Table 2. *Statistical comparison of vegetable leafminer (Liriomyza sativae* Blanchard) infestation indices taken from two 0.17 ha celery '2-14' fields at Zellwood, Florida (September 1976-January 1977); one field was treated with fungicides only and the second was treated with insecticides plus fungicides.

Average values for: (n=20 except for D-Vac where n=10)	Field treatments: Insecticides[z] plus fungicides[y]	Fungicides[y] only	Significance
Leafminers on sticky traps	23.8	32.4	N.S.
Leafminers in sweeps	14.1	20.5	0.01
Leafminers in D-Vac	134.2	198.3	0.01
Parasites in D-Vac	9.5	92.3	0.01
Active mines—leaflets	3.9	58.3	0.01
Leafminers reared—leaflets	18.8	83.8	0.01
Parasites reared—leaflets	0.5	15.9	0.01
Active mines—whole plant at harvest	2.7	15.0	0.01
Total mines—leaflets	33.5	167.4	0.01

[z]Insecticides used weekly on a per hectare basis included: oxamyl and dimethoate (1.1 liters each), *Bacillus thuringiensis* (1.03 kg), parathion (0.5 liters) and toxaphene (1.1 kg to 2.3 kg).
[y]Fungicides used weekly on a per hectare basis included: benomyl (0.28 kg to 0.56 kg), mancozeb (0.56 kg to 1.68 kg), copper hydroxide (2.2 kg), and chlorothalonil (2.3 liters).

The species of parasites reared from both treatments were the same; *Opius dimidiatus* (Ashmead) (Hymenoptera: Braconidae) was the most common species, followed by the chalcids, *Diglyphus intermedius* (Girault) and *Achrysocharella formosa* Westwood. Parasitism in the insecticide treated plots reached a peak in the 2 December 1976 samples at 7% (or 17 parasites/249 total reared); in the fungicide only plots the peak parasitism, 41% (690 parasites/1702 total reared), occurred during week 10 (2 December 1977). The peak of adult leafminer activity in both fall blocks occurred just prior to or during the time interval that marketable petioles were being added by the plants.

Statistically significant effects of insecticide treatments also were observed in all previously mentioned variables when data were analyzed on a weekly basis from transplant through harvest, although differences between the 2 treatments in terms of marketable, fresh weights and mine counts disappeared once the plants were stripped and trimmed (Table 1). These pre-harvest and harvest results on leafminer infestation are thus comparable to those reported earlier (1). An average of ca. 0.3 mines/plant remained in ready-to-crate celery from the fungicide treatment while 0.2 mines/plant remained on insecticide treated celery.

In conclusion, celery '2-15' naturally lost nearly half of the petioles that it produced during the growing season. An additional 18-29% of the total petioles were stripped at harvest. Regular insecticide applications in addition to fungicides significantly reduced numbers of leafminers and their parasites in treated fields. Vegetable leafminers seemed to have little effect on crop production in our fields at Zellwood in fall 1976 since plants in both treatments grew as comparable rates; further, yields for both fields were similar in terms of sizes, weights of plants, and numbers of leaf mines remaining on marketable plants. The added expense of insecticidal crop protection appeared excessive for a pest population of the light to moderate magnitude seen in that area at that point in time. Obviously, treatment thresholds and economic injury levels are needed for celery and other high value vegetable crops especially when they have pests that are very difficult to control chemically. Determining these pest thresholds becomes complicated in view of the natural losses of petioles during growth and at harvest. However, when useful threshold levels are determined and when the interactions of leafminer parasites and potent pesticides are more completely understood, researchers hopefully can help the grower make sound management decisions to achieve his goals of high yields and good quality.

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Proc. Fla. State Hort. Soc. 90:404-407. 1977.

EVALUATION OF THE IFAS CELERY SEEDLING HARVESTER USING PRECISION SEEDED PLANTS[1,2]

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Additional index words. coated seed.

