Strawberry Plasticulture Systems for Day-neutrals and June-bearers

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Section 1. Introduction to the Strawberry Plasticulture System

"Strawberry Plasticulture" is technically the annual hill training system in which "green" strawberry transplants (fresh dug plants or plugs) are planted in early fall in double rows at densities of approximately 15,000 to 17,500 plants/acre on fumigated, raised beds that are covered with black plastic mulch *Strawberry plasticulture* is technically the annual hill training system. The term *hill culture* refers to a type of strawberry training system where the runners are either manually or mechanically removed (in summer), or don't develop at all (fall-winter season). It is a training system that allows only for the growth and development of the mother plant. Hill system transplants are normally set in double rows with plants spaced 12-14 inches in-the-row by 12-14 inches between the row – this is variety-dependent as some varieties like Sweet Charlie benefit from closer spacing than more vigorous varieties like Chandler. Plants are normally set in a staggered pattern (alternate) with the adjacent row as indicated by the illustration in Fig. 1-H. The training systems shown in Figs. 1-D and 1-E are modifications of the older matted row system where mother plants are set in the early spring and allowed to "runner". In contrast, any runners that form in the hill system are removed. In actuality, by the time growers in the southeastern Coastal Plain plant in mid-October, there is no runnering at all.

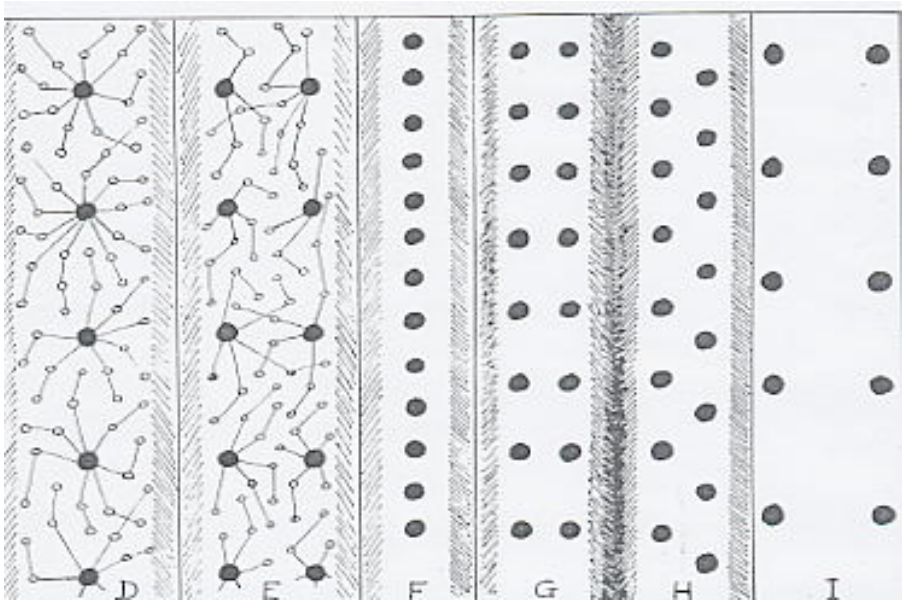

Fig. 1. Systems of training strawberries: D. Spaced Row (allows daughter plant development with mother plants set in center); E. Spaced Row (mother plants set near edge of raised bed); F. Single Row Hills; G. Double-Row Hills (opposite); H. Double-Row Hills (alternate); I. Stool Hills (Older European System).

We attach the word ***annual*** to ***hill culture*** to describe a training system where new strawberry plants are set out *each year* for fruit production as opposed to training systems that take advantage of the perennial growth habit of the strawberry (e.g. matted row, spaced row, and ribbon row). The first and perhaps most important principle of annual hill can simply be stated as follows: *Achieving large fruit size and excellent quality on a regular basis can only be achieved with first-year plants*. If you carry over a first-year planting, be prepared for smaller berries that are much more time-consuming to harvest. *The best "grower control" for optimizing fruit quality and size is to stick with the younger first-year plants.*

Don't carry-over to a second year! In the strawberry plasticulture system berries can be harvested in just 7 to 8 months after planting in the early fall. Following harvest (early to mid-June), the strawberry plants should be destroyed due to the high risk of infection in the Mid-South with anthracnose fruit rot (*Colletotrichum acutatum*) as well as anthracnose crown rot (*Colletotrichum gloeosporioides*) in second-year beds. Although anthracnose crown rot can be observed in fruit production fields during the fall and spring it is most severe in nurseries in the southeastern United States and is one of the primary reasons that production of transplants has moved to the mountains of Western North Carolina and Canada's Maritime Provinces, including Nova Scotia and Prince Edward Island. The plastic beds may be re-utilized for summer/fall vegetable crops, and these crops also would benefit from pre-plant fumigation for strawberries.

