ever, we believe it is reasonable to attribute at least a portion of the damage reduction at slower speeds to lower fruit-time impact forces caused by slower belt speeds.

Shower-type hydrocoolers are known to damage leafy vegetables because of water falling onto product from excessive distances (R.F. Kasmire, personal communication). Pitting was low when water drop was <8 inches (20 cm) (Fig. 2). Diffusing screens made only of expanded metal did not reduce damage as much as those made of expanded metal covered with plastic screening. Shower coolers that caused high levels of pitting damage also bruised a large percentage of fruit (Table 2), and reducing water drop height should reduce cherry bruising damage. Several types of screening are available and have been used successfully in hydrocoolers. The mesh size of screening used in this application must be small enough to intercept and reduce the velocity (but not the flow rate) of water droplets falling from the distribution pan.

Most prior work focusing specifically on packing house sources of damage has emphasized reducing the number and height of fruit drops to hard surfaces, or cushioning these drops at equipment transitions. Recent packing house designs have made increasing use of water flumes in place of conveyor belts and water troughs to receive fruit at elevators to accomplish these objectives. We have identified operations most likely to cause damage and have recommended design or operational changes that will help reduce damage.

Literature cited

- Crisosto, C.H., D. Garner, J. Doyle, and K.R. Day. 1993. Relationship between fruit respiration, bruising susceptibility, and temperature in sweet cherries. *HortScience* 28:132-135.
- Facteau, T.J. and K.E. Rowe. 1979. Factors associated with surface pitting of sweet cherry. *J. Amer. Soc. Hort. Sci.* 104:706-710.
- Facteau, T.J. 1985. Postharvest bruising, GA or Ca. *Proc. 81st Annu. Washington State Hort. Assn.*
- Kupferman, E.M. and K. Miller. 1990. Cherry warehouse survey report. Washington State Univ.
- Lidster, P.D. and M.A. Tung. 1979. Identification of deformation parameters and fruit response to mechanical damage in sweet cherry. *J. Amer. Soc. Hort. Sci.* 104:808-811.
- Lidster, P.D. and M.A. Tung. 1980. Effects of fruit temperatures at the time of impact damage and subsequent storage temperature and duration on the development of surface disorders in sweet cherries. *Can. J. Plant Sci.* 60:55-559.
- Lidster, P.D., K. Miller, and M.A. Tung. 1980. Effects of maturity on fruit composition and susceptibility to surface damage in sweet cherries. *Can. J. Plant Sci.* 60:865-871.
- Mitchell, F.G., G. Mayer, and A.A. Kader. 1980. Injuries cause deterioration of sweet cherries. *California Agr.* 34:14-15.
- Patten, K.D. and M.E. Patterson. 1985. Fruit temperature effects on mechanical damage of sweet cherries. *J. Amer. Soc. Hort. Sci.* 110:215-219.
- Patten, K.D. and M.E. Patterson. 1985. Fruit moisture status effects on mechanical damage of sweet cherries. *J. Amer. Soc. Hort. Sci.* 110:537-541.

Bell Pepper Yields Not Affected by Stand Deficiencies or Replanting

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ADDITIONAL INDEX WORDS. transplant, polyethylene mulch, missing plants, plant population, early yield, stand establishment

SUMMARY. Field studies were conducted in Spring 1991, 1992, and 1993 to determine if stand deficiencies of 10%, 20%, or 30% affected bell pepper (*Capsicum annuum* L.) yield and fruit size. Subsequent replanting to a 100% stand and timing of replanting also were evaluated for effects on fruit yield. Stand deficiencies of up to 30% and replanting to a complete stand 2 or 3 weeks after initial transplanting did not affect yield per acre and average weight per fruit of bell pepper plants grown on polyethylene-mulched beds during 3 years of tests. Bell pepper plants grown in 10%, 20%, or 30% deficient stand had greater marketable yield per plant than plants grown in 100% stand. Replanting to a complete stand 3 weeks after initial transplanting decreased early marketable yield and production per plant over replanting 2 weeks after initial transplanting.