Abstract. **The IFAS celery seedling harvester was tested for damage of transplants and for effect on yields. Two seedbeds were used, one seeded by the grower's conventional method using raw seed and the other seeded with coated seed by a precision seeder. Plants were pulled by using the seedling harvester or by hand. A pulling rate of up to 117 boxes/hr. using the seedling harvester with three workers was measured. An average of 12% of the plants pulled by the harvester were damaged. The marketable yield responses were highest for the hand pulled plants and lowest for the damaged machine pulled plants. The yield of undamaged plants pulled by the harvester from the precision seeded bed was higher than plants from the conventional seeding. Precision seeded plants with more uniform spacing were more effectively pulled by the seedling harvester and more effectively transplanted. Yield losses were due to loss in plant stand and the loss of stand could be reduced by improved irrigation techniques and improved harvester adjustment.**

[1]Florida Agricultural Experiment Station Journal Series No. 850.
[2]Acknowledgment is given to the Florida Celery Exchange, South Bay Growers, and A. Duda and Sons for their support and contributions to this study.

A machine to harvest celery seedlings from the seedbed has been developed by IFAS (1, 3). Mechanically the harvester performs very well and it is believed that using the principles developed, a successful commercial machine can be constructed.

The harvester pulls the seedlings by gripping the tops between opposing padded V-belts and transporting them up an incline. A rotating plastic fiber brush strikes the roots to remove excess soil. The plants are dumped from padded V-belts into an accumulator until approximately 300 plants are collected. They are removed by hand and placed into a standard field box for shipment to the field. Other major components of the harvester are a rotating square bar which travels beneath the roots to loosen the soil before pulling the plants and a control system which maintains the proper height and orientation of the pulling belts. Harvest rates of up to 7000 plants per minute were reported (3).

The objective of this study was to determine seedling damage, survival rate, and growth, responses of plants harvested by the seedling harvester under two methods of seedling production, conventional and precision seeding.

Procedure

Two seedbeds were seeded and maintained following industry procedures (2) at South Bay Growers Celery seedbed field. One seedbed was seeded in the conventional manner using raw seed (variety Fla. 2-14) and the other was seeded with coated seed (variety Fla. 683, the only available coated seed) using an experimental precision drum seeder[3]. Sections of each seedbed were harvested by machine or by hand. The workers traditionally selectively pull only acceptable plants when harvesting by hand; however, only the conventional seeded plants had a wide variation in plant size. In each case the plants were boxed as pulled and a record of harvest time and of the area from which plants were removed was maintained.

Full box samples were selected from each treatment. These plants were counted and sorted into good plants, damaged plants, and cull subsamples. In the case of hand pulled plants, it was assumed that all plants were undamaged and that the culls were left in the beds unpulled. The plant was considered to be damaged if any part showed bruised or crushed tissue. From each of these damaged and undamaged subsamples, 60 plants per replication were transplanted in the field using a randomized block design. In each the number of skips were counted and then a seedling was planted by hand to give a complete stand. After 4 weeks, and at harvest time, the plants were counted again to determine the survival rate for each treatment.

To give an indication of the handling efficiency of unsorted, machine harvested plants, a box of plants from the conventional seeded bed and a box of plants from the precision seeded bed was transplanted as harvested. Two transplanter operators were given a box of conventional seeded plants and 2 operators were given a box of conventional seeded plants and 2 operators were given a box of precision seeded plants and allowed to work as normal; after 30 m the boxes were switched between operators producing 2 replications and allowing each operator to use each seedling type. The number of skips were counted to measure the performance of each operator.

Results and Discussion

The 2 seedbeds used in this study were managed in similar fashion; however, due to the seeding techniques used, there were considerable differences between the plants. In the bed with conventional seeding, plant populations were in excess of 1000 plants/m^2 and sorting of plants showed that only 66% of the seedling were usable (Table 1). The seedlings from the bed with coated seed and with precision spacing were 96% usable. The plant population was 600 plants/m^2 which allowed for more uniform plants than in the more dense population. The damage to the plants from conventional seeding was 10% when pulled by the machine. The damage for the precision seeded plants was 14%.

Table 1. Mean in percent of good, poor and damaged seedlings when machine once-over harvested from conventional and precision seeded beds.

