (2011) stated that all of the biocontainers produced marketable plants. In addition, Koeser et al. (2013a) found no variation in leaf area, shoot dry weight and above ground plant volume of *Solenostemon* 'Florida Sun Jade' when grown in seven biocontainers for 7 weeks. Likewise, Beeks and Evans (2013a) found *C. persicum* grown in 10 biocontainers to have significantly higher shoot dry weight, with the exception of wood fiber containers, and equal to or higher root dry weight relative to plastic containers. These findings provide evidence that biocontainers do not negatively impact plant growth.

Water Use of Crops

Biocontainers can have a very significant effect on water use. Containers that are water-permeable have been shown to require shorter irrigation intervals and a significantly greater volume of total irrigation to produce a crop (Beeks and Evans, 2013b; Evans et al., 2010; Koeser et al., 2013b). Crops grown in water-permeable biocontainers can require almost twice as much irrigation as impervious containers (Koeser et al., 2013b). Based on the results of Koeser et al. (2013b), biocontainers can be divided into three categories based on water use (Table 2) that are representative of the results of Evans et al. (2010) and Beeks and Evans (2013b). Koeser et al. (2013b) did not include paper biocontainers in their water use study. Based on the findings of Evans et al. (2010) and Beeks and Evans (2013b), paper biocontainers have low to medium water use.

Table 2. Segregation of biocontainers into water use categories based on the total amount of irrigation required to produce a 5-week-old crop of *Petunia* × *hybrida* 'Yellow Madness' (adapted from Koeser et al., 2013b).

Water use category[z]	Type of biocontainer
Low	Bioplastic, rice hull (solid)
Medium	Coconut fiber, peat, rice hull (slotted)
High	Manure, rice straw, wood fiber

[z]The low, medium and high categories used 2.0-2.5 L, 2.5-3.0 L and >3.0 L of irrigation, respectively.

Algal and Fungal Growth on Containers

The growth of algae, fungi, and other organisms on the walls of biocontainers can be a serious problem. Manure, peat, and wood fiber biocontainers are most susceptible to the growth of algae and fungi (Table 3) (Beeks and Evans, 2013b; Evans et al., 2010).

Table 3. Results from two studies that measured the growth of algae and fungi on the outer walls of biocontainers.

Biocontainer	Algae and fungi coverage[z] (%)	
	Beeks and Evans, 2013b[y]	Evans et al., 2010[x]
Peat	85	47
Wood fiber	80	26
Manure	60	2-4
Rice straw	20	2-4
Paper	10	2-4
Coconut fiber	10	0
Bioplastic	0	0
Rice hull	0	0

[z] Expressed as a percentage of the total surface area of the container walls that were covered with algae and fungal growth.
[y] Results were recorded after 15 weeks of greenhouse production.
[x] Results were recorded after 6 weeks of greenhouse production.

Degradation of Plantable Biocontainers in the Field

A significant advantage of some biocontainers is the ability to plant them without removing the container. This only applies to biocontainers that are classed as plantable; compostable biocontainers do not breakdown readily in the soil and should be removed at planting. The rate of degradation in the soil does vary for different biocontainers (Table 4), but does not seem to negatively impact transplant growth. For instance, Kuehny et al. (2011) observed no reduction in shoot dry weight of *Catharanthus roseus* 'Grape Cooler', *Impatiens walleriana* 'Dazzler Lilac Splash', and *Pelargonium* 'Score Red' when transplanted to landscape beds in coconut fiber, manure, peat, rice straw, and wood fiber containers, with the exception of impatiens grown in manure containers. Nambuthiri and Ingram (2014) found similar results for plants grown in Ellepots and bioplastic sleeves. The lone exception in this study was peat containers. *Ajuga reptans* grown in bioplastic sleeves, plastic, and Ellepot containers covered 26-35% more ground after 15 weeks than in peat containers. Similarly, *Lamium galeobdolon* produced in bioplastic sleeves, plastic, and Ellepot containers, respectively, covered 2.6, 2.4, and 1.9 times more soil surface than in peat containers. Nambuthiri and Ingram (2014) pointed to slow degradation of peat containers as the reason for poor plant growth in that treatment. Although, they also suggested the water wicking nature of peat containers may have contributed to their poor performance, especially since the trial was conducted during a hot and dry summer.