Bell pepper is grown extensively in southeastern Louisiana on fumigated, raised beds, covered with polyethylene mulch, with irrigation and using transplants. Due to the intensive system of production, cost of establishing the crop is estimated at \$1600 per acre (\$4000 per ha) (Boudreaux et al., 1992). Plant losses occurring during or shortly after

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transplanting may affect yields and reduce returns per unit of production.

Growers use visual observations to determine reductions in plant population of a particular field and subjective judgements to determine if and when the field should be replanted to a full stand. Typically, a grower will reset the field within 2 weeks after transplanting.

Marketable yield increases in bell pepper due to closer plant spacing have been reported by Batal and Smittle (1981), Everett and Subramanya (1983), Locascio and Stall (1994), Porter and Etzel (1982), and Stoffella and Bryan (1988). Locascio and Stall (1994) reported that the number of plant rows per bed and bed width influenced total marketable yields of bell pepper more than in-row spacings. Batal and Smittle (1981) concluded that total plant population per

unit area had more affect on pepper yield than planting geometry. Motsenbocker (1996) indicated that pepperoncini pepper plants grown at the narrowest spacing of 3 inches (7.5 cm) produced the lowest early and total yield per plant but the most fruit per hectare.

Stoffella and Maynard (1988) reported that replanting stands of tomato (*Lycopersicon esculentum* Mill.) with deficiencies of 30% one to two weeks after initial transplanting increased marketable fruit weight and number in a stressful environment but not under favorable growing conditions. In field experiments with bean (*Phaseolus vulgaris* L.), Sullivan and Bliss (1981) reported that having an extra plant next to a skip (missing plant) provided more compensation for missing plants than did transplanting seedlings.

To my knowledge, the basis for determining if a deficient stand should be reset and timing of replacement planting has not been determined in bell pepper. My study was conducted to quantify at what levels stand deficiencies affect bell pepper production and to determine the effect of replant timing on production.

Materials and methods

Peppers were grown on a Cahaba fine sandy loam soil (thermic Typic Hapludult) near Hammond, Louisiana during 1991, 1992, and 1993. Fields were prepared in the same manner for all plantings. Fertilizer was banded into the bed at a rate of 128N-78P-149K pounds per acre (143N-87P-167K kg ha⁻¹) based on Louisiana Cooperative Extension Service recommendations (Boudreaux et al., 1994) and soil analysis. Raised beds, 6 inches (15 cm) tall and 4 feet (1.2 m) center to center, with a 19-inch (48-cm) bed top, were covered with black polyethylene mulch. Methyl bromide-chloropicrin (67:33) was applied at 200 pounds per acre (224 kg ha⁻¹) during the mulch-laying operation. Supplemental N (NH₄NO₃ or CaNO₃) at 45 kg ha⁻¹ was applied using a spoke-wheel liquid injector 6 weeks after the initial transplanting.

'Jupiter' seedlings (7 weeks old) were transplanted in one row per bed, 1 foot (30 cm) apart in 15-foot (4.6 m) plots during 1991 and 20-foot (6 m) plots during 1992 and 1993. Treatments during 1991 included a 15-

plant control (100% stand) and plots of 10, 12, and 13 plants (actual stand deficiencies of 33%, 20%, and 13%, respectively). Plots of 14, 16, and 18 plants (actual stand deficiencies of 30%, 20%, and 10%, respectively), with a 20-plant control, were established during 1992 and 1993. Treatments will be referred to as 10%, 20%, and 30% stand deficiencies to represent 10%–13%, 20%, and 30%–33% actual stand deficiencies, respectively. The incomplete stands were established at the time of the initial transplanting. Voids (missing plants) in the plant row were spaced equidistantly among the plants within the plot (Fig. 1). Stand deficiency treatments resulted in populations of 9801, 8712, 7623 plants per acre (24218, 21527, 18836 plants per hectare) for 10%, 20%, and 30% stands, respectively. One plot of the stand-deficient treatments was replanted (PL) to a complete stand 2 or 3 weeks after the initial transplanting or not replanted (NPL) resulting in 10 treatments per experiment. Complete stands had a population of ~10,890 plants per acre (26,909 plants per hectare), which parallels the usual grower practice of 1-foot (30 cm) plant spacing in single line per 4-foot (121 cm) bed. Seedlings used to reset the stand-deficient plots were from the initial transplant lot, representing the typical grower practice. Treatments were replicated four times in a randomized complete-block experimental design. Standard pesticide and cultural practices (Boudreaux et al., 1994) were followed throughout the season.