Seeding Methods	Quality of Transplants %			
	Good	Culls	Damaged	Usable
Conventional	56	34	10	66
Precision	82	4	14	96

The times required for harvest and the estimated efficiency with each method are presented in Table 2. These data were computed from the measured data of the harvest rates by scaling the times and output rates to an equal area basis. The reduction in labor associated with machine harvest was considerable. It is also noteworthy that a reduction in manhours was achieved when the precision seeded seedlings were hand pulled. Time was consumed for selective pulling of the plants with the conventional seeded bed and almost no time was required for the precision seeded bed.

Table 2. Efficiency expressed in time and output for machine and hand harvest of celery seedlings in relation to conventional and precision seeding.

Seeding Methods	Time in minutes	Output boxes	Number persons	Box/man/hr.
	Machine harvest			
Conventional	15.55	26	3	30
Precision	12.14	26	3	39
	Hand harvest			
Conventional	85.15	14	2	4
Precision	61.32	15	2	8

The level of damage to the plants was considered light, but reduction in yields occurred with the damaged plants (Table 3). From observation, the sources of visible plant damage was identified and solution to this damage appeared to be a problem of adjustment of the pick up conveyors. When the more densely populated plants were pulled, they would bunch up and be transported up the conveyor in groups. Because the opposing belts were flexible only over a short distance, these thickly layered plants would be crushed. In the case of the larger plants, damage occurred at the upper end of the pick up belts when the plants were squeezed through the drive pulleys. Proper adjustment in each case should eliminate most of the visible damage. The problem occurs when it is necessary to harevst different size plants and the adjustments are set compromising for each size. This was the situation during this test with the different seedling types.

The analysis of the field yield data are presented in Table 3. The damaged plants whether from conventional or precision seeding yielded the lowest and the hand pulled plants yielded the highest. Yield was significantly reduced by machine harvest, except for the undamaged precision seeded plants.

Guzman and Deen (Table 4) collected data on seedling responses after machine harvest using an earlier prototype (1) of the celery seedling harvester which they developed. The level of damage to the seedlings was 42% with light

[3]IFAS experimental seeder developed by V. L. Guzman located at AREC Belle Glade.

Table 3. Means of stand, yields and corrected yields for stand of celery seedlings harvested by machine and by hand in relation to conventional and precision seeding. Transplanted March 3, 1977 and harvested May 19, 1977 at South Bay Growers farm, South Bay, Fla.[z]

Seeding[y] Method	Damage	Harvest[x]	Stand/Plot	g/plant	Kg/plot	Marketable[w] Crates/ha	Corrected Kg/plot
Conv.	None	MH	50ab	707b	35.7bcd	2100c	32.2
Conv.	All	MH	45c	693b	31.5d	1910b	37.0
Conv.	None	HH	52a	892a	46.5a	2676a	40.9
Prec.	None	MH	47bc	829a	39.8abc	1702c	41.1
Prec.	All	MH	43c	788ab	34.7cd	1132c	42.3
Prec.	None	HH	51a	829a	42.8ab	1307c	37.5

[z]Means followed by a different letter are significantly different at 5% level.
[y]Conv. = Conventional seeding; Prec. = Precision Seeding.
[x]MH = Machine Harvest; HH = Hand Harvest.
[w]Treatments 1, 2 and 3 were Fla. 683 and 4, 5 and 6 were Fla. 2-14. Florida 683 bolts easily and the elimination of bolters as culls make crates/ha low for Fla. 683.

Table 4. Effect of damage when machine harvesting celery seedlings on plant mortality, number of petioles 15 days after transplanting, stand and yields (mean of four replications) transplanted December 14, 1967 and harvested March 14, 1968 at Duda and Sons Farm, Belle Glade, Florida (Guzman and Deen, unpublished data).

