Teaching Plasticulture Technology to Undergraduate Students

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Additional index words. undergraduate education, plastic mulches, drip irrigation, fertigation, growth-enhancing technology, vegetable crops

Teaching the course Plasticulture Technology, for the intensive production of vegetable crops, to researchers, extension professionals, industry personnel, and growers around the country has been very successful using short courses, seminars, and on-farm demonstrations (Lament, 1989; Lament et al., 1992, 1993, 1994). It is important that undergraduate horticulture-agriculture students also are introduced to the latest plasticulture technology and that they can practice using this technology as part of their undergraduate education. The challenge was to provide meaningful outdo-or activities involving the latest technology in the field of plasticulture for 55 undergraduate students enrolled in the Vegetable Production class. The objective of developing this hands-on instructional tool was to reinforce the information presented in the classroom lectures with actual field experiences or activities in the laboratory portion of the class. A secondary consideration and challenge was to provide these activities close to the greenhouse, so that valuable lab time was not consumed traveling to a grower's property or the Kansas State Univ. Horticulture Research Center-Manhattan. This location would allow the students to monitor the project easily. The answer was to develop a Mini Vegetable Production Unit on campus that incorporated all the latest plasticulture technology. The goal was to sequence the lab experiences to closely approximate (as feasible, given inherent limitations) an actual vegetable operation. The students were involved actively in all phases of the operation from planning, implementing, maintaining, and harvesting. The Mini Vegetable Production Unit was maintained by a paid undergraduate student during summer and fall, with sequential plantings, and became an educational asset to the entire community.

The site selected for the Mini Vegetable Production Unit (Fig. 1) was adjacent to the Horticultural Conservatory because of its availability and closeness to the greenhouse. This location meant that the labs could be adjusted or modified easily depending on the current weather conditions. (Fig. 2). In other words, the lab could be moved into the greenhouse, and students would work on another activity if the weather was inhospitable. This added a touch of realism, which parallels what growers encounter in their operations. The site was to become known to the students as the Vegetable Production Farm.

The area was split into eastern and western sections. or farms. by the walkway to the conservatory. This was convenient for planning purposes, because one farm could be nonplasticulture. whereas the other section was designated as the intensive plasticulture area. (Fig. 3). This arrangement allowed the areas to be reversed each year. thus promoting rotational practices. Because Vegetable Production is taught in the spring semester, some activities, such as establishing a fall cover crop of rye grain and rye grain windbreaks (Fig. 4) or fall-seeding a winter annual legume such as hairy vetch *(Vicia villosa* Roth) (Fig. 5), had to be accomplished the preceding fall. Discussions that follow will involve the entire production unit, with special emphasis on the plasticulture section.

Student involvement began with the actual planting plan. This involved selecting crops, row spacing, in-row spacing, whether the crop would be transplanted or direct- seeded, fertiizer requirements, when to seed to start transplants, how many transplants were required, and how much seed was needed. The students also were encouraged to investigate what potential pest problems might be encountered and what control measures were available. The students were provided, or had access to, a large collection of vegetable production guides, seed catalogs, and pest control information to aid them in their selections. Decisions made by the students were discussed and analyzed with them by myself and the teaching assistant in charge of the lab sections. This provided the students with feedback and also prevented any adverse decisions from being implemented.

The next step was to develop on paper maps of the two production areas. The dimensions of the eastern section were about 50 × 29 feet (15 × 9 m) (Fig. 6), and the western section was about 55 × 29 feet (17 × 9 m) (Fig. 7). This was about 0.07 acre (0.02 ha). A list of items and equipment needed for starting a project like this are presented in Table 1. The location of each kind of vegetable and the number of transplants required were determined. For direct-seeded crops, seeding dates were determined for the earliest crops, like potatoes, peas, onions, and spinach, and the following succession plantings. The amount of and type of plastic mulch and drip irrigation tape to be used were calculated for the plasticulture section. The location and date of transplanting for crops, such as tomatoes, pepper, eggplant, okra, squash, muskmelon, and cucumbers, were determined. It was decided, after discussion, whether the crop would be grown in a single or double row on the plastic mulch. The amount of vinyl lay-flat hose and the number of transfer tubes or plastic connectors needed for the drip irrigation system were determined. The concept of fertigation was introduced in class, and students in lab discussed and calculated the amount and determined the type of fertilizer to be applied preplant and as a supplement to each crop.