Raised beds. are another crucial "ingredient" to success with the *strawberry plasticulture system.* In reality, most of the strawberry beds in North Carolina are 10-inch high "super beds" (not 12-inch as shown in Fig. 2), and the 10-inch high beds are typically 32 inches wide at the base and 30 inches wide on the top. The beds are slightly crowned so water will run off and not rest on the plastic (a bed with a 30-inch top should slope from the center to the edge with a drop of 1.25 inches). Beds are on 5-ft centers in North Carolina (not 52-inch as shown in Fig. 3). There are 8,712 linear ft of row per acre with the 5 ft center. Most growers use a 60-inch wide plastic film roll (not 54-inch).

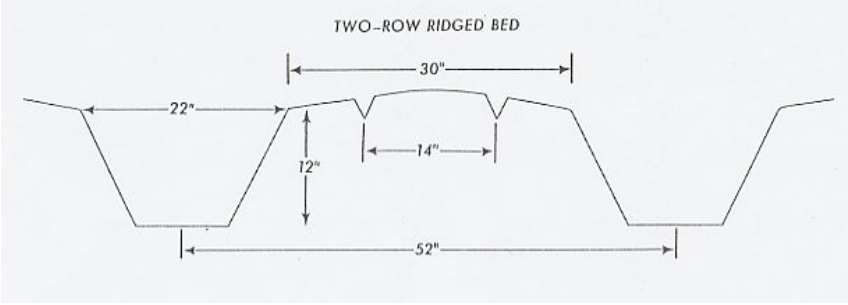

Fig. 2. Schematic of older two-row ridged bed used in California.

The "super-beds" provide a nearly ideal air-soil-water environment for vigorous strawberry root development. The beneficial effect of these beds on root growth is easily observed by excavating the soil beneath the plastic mulch film at the end of the season.

George Darrow (1966) also identified the importance of raised beds for healthy root development:

> "Roots of the strawberry grow chiefly downward in well-drained sandy soils and a few roots may be found as deep as 24 inches. In clay soils they spread more horizontally. In late fall when the water table rises and the oxygen in the deeper layers becomes low, root growth is shallow. *The oxygen content of the air in the soil where root growth is active is nearly that of the air above the soil,* but where soil is water, it may be as little as 1/10,000 the normal."

Black plastic. Late fall and early winter field conditions in North Carolina and the mid-South are actually *too cold* for the strawberry annual hill, raised bed system to be economical without the addition of *black plastic mulch*. The black plastic film must be in direct contact with the soil beneath to achieve the desired soil-warming effect needed for rapid plant establishment in the fall. With the plastic mulch, heat does not radiate so rapidly off the soil under the plastic, so that with several degrees warmer soil for several months, more extensive root and crown development occurs.

Fig. 3. A North Carolina raised bed covered with embossed black plastic mulch – 5 ft centers.

With the addition of raised beds and black plastic mulch to the total package, you can better see why the name ***strawberry plasticulture***, is preferred to the *annual hill, raised bed, black plastic mulch system*!

Weather risks. In very good weather years it may be possible to achieve another ½ pound per plant above the average yield for a given growing region, but in erratic weather years, like the 2009-2010 season, growers in the coastal plains of North Carolina, for example, saw their average yields plummet to less than 1 pound of berries per plant. Based on research completed at N.C. State University, strawberry growers need to achieve yields of at least 1 pound of berries per plant, or 15,000 pounds per acre (7 ½ tons), to make a profit using plasticulture (Safley and Poling, 2004). Another seasonal risk with strawberry

plasticulture production is the potential for having a harvest season in which the crop is very concentrated. In the spring of 2011, the North Carolina crop was very concentrated in ripening, and instead of picking for 4 to 5 weeks, the season only lasted about 2 ½ to 3 weeks on many farms (for reasons that are still not well understood). There is the added problem in years of concentrated crops that growers will likely experience great difficulty in locating *enough pickers and markets* during the peak production period.