Harvested	Damage	Total dead seedlings	Leaves in 10 plants		Stand at Harvest	Weight kg[z]		Petiole cm	
			Dead	Alive		Total	Trimmed	Length	Width
Hand	None	3	17	52	51	67.70	47.51	22.25	2.08
Machine	None	3	17	44	51	64.05	44.07	22.00	1.99
Machine	Light	3	20	44	50	63.78	44.03	21.75	1.97
Machine	Severe	4	21	43	50	60.47	41.13	21.50	1.96

[z]Differences in yields were not significate.

damage, 26% with severe, and 32% with no damage. This compares to 10% and 14% damage using the data in Table 1 for conventional and precision seeded plants, respectively. They found no significant reduction in yield with the machine harvested plants; however, there was a trend to lower yields with damaged seedlings and with machine harvest but the reduction was much less than in the current study. Another important difference was the number of dead plants in each study. In the earlier data a total of 3 or 4 plants per treatment died, which resulted in a near complete stand. However, in the data in Table 3 a significant difference in plant stand was found. To estimate the effects of plant stand on yields covariance analysis was used and the yields corrected. No differences in corrected yields due to machine harvest could be found. The damaged plants showed yields higher than machine harvested undamaged plants. Machine harvesting had an effect on plant stand which was reflected in low yields. Guzman and Deen's data were collected on plants transplanted in December when moisture and heat stress was probably minimal; therefore, they did not lose as many plants. It is unknown why the mechanical harvesting of the seedlings had an effect on plant survival rate, but this reduction in stand probably may be overcome by better irrigation after transplanting and by avoiding delays in wetting of the seedlings after harvest. In each study the machine harvested plants were sorted thus exposing them to additional time delays before irrigation.

The precision seeded damaged plants had a lower yield of 12.1% below the precision seeded undamaged machine harvested plants (Table 3). This difference was not sufficient, however a strong trend appears to exist. If the level of reduction were to appear in an operational system and with 14% damaged plants, the actual reduction in yields would be 14% of the 12.1 or 1.6% loss in total yields.

From observation, it appears that the machine harvested plants grow at a slower rate than the hand harvested plants. During this study a marked difference was observed between the treatments. The stresses which are present with machine harvested plants slowed growth as well as caused a reduction in stand. Perhaps as little as three or four additional days of growth will correct this situation.

Another important criterion to consider is the physical ability to transplant the seedling. With plants that were harvested and transplanted without sorting, a mean of 7.5% skips were found in 30 m of row for conventional seeding and a mean of 2.2% skips for the precision seeding (Table 5). After four weeks the number of skips had increased to 9.8% for the conventional seeded plants and 5.0% for the precision seeded plants. This verifies what observations indicated in that the larger, more uniform, plants are much easier to handle and less skips occur.

Table 5. Means in percent of skips and dead plants in 30 m rows when four operators transplanted unsorted celery seedlings harvested mechanically from conventional and precision seeded beds.

Seeding methods	Operators 1	2	3	4	Means
	Skips after transplanting				
Conventional	1.8	7.6	10.5	9.9	7.5
Precision	0.5	4.1	1.8	2.3	2.2
	Skips and dead plants after 28 days				
Conventional	9.4	12.9	5.8	11.1	9.8
Precision	4.7	2.3	2.3	10.5	5.0

Conclusions

A reduction in yield occurs when plants are machine harvested because the survival rate of these plants is less than of hand harvested plants causing a reduction in stand. A machine can be constructed which will reduce seedling damage to an acceptable level; however, use of the harvester will require excellent management and attention to detail adjustment and operation. By use of precision seeding equipment and good seed a uniform seedling stand can be obtained. This will improve the ability of the machine to harvest the plants and improve the efficiency of the transplanter operators to handle the plants without producing skips. In addition, improved techniques of irrigation after transplanting and improved watering of the seedlings after harvest need to be developed to minimize seedlings exposure to damaging stress.

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Proc. Fla. State Hort. Soc. 90:407-409. 1977.

EFFICACY OF ONE STREAM VERSUS THREE OF A SOIL FUMIGANT FOR PRODUCTION OF TOMATO[1]

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Additional index words. Root-knot nematodes, Verticillium wilt, Fusarium wilt, containerized transplants.