Furrow irrigation was used to maintain soil moisture at field capacity. From the initial transplant date to first harvest, plants received 22, 8, and 18 inches (57, 21, and 47 cm) of precipitation during 1991, 1992, and 1993, respectively. Weather conditions were wet during 1991, with precipitation occurring almost daily. Dry conditions prevailed during 1992, until 5 inches (12 cm) of the total 8 inches (21-cm) of precipitation occurred during a 7-day period within 2 weeks of first harvest. Weather conditions were conducive for bell pepper production during 1993 with uniform distribution of precipitation and warm temperatures.

Fruit were manually harvested ~75 days after the initial transplanting and every 7 to 10 days. Two harvests were made in 1991 and 1993; three harvests

Stand deficiency treatment			
0%	10%	20%	30%
+	+	+	+
+	+	+	+
+	+	+	-
+	+	-	+
+	+	+	+
+	+	+	-
+	-	+	+
+	+	-	+
+	+	+	-
+	+	+	+
+	+	+	+
+	+	-	-
+	+	+	+
+	-	+	+
+	+	+	-
+	+	-	+
+	+	+	+
+	+	+	-
+	+	+	+
+	+	+	+
+	+	+	+

+ = Plant, - = Void (missing plant)

Fig. 1. Plant and void (missing plant) arrangement representative of field plots of each spacing deficiency treatment for the 1992 and 1993 experiments.

were made in 1992. The number of harvests was typical for the area, as growers in the local area ship to markets requiring early, extra-large bell

peppers. Fruit for each harvest were graded into U.S. Fancy and no. 1 (Federal Register, 1963), counted, and weighed. Total marketable fruit weight

and numbers were expressed on per-acre and per-plant basis. Data were subjected to analysis of variance for each experiment using the SAS general

Table 1. Marketable bell pepper fruit yields as influenced by stand deficiencies and replanting, Spring 1991.

Stand deficient (SD) treatments ^z	Time of replanting (PL) (weeks) ^y	Marketable (Fancy + No. 1) yield				Mean fruit wt (g/fruit)
		tons/acre		per plant		
		Early	Total	Pound	No.	
0 (Control)		4.4	7.8	1.43	3.6	177
10	NPL ^x	4.0	7.5	1.59	4.0	180
	2	5.7	8.3	1.52	3.8	181
	3	4.4	7.9	1.43	3.8	171
20	NPL	4.5	6.5	1.48	3.8	179
	2	4.7	7.1	1.32	3.5	172
	3	5.2	8.5	1.57	3.9	178
30	NPL	4.8	6.6	1.83	4.6	181
	2	3.5	6.8	1.26	3.4	167
	3	4.1	6.4	1.17	3.1	170
Contrast effects of stand reduction treatments						
Control vs. 10% NPL		NS	NS	NS	NS	NS
Control vs. 20% NPL		NS	NS	NS	NS	NS
Control vs. 30% NPL		NS	NS	NS	NS	NS
10% NPL vs. 10% PL 2 weeks		NS	NS	NS	NS	NS
10% NPL vs. 10% PL 3 weeks		NS	NS	NS	NS	NS
20% NPL vs. 20% PL 2 weeks		NS	NS	NS	NS	NS
20% NPL vs. 20% PL 3 weeks		NS	NS	NS	NS	NS
30% NPL vs. 30% PL 2 weeks		NS	NS	**	NS	NS
30% NPL vs. 30% PL 3 weeks		NS	NS	**	NS	NS

^zSD at 0% (control) = 0; 10% to 13% = 10; 20% = 20, 30% to 33% = 30.

