Effect of Humic Acids on Growth of Annual Ornamental Seedling Plugs

M.R. Evans and G. Li

Additional index words. bedding plants, humates, roots, substrates, soils

Summary. The annual bedding plants 'Dazzler Rose Star' impatiens (*Impatiens wallerana*), 'Cooler Blush' vinca (*Catharanthus roseus*), 'Orbit Cardinal' geranium (*Pelargonium ×hotorum*), 'Janie Bright Yellow' marigold (*Tagetes patula*) and 'Bingo Azure' pansy (*Viola tricolor*) were grown on germination papers treated with deionized water (DI), 2500 or 5000 mg·L^{-1} (ppm) humic acid (HA) or nutrient control (NC) solutions. Seedlings grown on HA-treated germination papers had higher dry root weights than those grown on DI or NC-treated germination papers. Except for impatiens, seedlings germinated on HA-treated germination papers had higher lateral root numbers and higher total lateral root lengths than those grown on DI and NC-treated germination papers. Impatiens grown on NC-treated germination papers had higher lateral root numbers than those grown on DI or HA-treated germination papers. Overall, lateral root numbers for impatiens were higher for seedlings germinated on HA-treated papers than DI or NC-treated papers and highest lateral root numbers occurred on those impatiens germinated on papers treated with 5000 mg·L^{-1} HA. Except for geranium, seedlings grown in HA-amended sphagnum-peat-based substrates had similar dry root and dry shoot weights as those grown in unamended substrates. Geranium seedlings grown in HA-amended sphagnum peat-based substrates had significantly higher dry root weights than those grown in unamended substrates. However, dry shoot weights of geranium grown in HA-amended sphagnum peat-based substrates were similar to those grown in unamended substrates.

Department of Horticulture, 315 Plants Sciences Building, University of Arkansas, Fayetteville, AR 72701.

This project was supported by the Bedding Plants Foundation, Inc. and the Arkansas Agricultural Research and Extension Service.

Humic acids have been shown to have numerous effects on plant growth, and the subject has been extensively reviewed by Chen and Aviad (1990). One of the most common responses of plants to HA treatment has been the promotion of root growth. Significant fresh root weight increases were reported (Hartwigsen and Evans, 2000) for 'Bonanza' marigold, 'Salad Bush' cucumber (*Cucumis sativus*), 'Golden Summer Crookneck' squash (*Cucurbita pepo*), and 'Freckles'geranium when grown on HA-treated germination papers. David et al. (1994) examined growth of tomato (*Lycopersicum esculentum*) in solution culture and found increased fresh and dry root weights of plants grown in HA solutions as compared to those grown in control solutions. Mylonas and McCants (1980) reported that tobacco (*Nicotianna tabacum*) plants grown on filter paper saturated with HA solutions had higher root numbers and total root length than plants grown on filter paper saturated with nutrient solutions or deionized water. Tan and Tantiwiramanond (1983) found increased fresh and dry root weights for soybean (*Glycine max*), peanuts (*Arachis hypogea*) and clover (*Trifolium alexandrium*) grown in sand culture amended with HA and fulvic acid. Sanders et al. (1990) examined the effect of HA incorporation into the fluid drill solution used in carrot production and found a 50% to 75% increase in the number of carrot (*Daucus carrota*) seed germinating. Carrot germinated in a substrate drenched with HA had a 100% higher fresh root weight than those germinated in a root medium drenched with water.

Many commercial enterprises produce and market various formulations of HA designed to be used as soil amendments for promoting root growth and stand establishment of crops. Although many of these products list recommendations for the use of HA on annual ornamental plant species, no research has been published regarding the efficacy of HA on annual ornamental plant species. The objectives of this study were to determine the response of various annual ornamental plant species to HA and to determine the potential of HA as a substrate amendment for promoting root growth and stand establishment of annual ornamental plant plugs.

Materials and methods

Experiment one: Evaluation of root growth of seedlings grown on HA-treated germination papers. Treatment solutions included deionized water, HA, and nutrient controls. Humic acid solutions were prepared using the commercial HA product Enersol (American Colloid Co., Skokie, Ill.). Nutrient control solutions that provided equivalent mineral elements contained in each concentration of HA solution were prepared as described by Hartwigsen and Evans (2000). The pH of HA solutions prepared ranged from 8.0 to 9.5. Therefore, to test for potential pH effects, the pH of HA and NC solutions were adjusted to either 9.0 or 7.0 using 0.1 N potassium hydroxide or 0.1 N hydrochloric acid. Solutions were stored in a refrigerator and allowed to warm to room temperature [about 23 °C (73.4 °F)] before use. Fresh solutions were prepared at 14-d intervals.