Abstract. **In a tomato production system which included a full-bed mulch, 'Walter' tomato yielded as well with a single stream application of the soil fumigants MBC (Dowfume MC-33) methyl bromide 66% + chloropicrin 33%, or DD-MENCS (Vorlex) methylisothiocyanate 20% + 1,3-dichloropropane-1,2-dichloropropene 80%, as with 3 streams of either fumigant spaced 8 inches (27 cm) apart. MBC also increased marketable yield of 'Tropic' tomato, regardless of type of application. Incidence of root-knot nematodes, Verticillium wilt and Fusarium wilt were reduced on susceptible cultivars by either method of treatment.**

The high value of Florida's tomato (*Lycopersicon esculentum* Mill.) crop is the result of a crop management program which includes soil treatment with a broad-spectrum soil fumigant under a full-bed mulch (i.e., 75-80 cm wide raised bed covered the entire width with 0.0025 cm thick polyethylene plastic film). Although single stream fumigation resulted in an increase in yield (1, 7), it has been the practice, especially with the development of Fusarium wilt, incited by *Fusarium oxysporum* Schl. f. sp. *lycopersici* (Sacc.) Snyder & Hansen race 2, in Florida to use multiple streams of a fumigant for the high yields expected of tomato under the full-bed mulch culture. With placement of fertilizer on the shoulders of the bed (2), it was thought that plant roots must be protected from root-rotting pathogens (*Rhizoctonia solani* Kuhn and *Pythium* spp.) and the vascular pathogens which can greatly reduce yields. It was further conjectured that this protection must be adequate to permit the absorption of nutrients by a healthy, expanding root system. Consequently, fumigants were and are currently applied with 3-5 chisels 8-12 inches (20-27 cm) apart and 6-8 inches (15-20 cm) deep to protect the tomato crop from soil-borne pathogens, nematodes, and weeds (5).

Two factors developing simultaneously in Florida's tomato industry suggested the possibility that this stringent fumigation practice might be relaxed: 1) the commercial success of the tomato cultivar 'Walter' which is resistant to Fusarium wilt race 1 and 2; and susceptible, but somewhat tolerant (3) to Verticillium wilt (*Verticillium albo-atrum* Reinke and Bert.), and 2) the introduction of containerized seedling transplants (produced in sterile media) to the planting procedure.

To test the premise that an alternate, more economical, pest management program combining a reduced zone of fumigated soil, plant resistance, and hardened 5-week old transplants could effectively maintain high yields of the 'Walter' tomato, 3 field experiments were carried out on Myakka fine sand.

Materials and Methods

In 2 expt [Fall 1976 and Spring 1977 (A)], both MBC (Dowfume MC-33) (methyl bromide 66% + chloropicrin 33%) and DD-MENCS (Vorlex) (methyl isothiocyanate 20% + 1,3-dichloropropane-1,2-dichloropropene 80%) were injected with 1 and with 3 chisels, 8 inches (20 cm) apart, in a 30-inch (75 cm) wide bed prepared in the standard manner (1). With MBC, 350 lb/acre (392 kg/ha) and with DD-MENCS 35 gals/acre (327 l/ha) were applied through each chisel. Thus 1/3 of the amount of chemical was applied with 1 chisel as with 3 chisels. In the third experiment [Spring 1977 (B)] only MBC was applied within blocks of the field held at 3 pH levels: 5.5, 6.5, and 7.5. Two weeks after fumigant application in all expt, containerized 'Walter' seedlings were transplanted into 4 replicates of treated and nontreated plots. The third expt [Spring 1977 (B)] was of split plot design in which transplants of both 'Walter' (susceptible to Verticillium wilt) and 'Tropic' (susceptible to Fusarium wilt race 2) were used.

All data were submitted to statistical analyses.

Results

Yield. All treatments in the 3 expt increased yields over the control except DD-MENCS in the fall 1976 (Table 1). MBC was better than DD-MENCS in all comparisons. Although plant mass in plots treated with 1 stream of DD-MENCS was obviously poorer than with 3 streams, there were no differences in total marketable yield between 1 and 3 streams of either fumigant, except that, in the fall expt, 1 stream of MBC was better than 3 streams. However, there was a difference in quality of the yield from 1 vs. 3 streams of DD-MENCS in that combined weight of extra large fruit (size 5 x 5 and 5 x 6) was 22% less with 1 than 3 streams.

In the second spring experiment (B), the number of streams of MBC did not affect the yield of large sized fruit

[1]Florida Agricultural Experiment Stations Journal Series No. 822.