The importance of proper soil preparation and some of the problems that would be encountered if the rye cover crop were not turned under in time were a focus of lab instruction. The advantages of using a winter annual legume such as the hairy vetch (Fig. 8) were discussed, and students determined a rough calculation of the

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Fig. 1. *The Mini Vegetable Production Unit-an educational asset to the entire community.*

Fig. 2. *Mini Vegetable Production Unit was near the Kansas State Univ. greenhouse.*

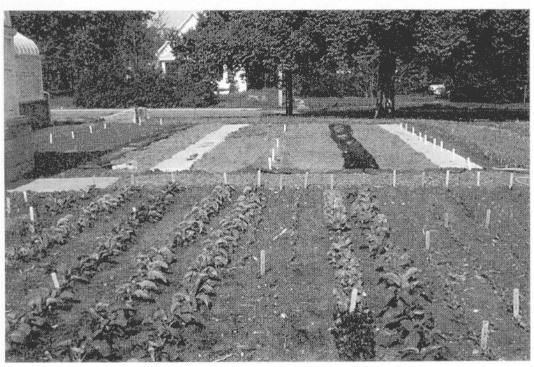

Fig. 3. *The nonplasticulture and plasticulture sections divided by the walkway of the Conservatory.*

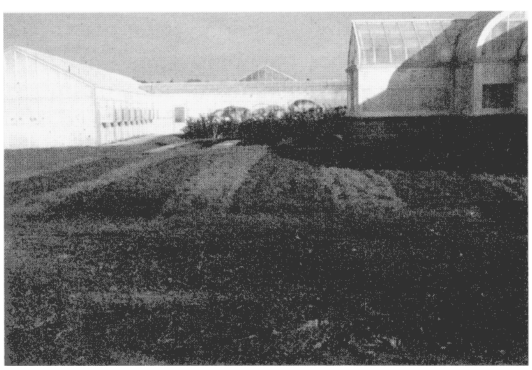

Fig. 4. *A fall cover crop and rye grain windbreaks were established the preceding fall for use in the spring.*

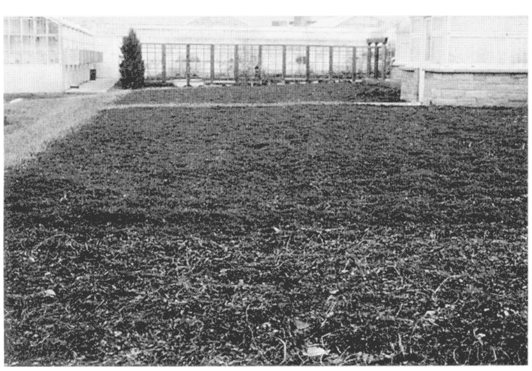

Fig. 5. *Hairy vetcb, a winter annual legume.*

amount of nitrogen being supplied by the legume. The opportunity for students to observe first-hand and discuss nitrogen fixation and to see active pink nodules on the legume roots reinforced classroom discussions and clearly demonstrated the benefits of using legumes in a vegetable production system. The reasons why plasticulture can further enhance the performance of a legume-based fertility system were demonstrated. The students prepared the soil using an 8-hp tiller (Troy-Bilt, Troy, N.Y.), which allowed them to note soil structure and tilth plus the presence of a clay hardpan about 8 to 10 inches (20 to 25 cm) deep. (Fig. 9). This exposed the students to the importance of organic matter and the ability of legumes and cover crops to improve the soil over a period of time. The Mini Farm was started by turning under sod in 1990. The soil was a heavy clay with poor structure when the project began. Each successive growing season has seen marked improvement in the arability of soil.

The students measured, applied, and incorporated preplant fertilizer on the nonplasticulture side. The rows were marked and planted with a Cole Planet Jr. (Market Farm Implement, Friedens, Pa.). Other vegetable crops were either direct-seeded or transplanted, depending on the master plan. Irrigation was accomplished using an impact sprinkler specially developed for the course, and the number of gallons of water applied for each irrigation event was recorded in the students' logbooks. (Fig. 10).