Two germination paper (Anchor Paper Co., St. Paul, Minn.) systems were used to conduct screenings of different concentrations of HA and NC solutions. The first system was used for vinca, marigold, and geranium because of their relatively large seed size. Each 30 × 30 cm (11.8 inches) germination paper was saturated with 25 mL (0.85 fl oz) of each treatment solution. Five seed were placed along one side of each germination paper about 1 cm (0.4 inch) from the top edge. The papers were rolled and placed in plastic bags and about 10 mL (0.34 fl oz) of solution was placed in the bottom of the plastic bag to serve as a reservoir. Bags were placed upright in a growth chamber. The moisture level of papers was monitored daily and solutions were added as necessary to maintain moist papers. The HA solution concentrations were based upon results obtained by Hartwigsen and Evans (2000) and included HA at 2500 and 5000 mg·L^{-1}, their respective nutrient controls, and deionized water.

The second system was used for impatiens and pansy because of their relatively small seed size. Three pieces of circular [10 cm (3.9 inches) diameter] germination paper were cut in half and placed in 10-cm-diameter petri dishes. Three seed were placed along the straight edge of the germination papers about 0.5 cm (0.20 inch) from the top edge. The seed were covered with an additional three layers of filter paper. The germination papers in the each petri dish were saturated with 10 mL of each treatment solution as described for the previous experiment. The petri dishes were partially sealed with parafilm (American National Can Co., Greenwich, Conn.) and placed on edge with the flat edge of the germination paper up. A small amount of reserve solution remained in the bottom of the petri dishes. The moisture level of germination papers was monitored daily and solutions were added as necessary.

The papers and petri dishes were placed in a growth chamber. The growth chamber was maintained at a constant temperature of 22 °C (71.6 °F). A 12-h photoperiod with an average light level of 275 $\mu mol\cdot m^{-2}\cdot s^{-1}$ was maintained. After 10 d for marigold, 15 d for geranium, and 18 d for impatiens, vinca and pansy, seedlings were removed from the papers or petri dishes. Dry root weight, the number of lateral roots greater than 1 mm (0.04 inch) in length and combined lateral root length were determined. One germination paper or one petri dish was considered a replication and each treatment was replicated three times. The experiment was repeated twice (blocked over time). An analysis of variance (ANOVA) and single-degree-of-freedom contrasts were conducted to determine if HA significantly affected seedling root development. Because no significant difference occurred across time, data were pooled across time.

EXPERIMENT TWO. EVALUATION OF ROOT AND SHOOT GROWTH OF SEEDLINGS GERMINATED IN HA-AMENDED SPHAGNUM-PEAT-BASED SUBSTRATES. The germination substrate used in this experiment was prepared by mixing sphagnum peat (Sun Gro Horticulture, Bellvue, Wash.) and vermiculite (Strong-Lite Products Corp., Pine Bluff, Ark.) at a rate of 5:1 (v:v), respectively. Before use, the pH of the sphagnum peat was adjusted to about 5.4 by mixing 1.5 g of ground calcitic limestone per liter of substrate (0.20 oz/gal) 1 week before use. Enersol was blended with the substrate at rates to provide 0, 3, 6, or 9 mg (28,350 mg = 1 oz) of HA per 5 mL (0.17 fl oz) of substrate (one plug cell). Fifteen-cell plastic plug trays (#288) were filled with the test substrates. Each cell contained 5 mL of substrate. Single seed of the test species were sown per cell. Plug trays were placed in a greenhouse and randomized on the bench. Seedlings were grown under an average irradiance of 310 $\mu mol\cdot m^{-2}\cdot s^{-1}$ at 12:00 HR. Temperatures ranged from 18 to 27 °C (64.4 to 80.6 °F). After 3 weeks for marigold, 4 weeks for vinca and geranium and 5 weeks for impatiens and pansy, percentage germination, dry root weights and dry shoot weights were determined. A 15-cell plug tray served as a replication, and each treatment was replicated 6 times. The experiment was repeated twice (blocked over time). An analysis of variance was conducted to determine whether HA incorporation significantly affected germination or seedling root or shoot growth. Because no significant difference occurred across time, data were pooled across time.