^yWeeks following initial transplanting.

^xNPL = Not replanted.

Table 2. Marketable bell pepper fruit yields as influenced by stand deficiencies and replanting, Spring 1992.

Stand deficient (SD) treatments ^z	Time of replanting (PL) (weeks) ^y	Marketable (Fancy + No. 1) yield				Mean fruit wt (g/fruit)
		tons/acre		per plant		
		Early	Total	Pound	No.	
0 (Control)		4.4	12.1	2.2	4.4	229
10	NPL ^x	4.6	13.5	2.9	6.1	206
10	2	4.3	12.1	2.2	4.7	216
10	3	3.2	11.5	2.2	4.7	205
20	NPL	3.5	11.0	2.4	5.5	207
20	2	3.8	11.0	2.0	4.1	221
20	3	3.4	11.2	2.0	4.7	201
30	NPL	3.4	9.6	2.4	5.5	209
30	2	4.3	12.1	2.2	4.9	209
30	3	3.6	10.8	2.0	4.3	212
Contrast effects of stand reduction treatments						
Control vs. 10% NPL		NS	NS	NS	NS	NS
Control vs. 20% NPL		NS	NS	NS	NS	NS
Control vs. 30% NPL		NS	NS	NS	NS	NS
10% NPL vs. 10% PL 2 weeks		NS	NS	**	**	NS
10% NPL vs. 10% PL 3 weeks		NS	NS	**	**	NS
20% NPL vs. 20% PL 2 weeks		NS	NS	*	**	NS
20% NPL vs. 20% PL 3 weeks		NS	NS	*	NS	NS
30% NPL vs. 30% PL 2 weeks		NS	NS	NS	NS	NS
30% NPL vs. 30% PL 3 weeks		NS	NS	**	*	NS

^zSD at 0% (control) = 0; 10% to 13% = 10; 20% = 20, 30% to 33% = 30.

^yWeeks following initial transplanting.

^xNPL = Not replanted.

linear models procedure (SAS Institute, 1987). Orthogonal contrasts between the control and main effects of stand deficient and replanting treatments were obtained to determine what affect stand deficiencies or replant timing had on each measured or calculated variable.

Results and discussion

Marketable fruit yields averaged over all treatments were 7.3, 10.3, and 23.0 tons per acre (16.4, 23.1, and 51.5 t·ha⁻¹) during 1991, 1992, and 1993, respectively. As stand deficiency treatments were different during 1991, data for that season was analyzed separately from data collected during the other 2 years. Yield responses to stand deficiencies and replanting were similar during 1992 and 1993, and interactions were not significant. Differences among years were significant however, so data is presented by year.

During 3 years of experiments, total yield and average weight per fruit of marketable bell pepper were not affected by stand deficiencies of up to 30% or replanting stand-deficient plots to a complete stand (Tables 1–3). These results are contrary to findings reported by Stoffella and Maynard (1988) in similar work with tomatoes. In that

study, plots with 30% stand reduction produced a lower weight and number of marketable tomatoes per hectare than control plots during two seasons.

Early production of marketable fruit was not affected by stand deficiencies or replanting during 1991 and 1992. During 1993, peppers from plots not replanted or replanted 2 weeks after initial transplanting produced greater early yield than plants in complete stands (Table 3). Early yield in 1993 was greater from plots replanted 2 weeks after initial transplanting than from plots replanted 3 weeks after transplanting.

Yield of marketable fruit per plant was significantly affected by stand deficiencies during all years. Highest yields of marketable fruit per plant were obtained from plants grown in 30% deficient stands not replanted. Differences in yield per plant were significant among plants grown in deficient stands not replanted and those replanted to complete stands (Tables 1–3).