The section receiving plastic mulch, drip irrigation, row covers, etc., was tilled, and the calculated amount of preplant fertilizer was incorporated. The different plastic mulches and drip-irrigation tapes were applied by hand on a slightly raised bed. If a double-row crop such as peppers was to be planted, the drip tape was buried 3 inches (8 cm) deep and down the center of the bed, whereas, with a single-row crop like tomatoes, the drip tape was buried 3 inches (8 cm) deep and about 4 inches (10 cm) away from the center of the bed. The plastic-mulched beds were on 5-foot (1.5-m) centers similar to standard commercial practices. Different plastics were used so that the students could observe the advantages and disadvantages of each. (Fig. 11). The students measured soil temperatures under the mulches and discussed how the degree of contact between the soil and plastics can influence the thermal properties of the soil and the plastic. Plastic mulches that have been used in class over the years are clear, black, white-on-black,

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Fig. 6. *The eastern section of the production unit.*

Fig. 7. *The western section of the production unit.*

silver reflective, green IRT, brown wavelength-selective, paper, and several photodegradable mulches.

The drip-irrigation system was assembled by the students (Fig. 12) using a hydrant for the water source and a small screen filtration-pressure regulation unit [(3/4-inch (2-cm) Amiad 200-mesh (0.60-mm) screen filter, 3/4-inch (2-m) Senninger irrigation pressure reducer at 10 psi at 4 to 16 gal/rein (4.5 kg-cm^{-2} at 15 to 60 liters. rein-l)] and a pressure gauge to ensure a clean water supply and reduce the operating pressure of the systems. The cost of the unit is about $50.00 (Fig. 13). The pressure gauge on the unit allowed the students to track any changes in pressure that might indicate a potential clogging problem. The fertigation unit consisted of a simple venturi-type system brass siphon mixer (Hyponex, Mayville, Ohio) connected to the hydrant. (Fig. 14). To have a sufficient flow rate for the siphon to draw the fertilizer out of the bucket, a minimum of 500 feet (152 m) of high-flow 0.4 gal/rein (1.5 liter·min^{-1}) drip tape is required. A simple backflow prevention device (Cash Acme Backflow Preventive, Galdstone, Winnelson, Kansas City, Kan.) was inserted ahead of the fertigation unit to ensure that no injected fertilizer or other chemical could enter the water source. Other more-sophisticated irrigation and fertigation systems were discussed in class lectures. The students calculated the amount of fertilizer required per week and determined the injection schedule. To learn how to determine soil moisture status under the plastic mulch, students set up and maintained tensiometer stations at 6- and 12-inch (15- and 30-m) depths. The students maintained a log of all water applied and fertilizer injected.

Rowcovers and a small plastic-covered tunnel were used to demonstrate and teach growth-enhancing

Table 1. *Suggested list of equipment/items[z] needed for the production unit.*

Equipment/item	Unit quantity	Unit price	Total price ($)
Drip irrigation tape (8 mil)	1 roll (7200 ft)	135.00	135.00
Layflat hose × loc sleeve fittings	15	1.28	19.20
2-inch Vinyl layflat hose	1 roll (300 ft)	150.0	150.0
Screen filtration/pressure regulation unit	1	50.00	50.00
Irrometer 6- and 12-inch	2 each	47.00	188.00
Irrometer test_pump service unit	1 each	46.00	46.00
Black plastic mulch	1 roll (2400 ft)	71.50	71.50
Hozon brass siphon mixer	1	7.75	7.75
Plastic inserts 72 cells	2 cases	25.45	50.90
Flats	2 cases	41.50	81.00
Metro Mix 360	8 bags	7.75	62.00
Plastic labels (4-inch × 5/8 wide)	2 boxes	14.10	28.20
Fertilizer	---	50.00	50.00
Seeds	---	---	120.00
Hand tools (hoes, digging forks, rakes, shovels, trowels, bulb setter, etc.)	---	---	300.00
8-hp Troy Bilt tiller	1 each	1300.00	1300.00
Planet Jr. hand seeder	1 each	329.00	329.00
Solo 410 backpack gas power mistblower	1 each	439.95	439.95
Solo Jetpak model 425	1 each	109.95	109.95
Solo 456 tank sprayer	1 each	39.95	39.95
Pesticides	---	---	150.00
Misc. (buckets, hoses, etc.)	---	---	75.00
Total			3804.40

[z]*Some items are large one time expenses, while other items such as plastic mulch and drip tape will supply enough material for several years, and many items may already be available in the department inventory.*