Results and discussion

EXPERIMENT ONE: EVALUATION OF ROOT GROWTH OF SEEDLINGS GERMINATED IN HA-TREATED GERMINATION PAPERS. Overall, impatiens, vinca, geranium and marigold grown on HA-treated germination papers had significantly higher dry root weights than those grown on DI or NC-treated papers (Table 1). Pansy grown on HA-treated papers had significantly higher dry root weights than those grown on DI-treated papers but not as compared to those grown on NC-treated papers. Overall, geranium, marigold and pansy grown on NC-treated papers had higher dry root weights than those grown on DI-treated papers. However, impatiens and vinca grown on NC-treated papers had similar dry root weights as those grown on DI-treated papers. For certain species and concentrations, significant differences in dry root weights occurred among HA treatments and their respective NC treatments while no significant differences occurred among others. For all species, highest dry root weights occurred for seedlings grown on HA-treated papers. However, species varied with respect to the optimal

Table 1. Effect of humic acids on dry root weights of impatiens, vinca, geranium, marigold, and pansy plugs when grown on germination papers.

		Dry root wt (mg)				
Solutions[z]	df	Impatiens	Vinca	Geranium	Marigold	Pansy
DI		0.5	0.6	0.5	0.7	0.3
NC2500 at pH 7		0.5	0.5	0.8	0.9	0.6
NC2500 at pH 9		0.5	0.6	0.6	0.8	0.5
NC5000 at pH 7		0.6	0.7	0.7	0.5	0.7
NC5000 at pH 9		0.6	0.5	0.8	0.7	0.6
HA2500 at pH 7		0.7	0.7	0.9	1.5	0.5
HA2500 at pH 9		0.6	0.9	1.1	1.4	0.6
HA5000 at pH 7		0.7	0.8	0.7	1.6	0.7
HA5000 at pH 9		0.7	0.8	0.8	1.4	0.7
Significance						
Treatment	8	*	*	***	***	**
NC2500 vs. HA2500 at pH 7	1	*	**	*	**	NS
NC2500 vs. HA2500 at pH 9	1	NS	*	***	**	NS
NC5000 vs. HA5000 at pH 7	1	NS	NS	NS	**	NS
NC5000 vs. HA5000 at pH 9	1	NS	***	NS	**	NS
HA at pH 7 vs. HA at pH 9	1	NS	NS	NS	NS	NS
HA vs. NC	1	*	**	*	**	NS
HA vs. DI	1	*	***	***	***	*
DI vs. NC	1	NS	NS	**	*	*

[z]DI = deionized water, NC = nutrient control solutions, and HA = humic acids. Numbers represent $mg\cdot L^{-1}$ (ppm) and solution pH (7 or 9); 28,350 mg = 1 oz.

[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

HA concentration. The pH of the HA solution did not have a significant effect on dry root weights.

Overall, all species grown on HA-treated papers had significantly higher lateral root numbers than those grown on DI or NC-treated papers (Table 2). Overall, all species grown on NC-treated papers had higher lateral root numbers than those grown on DI-treated papers. For certain species and concentrations, significant differences in lateral root number occurred among HA treatments and their respective NC treatments while no significant differences occurred among others. Vinca, geranium, marigold and pansy lateral root numbers were highest for seedlings grown on HA-treated papers. However, species varied with respect to the optimal concentration and solution pH. Impatiens grown on NC and HA-treated papers had higher lateral root numbers than those grown on DI-treated papers. However, impatiens was unique among the species tested in that impatiens grown on NC-treated papers had higher lateral root numbers than those of respective HA treatments.

Overall, all species grown on HA-treated papers had significantly higher lateral root lengths than those grown on DI or NC-treated papers (Table 3). Overall, all species grown on NC-treated papers had higher lateral root length than those grown on DI-treated papers. For certain species and concentrations, significant differences in lateral root lengths occurred between

Table 2. Effect of humic acids on lateral root number of impatiens, vinca, geranium, marigold, and pansy when grown on germination papers.