Fruit number per plant was not affected by stand deficiencies during 1991 (Table 1). During 1992 and 1993, plots replanted to 100% stand 2 or 3 weeks after initial transplanting generally had lower yield and fruit

number per plant than corresponding plots not replanted (Tables 2 and 3). Stoffella and Maynard (1988) reported greater or equal marketable yield from tomato plots with 10% to 30% stand deficiencies compared to plots replanted to 100% stand 1, 2, or 3 weeks after initial transplanting. Several researchers have reported that marketable fruit number and weight per plant of bell pepper have increased with row arrangements or plant spacings that had the fewest plants per hectare (Everett and Subramanya, 1983; Locascio and Stall, 1994; Stoffella and Bryan, 1988).

Replanting bell pepper to a complete stand 2 weeks after the initial transplanting yielded greater fruit weight and number per plant than replanting 3 weeks after initial transplanting at all stand deficiencies. Significant differences were noted in 1993 as delaying replanting by 1 week decreased the weight and number of fruit per plant (Table 3). Plants transplanted 3 weeks after initial transplanting were not visually distinguishable in size from the initial transplants by harvest time. The later transplants occupied space and used nutrients, moisture, and light but did not appear to contribute to the yield.

Table 3. Marketable bell pepper fruit yields as influenced by stand deficiencies and replanting, Spring 1993.

Stand deficient (SD) treatments ^z	Time of replanting (PL) (weeks) ^y	Marketable (Fancy + No. 1) yield				Mean fruit wt (g/fruit)
		tons/acre		per plant		
		Early	Total	Pound	No.	
0 (Control)		12.7	22.2	4.2	4.9	381
10	NPL ^x	16.2	24.0	4.4	4.7	425
10	2	19.0	27.4	5.1	5.5	417
10	3	12.1	20.7	3.7	4.3	401
20	NPL	19.1	28.1	5.1	5.5	429
20	2	11.6	20.6	3.7	4.4	389
20	3	10.3	19.1	3.5	4.1	394
30	NPL	16.8	24.1	6.4	6.7	425
30	2	16.1	24.7	4.6	4.8	424
30	3	11.8	19.2	3.5	3.8	412
Contrast effects of stand reduction treatments						
Control vs. 10% NPL		NS	NS	NS	NS	NS
Control vs. 20% NPL		NS	NS	NS	NS	NS
Control vs. 30% NPL		NS	NS	NS	NS	NS
10% NPL vs. 10% PL 2 weeks		NS	NS	NS	NS	NS
10% NPL vs. 10% PL 3 weeks		NS	NS	NS	NS	NS
20% NPL vs. 20% PL 2 weeks		*	NS	*	NS	NS
20% NPL vs. 20% PL 3 weeks		**	NS	**	*	NS
30% NPL vs. 30% PL 2 weeks		NS	NS	**	**	NS
30% NPL vs. 30% PL 3 weeks		NS	NS	**	**	NS

^aSD at 0% (control) = 0; 10% to 13% = 10; 20% = 20, 30% to 33% = 30.

^bWeeks following initial transplanting.

^cNPL = Not replanted.

Stand deficiencies of up to 30% did not affect total or early marketable weight and fruit size of bell pepper grown on polyethylene-mulched beds during 3 years of testing. Even during years of low production due to less than favorable climatic conditions, stand deficiencies did not significantly decrease marketable fruit weight and size. Replanting 10% to 30% stand-deficient plots to complete 100% stands did not significantly improve marketable yield per acre or fruit size.

Literature cited

Boudreaux, J.E., H.K. Whitam, and D.K. Pollet. 1994. Bell pepper production. Louisiana Coop. Ext. Serv. Publ. 2433.

Batal, K.M. and D.A. Smittle. 1981. Response of bell pepper to irrigation, nitrogen, and plant population. J. Amer. Soc. Hort. Sci. 106:259-262.

Everett, P.H. and R. Subramanya. 1983. Pepper production as influenced by plant spacing and nitrogen-potassium rates. Proc. Fla. State Hort. Soc. 96:79-82.

Federal Register. 1963. United States standards for grades of sweet peppers 28 FR 12117, U.S. Dept. of Agriculture, Washington, D.C.

Locascio, S.J. and W.M. Stall. 1994. Bell pepper yield as influenced by plant spacing and row arrangement. J. Amer. Soc. Hort. Sci. 119:899-902.