Table 4. The decomposition of five biocontainers 8 weeks post-transplanting at trial sites in Pennsylvania and Louisiana (Evans et al., 2010).

	Decomposition (%)	
	Pennsylvania	Louisiana
Manure	62	48
Peat	32	10
Rice straw	28	9
Wood fiber	24	2
Coconut fiber	4	1.5

SUMMARY

Today, a wide range of biocontainers are commercially available for use by nursery growers. Research has shown that there are differences in the performance of biocontainers, which must be taken into account when selecting and using them. The shortcomings of some biocontainers are premature breakdown, higher water use, and unsightly growth of algae and fungi on the container walls. Cost is another drawback of biocontainers but was not reviewed in this paper. Some shortcomings may be resolved by adjusting production practices. For instance, using plastic shuttle trays and a less porous growing medium may reduce water use of permeable pots (Koeser et al., 2013). Research continues to develop new containers, which will result in more innovative biocontainers being commercialized in the future.

Literature Cited

Beeks, S.A. and Evans, M.R. 2013a. Growth of cyclamen in biocontainers on an ebb-and-flood subirrigation system. HortTech. 23:173-176.

Beeks, S.A. and Evans M.R. 2013b. Physical properties of biocontainers used to grow long-term greenhouse crops in an ebb-and-flood irrigation system. HortSci. 48:732-737.

Behe, B.K., Campbell, B.L., Hall, C.R., Khachatryan, H., Dennis, J.H. and Yue, C. 2013. Consumer preferences for local and sustainable plant production characteristics. HortSci. 48:200-208.

Dennis, J.H., Lopez, R.G., Behe, B.K., Hall, C.R., Campbell, B.L. and Yue, C. 2010. Sustainable production practices adopted by greenhouse and nursery plant growers. HortSci. 45:1232-1237.

Evans, M.R., and Hensley, D.L. 2004. Plant growth in plastic, peat, and processed poultry feather fiber growing containers. HortSci. 39:1012-1014.

Evans, M.R., Taylor, M. and Kuehny, J. 2010. Physical properties of biocontainers for greenhouse crops production. HortTech. 20:549-555.

Hall, C.R., Campbell, B.L., Behe, B.K., Yue, C., Lopez, R.G. and Dennis, J.H. 2010. The appeal of biodegradable packaging to floral consumers. HortSci. 45:583-591.

Helgeson, M.S., Graves, W.R., Grewell, D. and Srinivasan, G. 2010. Zein-based bioplastic containers alter root-zone chemistry and growth of geranium. J. Environ. Hort. 28:74-80.

Koeser, A., Kling, G., Miller, C. and Warnock, D. 2013a. Compatibility of biocontainers in commercial greenhouse crop production. HortTech. 23:149-156.

Koeser, A., Lovell, S.T., Evans, M. and Stewart, J.R. 2013b. Biocontainer water use in short-term greenhouse crop production. HortTech. 23:215-219.

Kuehny, J.S., Taylor, M. and Evans, M.R. 2011. Greenhouse and landscape performance of bedding plants in biocontainers. HortTech. 21:155-161.

Lopez, R.G., and Camberato, D.M. 2011. Growth and development of ‘Eckespoint Classic Red’ poinsettia in biodegradable and compostable containers. HortTech. 21:419-423.

Nambuthiri, S.S. and Ingram, D.L. 2014. Evaluation of plantable containers for groundcover plant production and their establishment in a landscape. HortTech. 24:48-52.
Schrader, J.A., Srinivasan, G. , Grewell, D., McCabe, K.G. and Graves, W.R. 2013. Fertilizer effects of soy-plastic containers during crop production and transplant establishment. HortSci. 48:724-731.
Yue, C., Dennis, J.H., Lopez, R.G., Campbell, B.L., Hall, C.R. and Behe, B.K. 2010. Are consumers willing to pay more for biodegradable containers than for plastic ones? Evidence from hypothetical conjoint analysis and nonhypothetical experimental auctions. J. Agric. Applied Econ. 42:757-772.

QUESTIONS AND ANSWERS

Diego Martinez: Our experience with rice hull pots is they are heavy (about 20% more than conventional, plastic pots) and somewhat brittle.

David Woodske: Thanks for bringing that up. The cost of some of the biocontainers is also an issue.

Jim Conner: Were the peat pots mentioned Jiffypots® or some other type of peat pot?

David Woodske: All of the studies summarized here used Jiffypots.