		Lateral roots (no.)				
Solutions[z]	df	Impatiens	Vinca	Geranium	Marigold	Pansy
DI		4.5	3.4	2.7	5.1	3.2
NC2500 at pH 7		5.8	3.6	1.9	7.8	3.4
NC2500 at pH 9		7.0	3.5	2.7	8.7	2.4
NC5000 at pH 7		7.6	4.0	3.7	2.8	2.6
NC5000 at pH 9		7.4	3.6	3.5	4.8	3.7
HA2500 at pH 7		5.7	4.0	2.1	12.5	3.3
HA2500 at pH 9		6.1	4.6	3.9	9.6	4.9
HA5000 at pH 7		5.6	4.7	5.8	14.6	3.9
HA5000 at pH 9		5.2	3.8	3.9	11.3	2.5
Significance						
Treatment	8	*	*	*	**	**
NC2500 vs. HA2500 at pH 7	1	NS	*	NS	**	NS
NC2500 vs. HA2500 at pH 9	1	*	*	**	*	**
NC5000 vs. HA5000 at pH 7	1	**	*	**	***	**
NC5000 vs. HA5000 at pH 9	1	**	NS	NS	***	**
HA at pH 7 vs. HA at pH 9	1	NS	NS	*	*	*
HA vs. NC	1	**	*	*	***	**
HA vs. DI	1	**	**	**	***	**
DI vs. NC	1	**	*	*	**	*

[z]DI = deionized water, NC = nutrient control solutions, and HA = humic acids. Numbers represent $mg \cdot L^{-1}$ (ppm) and solution pH (7 or 9).

[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 3. Effect of humic acids on lateral root length of impatiens, vinca, geranium, marigold, and pansy when grown on germination towels.

		Lateral root length (mm)				
Solutions[z]	df	Impatiens	Vinca	Geranium	Marigold	Pansy
DI		127	4	4	34	25
NC2500 at pH 7		134	5	6	71	44
NC2500 at pH 9		141	5	6	58	34
NC5000 at pH 7		158	5	7	24	19
NC5000 at pH 9		164	6	11	44	27
HA2500 at pH 7		135	7	8	111	30
HA2500 at pH 9		147	10	20	83	34
HA5000 at pH 7		185	10	15	154	39
HA5000 at pH 9		180	7	10	99	28
Significance						
Treatment	8	*	**	*	**	**
NC2500 vs. HA2500 at pH 7	1	NS	*	NS	*	*
NC2500 vs. HA2500 at pH 9	1	NS	***	**	*	NS
NC5000 vs. HA5000 at pH 7	1	**	**	**	***	**
NC5000 vs. HA5000 at pH 9	1	*	**	*	**	*
NC at pH 7 vs. HA at pH 9	1	NS	*	**	**	*
HA vs. NC	1	*	**	*	**	*
HA vs. DI	1	**	**	**	***	*
DI vs. NC	1	**	*	*	*	*

[z]DI = deionized water, NC = nutrient control solutions, and HA = humic acids. Numbers represent $mg \cdot L^{-1}$ (ppm) and solution pH (7 or 9); 2.54 mm = 1.0 inch.

[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

HA treatments and their respective NC treatments while no significant differences occurred among others. For all species, highest lateral root numbers occurred for seedlings grown on HA-treated papers. However, species varied with respect to the optimal HA concentration and solution pH.

As was reported for numerous food crop species (Chen and Avid, 1990), ornamental plant seedlings grown on HA-treated germination papers had higher root dry weights than those grown on DI or NC-treated papers. Numerous researchers have demonstrated that in addition to generally increasing dry root weight, HA resulted in an increase in both lateral root number and length (Chen and Avid, 1990; Hartwigsen and Evans, 2000). This was also the case in our research for vinca, geranium, marigold and pansy in which lateral root numbers and lengths were significantly higher when grown on HA-treated germination papers than when grown on DI or NC-treated papers. Impatiens was an exception in that lateral root number was higher for seedlings grown on papers treated with both HA and NC seedlings than in DI seedlings, but lateral root number was higher for seedlings grown on NC-treated papers than for seedlings grown on HA-treated papers. These results may have been a species-specific response or a data artifact.

Previous researchers have not examined the specific effect of the HA solution pH on HA efficacy. We found that pH of the HA solution did not significantly affect dry root weight, but did significantly affect lateral root number and length for certain species tested. Regardless of the pH of the HA solution, seedlings grown on HA-treated papers had higher lateral root numbers and lengths than those grown on DI-treated papers. Previous researchers have reported numerous potential mechanisms by which HA may promote root growth in seedlings. Most researchers have concluded that mechanisms other than the provision of mineral nutrients was responsible. In our study, we found that although dry root weights were higher in seedlings germinated on HA-treated towels than for seedlings germinated on DI or NC-treated papers, seedlings germinated on NC-treated towels often had higher dry root weights than those germinated on DI-treated towels. This was not an unexpected response as numerous reports have been published (Drew, 1975; Drew and Saker, 1975; Drew et al., 1973; Granato and Raper, 1989) in which researchers have reported higher lateral root initiation in the presence of high concentrations of mineral elements.