Motsenbocker, C.E. 1996. In-row plant spacing affects growth and yield of pepperoncini pepper. HortScience 31:198-200.

Porter, W.C. and W.W. Etzel. 1982. Effects of aluminum-painted and black polyethylene mulches on bell pepper, *Capsicum annuum* L. HortScience 17:942-943.

Stoffella, P.J. and H.H. Bryan. 1988. Plant population influences growth and yield of bell pepper. J. Amer. Soc. Hort. Sci. 113:835-839.

Stoffella, P.J. and D.N. Maynard. 1988. Stand deficiencies and replanting effects on tomato fruit yields and size. J. Amer. Soc. Hort. Sci. 113:689-693.

Sullivan, J.G. and F.A. Bliss. 1981. Compensation for missing plants in field experiments with the common bean. HortScience 16:185-186.

Composted Poultry Litter as Potting Media does not Affect Transplant Nitrogen Content or Final Crop Yield

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ADDITIONAL INDEX WORDS. vegetable, fertilizer

SUMMARY. The use of composted waste materials as an alternative source of potting media has received much interest in recent years. Our objective was to incorporate composted, ground poultry litter into a standard greenhouse potting mix, and evaluate the effect of the poultry litter on vegetable transplants grown in the greenhouse and transplanted to the field. Treatments consisted of potting mixes of 100% potting media or 50/50 media/poultry litter. Collards (*Brassica oleracea* L. var. *acephala* DC.), broccoli (*Brassica oleracea* var. *italica* Plenck.), cabbage (*Brassica oleracea* L. var. *capitata* L.) and three tomato (*Lycopersicon esculentum* Mill.) cultivars were utilized as test crops. A nutrient solution treatment of 8 oz of 8N-11P-7K fertilizer or 8 oz of water was added when transplants were set in the field. Plant weight and nitrogen content were measured weekly during the greenhouse production stage, and final crop yield was recorded at harvest. Any effect from the inclusion of poultry litter in the potting media on cole crop (collards, broccoli, cabbage) transplant dry weight had disappeared by the fourth week of sampling in the greenhouse, and final yield of cole crops was unaffected by either type of

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potting mix or presence or absence of starter nutrient solution. Dry weight of tomato transplants was not affected by type of potting media. Differences in tomato yield due to type of potting mix were observed, as plots with transplants grown in the 50/50 mix had greater nonmarketable yields ('Bonnie' and 'Big Boy'). Yield of 'Big Boy' tomato was increased by the addition of starter nutrient solution. It appears that composted, uniformly prepared waste materials are suitable for production of vegetable transplants.

Five billion broiler chickens are produced yearly in the southern United States; nearly 80% of the nation's broiler chickens (USDA-NASS, 1993). From 1983 to 1992 the number of broiler chickens in the United States has increased by 65 percent (USDA-NASS, 1993). Because of this enormous increase in poultry production, outlets for environmentally safe disposal of poultry litter (a mixture of chicken excreta and bedding material) have become important. Because limited pasture and agricultural fields are available for land disposal of litter, use of poultry litter for potting media is an option that shows promise. Fresh broiler litter has fertilizer value (Stevenson et al., 1990), but its odor and heterogeneous composition (sawdust, feathers, wood chips, etc.) make it an undesirable potting material. Composted poultry litter may make suitable potting mate-

Table 1. pH, soluble salts and nutrient content of 50 poultry litter : 50 media mix and Fafard growing medium.

Element	50:50 ²	100 ²
pH		5.80
5.48		
Soluble salts		
(mg·kg ⁻¹)	2450	840
P (ppm)	177	20
K (ppm)	702	107
Mg (ppm)	110	66
Ca (ppm)	143	75
Fe (ppm)	2500	150
Mn (ppm)	255	166
Zn (ppm)	150	60
Cu (ppm)	175	50
Al (ppm)	1500	---
N (%)	1.32	1.40

²50:50 = 50 poultry litter : 50 Fafard medium; 100 = 100% Fafard medium.