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Fig. 8. *The advantages of using a winter annual legume such as hairy vetcb was discussed with the class.*

Fig. 9. *Soil preparation using an 8-hp tiller.*

Fig. 10. *The use of overhead irrigation with some crops.*

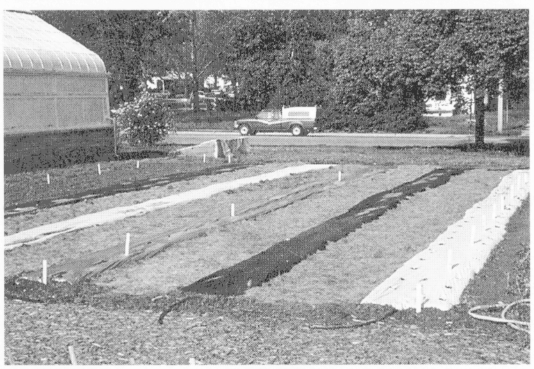

Fig. 11. *The use of different colors and types of plastic mulches exposed students to their thermal characteristics, degree of reflectivity, and photodegradability.*

Fig. 12. *Sudents assemble the drip-irrigation system used in the plasticulture section.*

technology. (Figs. 15 and 16). The students applied the rowcovers made of several different types of materials to evaluate what is currently commercially available to vegetable growers.

Windbreaks of rye grain were grown to reinforce a discussion of the importance of protecting young vegetable plants from the adverse effects of winds. (Fig. 17). The windbreaks were cut down when they were no longer needed for wind protection.

All vegetables were labeled with varietal names, and the students constantly scouted for the presence of insect pests and beneficial insects. This activity-integrated nicely with their Horticultural Entomology course. They learned to recognize diseases and physiological disorders of vegetable crops. Weed control was accomplished either by hoeing or spraying an approved herbicide between the rows of plastic mulch using a two-nozzle, pump-type backpack sprayer. Pesticides, if deemed necessary, were applied by either a pump-up, hand-held sprayer or an air-blast backpack sprayer under faculty supervision.

Given the time constraints of the semester, only a few crops were ready for harvest in May. These were used in discussions on time of harvest, grading, packing, and marketing. The students who are going to be around during the summer and those who are returning in the fall are encouraged to visit the production units and discuss how the production cycle worked out with myself

The main objective of developing this Mini Vegetable Production Unit was to provide some hands-on experience in vegetable production and the use of plasticulture technology in a restricted of area. (Fig. 18). The students gained a better appreciation of intensive vegetable production practices and will be better prepared for entering the job market. (Fig. 19).

In the future, we hope to have more plasticulture machinery suitable for small farming operations and teaching purposes that wi11 take this experience to an even more realistic plane. Also, we need to be far more innovative and offer vegetable-fruit production courses in the summer that are multi-disciplinary and allow students not only to experience real-world decision making but also to earn money from the course, just like a working operation. The industry people are very supportive of this idea and have always been willing to donate materials for use in formal educational or extension related activities.

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Fig. 13. *The small screen filtration-pressure regulation unit with pressure gauge used to ensure a clean water supply and reduce the operating pressure of the system.*

Fig. 16. *Growth-enhancing technology using small plastic-covered tunnel.*

Fig. 14. *Simple venturi-type fertigation unit (brass siphon mixer) connected to a hydrant.*

Fig. 17. *Use of windbreaks of fall-planted rye grain to protect young vegetable plants from adverse effects of spring winds.*

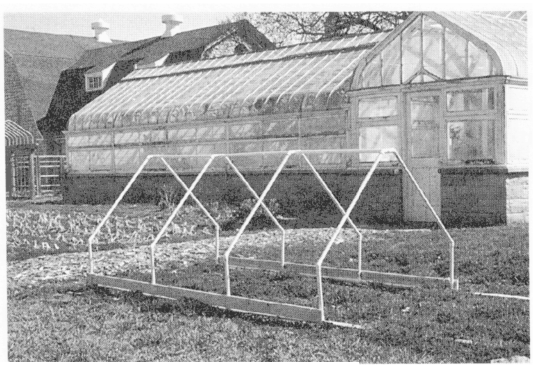

Fig. 15. *Growth-enhancing technology using row covers.*

Fig. 18. *Student activity in the Mini Vegetable Production Unit.*

Fig. 19. *Students are better prepared for entering the job market.*

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