EXPERIMENT TWO: EVALUATION OF ROOT GROWTH OF SEEDLINGS GERMINATED IN SUBSTRATES AMENDED WITH HA. Percent germination ranged from 75% to 90%, 85% to 90%, 90% to 95%, 90% to 95%, and 85% to 95% for impatiens, vinca, geranium, marigold and pansy, respectively, and was not significantly affected by HA incorporation into the germination substrate. Dry shoot weight ranged from 98 to 107 mg, 64 to 73 mg, 270 to 304 mg, 122 to 132 mg, and 180 to 194 mg for impatiens, vinca, geranium, marigold and pansy, respectively. Dry shoot weight was not significantly affected by HA incorporation into the germination substrate. Dry root weight ranged from 50 to 53 mg, 38 to 42 mg, 110 to 126 mg, and 66 to 72 mg for impatiens, vinca, marigold and pansy, respectively. Dry root weight was not significantly affected by HA incorporation into the germination substrate. Dry root weight of geranium ranged from 157 mg for the untreated control to 180 mg for seedlings germinated in substrate amended with 10 mg HA per plug cell, and only those germinated in the substrate amended with 10 mg HA were significantly higher than the control.

Although root growth of the ornamental species tested in this study was higher when seedlings were grown on HA-treated germination papers, when grown in a sphagnum-peat-based substrate amended with HA, only geranium had significantly higher dry root weights than seedlings grown in the unamended sphagnum-peat-based substrate. Since the species tested were responsive to HA when grown on germination papers, the lack of response to HA when grown in the sphagnum-peat-based substrate cannot be entirely explained by species differences. Most research that has been published on the effects of HA on plants, has been conducted in liquid cultures, on germination papers or in sand. Where field experiments have been conducted, they have been in mineral soils. These environments would typically be low in naturally occurring HA. Researchers have established that there was an optimal threshold for HA (Chen and Aviad, 1990), above which either no additional response was observed or reduced root growth was observed. Sphagnum peat is naturally high in HA (Chen and Aviad, 1990) and may contain optimal HA concentrations for these species, and thus incorporation of additional HA elicited no additional response. The threshold for geranium may be higher than that of the other species tested so that an additional growth promotion occurred as a result of HA incorporation or the geranium response may be a data artifact. None of the species showed an increase in shoot growth as a result of HA incorporation. This is consistent with reports (Chen and Aviad, 1990; Hartwigsen and Evans, 2000) from researchers who found even when HA promoted root growth, shoot growth was often not significantly affected.

Conclusions

Seedlings of vinca, impatiens, marigold, geranium and pansy grown on germination towels treated with HA had higher dry root dry weights than those grown on towels treated with NC or DI. However, when grown in a sphagnum-peat-based germination substrate, this response only occurred in geranium. The increased dry root weight in geranium resulted in neither an increased germination percentage nor an increased dry shoot weight. Even if certain species, such as geranium, were responsive to HA when added to a sphagnum-peat-based germination substrate, there are two problems that would make the use of HA impractical. First, for those species such as geranium that did have a significant response to HA, the small increase in root growth would not be of practical value and would not result in increased germination percentage or increased shoot growth. Second, differences in species responses to HA would require that each substrate be designed specifically for each species. The increased cost of such a practice would far out weigh any benefits of HA incorporation.

Literature cited

Chen, Y. and T. Aviad. 1990. Effects of humic substances on plant growth, p. 161–186. In: P. MacCarthy, C. Clapp, R. Malcolm, and P. Bloom (eds.). Humic substances in soil and crop sciences, selected readings. Amer. Soc. Agron.–Soil Sci. Soc. Amer., Madison, Wis.

David, P.P., P.V. Nelson, and D.C. Sanders. 1994. A humic acid improves growth of tomato seedlings (sic) in solution culture. J. Plant Nutr. 17:173–184.

Drew, M.C. 1975. Comparison of the effects of a localized supply of phosphate, nitrate, ammonium and potassium on the growth of the seminal root system and the shoot in barley. New Phytol. 75: 479–490.

Drew, M.C. and L.R. Saker. 1975. Nutrient supply and growth of the seminal root system in barley: II. Localized, compensatory increases in lateral root growth and rates of nitrate uptake when nitrate supply is restricted to only part of the root system. J. Expt. Bot. 26:79–90.

Drew, M.C., L.R. Saker, and T.W. Ashley. 1973. Nutrient supply and the growth of the seminal root system in barley: 1. The effect of nitrate concentration on the growth of axes and laterals. J. Expt. Bot. 24:1189–1202.

Granato, T.C. and T.C. Raper. 1989. Proliferation of maize (*Zea mays* L.) roots in response to localized supply of nitrate. J. Expt. Bot. 40:263–275.

Hartwigsen, J.A. and M.R. Evans. 2000. Humic acid seed and substrate treatments promote seedlings root development. HortScience 35(7):1231–1233.

Mylonas, V.A. and C B. McCants. 1980. Effects of humic and fulvic acids on growth of tobacco: I. Root initiation and elongation. Plant Soil 54:485–498.

Sanders, D.C., J.A. Ricotta, and L. Hodges. 1990. Improvement of carrot stands with plant biostimulants and fluid drilling. HortScience 25(2):181–183.

Tan, T.K. and D. Tantiwiramanond. 1983. Effect of humic acids on nodulation and dry matter production of soybean, peanut and clover. Soil Sci. Soc. Amer. J. 47: 1121–1124.

Biodegradable Mulch Films for Weed Suppression in the Establishment Year of Matted-row Strawberries

C.A. Weber[1]

ADDITIONAL INDEX WORDS. weed control, plasticulture, *Fragaria*, strawberry production, degradable mulch

SUMMARY. Adequate weed control in the establishment year of matted-row strawberries (*Fragaria* ×*ananassa*) is crucial for the long-term viability of plantings. Suppression of weed growth until the new strawberry plants are established and runners rooted is an effective strategy in new plantings. Three biodegradable mulch films were compared to standard weed control for establishing matted-row strawberries. Two films were test products using a biodegradable polymer, either clear or black, covering brown 40-lb kraft paper (IP40 Clear and IP40 Black, respectively). The third material was Planters paper, a black paper mulch. The films were evaluated for weed suppression, rate of degradation and effects on runner production and fruit yield. Additionally, the ability of runners that were formed to root as the film degraded was also observed. The IP40 Black mulch reduced the number of weeds compared to the standard control but did not degrade quickly enough for runners to root. The Planters paper also had fewer weeds, but it degraded quickly along the edges where it was covered by soil. This allowed the wind to tear it and blow large pieces off the plots. The IP40 Clear degraded in a timely manner and allowed runner rooting, but it was not acceptable as a weed suppression material. The IP40 Black and Planters paper mulches were effective for weed control in the establishment year, but rate of degradation was too slow in the former case and too fast in the latter. Runner production and fruit yield were not affected by any of the mulch materials compared to standard control.

[1]Assistant professor, Department of Horticultural Sciences, New York State Agricultural Experiment Station, Cornell University, Geneva, NY 14456; e-mail caw34@nysaes.cornell.edu.

This research was funded in part by a grant from the New York State Integrated Pest Management Program.

Weed control is the most pressing problem encountered by strawberry growers using a matted-row strawberry production system. Newly planted strawberries in the matted-row system are most susceptible to weed competition during the first 2 months after planting. Yield losses of up to 65% have been documented when early season weed competition was not controlled (Pritts and Kelley, 2001). Weed control during this period is especially critical for the long-term viability of new plantings and is difficult because only a few herbicides with limited residual activity are available for establishment year weed control (Pritts and Kelley, 2001). Thus, using herbicides alone is not effective for preventing weed competition in the establishment year and yield reduction in future seasons.

In a matted-row system, plants are planted from 12 inches (30.5 cm) to 24 inches (61.0 cm) apart in the row and runners from the transplants fill in the remainder of the row space. Row spacing varies from 42 to 52 inches (106.7 to 132.1 cm) from center to center (Pritts and Handley, 1988). Wheat (*Triticum aestivum*), rye (*Secale cereale*), or barley (*Hordeum vulgare*) straw is applied on established fields in the late fall of each year for winter cold protection and weed control in the following year. However, new plantings are without straw mulch for weed control until the second season. Weed competition within the rows can inhibit stand establishment and reduce future yields. Current plasticulture with non-degradable plastic mulch provides excellent weed control but cannot be used for establishing a matted-row planting because the plastic mulch stops runners from rooting and filling in the row. By using a material that degrades within 60 to 90 d of application, weed suppression during the critical part of the season could be accomplished while still allowing runners to fill in the row as the material degrades. The subsequent straw application in early winter would further aid in the degradation process and prevent blowing of mulch fragments thus making complete degradation more likely.

Photodegradable and biodegradable mulches made of plastic, paper, or other materials have been tested for their utility for annual food production with varying degrees of success (Greer and Dole, 2003). As early as the 1920s researchers developed acceptable pro-