Section 2. Preliminary Considerations

A number of strawberry plasticulture production recommendations have changed over the last decade, and the balance of this *Introduction to Strawberry Plasticulture* is intended to provide current information on a full range of plasticulture production-related topics, from variety selection to plant tissue testing and the latest recommendations on row cover management.

Before setting the first strawberry plant, there are several preliminary considerations to address, including site, soil, equipment, plant material, nursery plant health and varieties.

2.1 Site

Windbreaks. The most reliably productive strawberry plasticulture sites are almost always those with a wooded area or a windbreak on the north or northwest side of the field. Wind not only has a drying affect on plant foliage, it can also impede frost protection efforts. New leaves in the early spring are especially susceptible to mechanical wind injury on exposed sites.

Crop rotation. It is best to rotate strawberry field sites as often as possible, but the general practice in most areas is to crop strawberries continuously on the same land because of existing irrigation lines and market location. Avoid rotations with crops treated with herbicides or plant growth regulators (or a combination of these) that could be residual in the soil and cause crop losses in strawberries. Read all pesticide labels carefully for rotational restrictions.

Row orientation. A north-to-south row orientation is recommended for more uniform plant stands and ripening. However, if the field is almost flat, facilitating soil drainage is the most important factor.

Wildlife. Most strawberry plasticulture sites require protection from deer within a month or two of planting. In areas with intense deer pressure, appropriate fencing should be erected no later than two weeks after planting. If deer are allowed to graze once, the likelihood of their return for another meal drastically increases. Fences provide the most effective control for prohibiting deer. Several configurations of electric fences are available. The most effective fence utilizes two fences spaced one and a half feet apart (an inner fence and an outer fence) using white electric tape instead of wire. The two layers of tape alter the deer's depth perception deterring its effort to cross the first fence line. Many growers also manage deer pressure by practicing population reduction. Hunting deer outside of the regulated season requires a special permit from the N.C. Wildlife Resources Commission.

2.2 Soil

Soil structure is important for bed formation. Beds are made five feet apart, center-to-center.

Soil content. Strawberries grow and produce satisfactorily in a wide range of soil types, but sandy loam and sandy clay-loam soils are ideal for building and shaping the 8-inch-deep raised beds that are critical to the success of the strawberry plasticulture system. Soils with high clay content or those that are rocky or very stony are more difficult for bedding, fumigation and plastic-mulch equipment. As a general rule, growers should consider using plug plants on soils with a high clay content for semi-mechanical transplanting (with a water wheel) rather than bare-root, fresh dug plants (which require hand transplanting). Sandy soils will require more careful irrigation and nutrient management. Research is ongoing to identify useful soil amendments, such as chicken compost, and testing of summer cover crops to improve soil structure.

Soil pH. Optimal strawberry production requires a favorable root environment and the availability of essential nutrients. Soil pH is a key factor in maintaining a favorable root environment. Soils with a pH between 6.0 to 6.2 promote the best growth. A soil test can indicate what amendments need to be added to correct the pH. Soil testing services are available from NCDA&CS regional agronomists. Low pH is one of the most frequent problems identified on soil samples. Because the problem cannot be corrected after planting and low calcium (Ca) usually accompanies a low soil pH, testing and liming the soil as needed is especially important. Incorporate the lime based on the soil test recommendation at least two months before transplanting.

Soil moisture. Strawberry plants require a continuous supply of water during periods of active growth, and drip irrigation is the most efficient method for slowly applying small amounts of water directly to the strawberry plant' s root zone in the pre-bloom, bloom and harvest period. It is important for growers to keep in mind that a standard 8- to 10-inch strawberry plasticulture bed has very poor capillary water movement and a drip irrigation system is going to be required to meet most of the moisture requirements of the crop. But, with good management of a drip irrigation system, strawberry root zone moisture content can be maintained close to optimum for plant growth, or near what is called "field capacity." In North Carolina, it is common practice to use the drip system to establish plug transplants in the late summer, but some overhead sprinkler irrigation should still be applied for the first two to three days after transplanting. It is also recommended that growers hook up their drip systems soon after planting for a post-plant chemical injection of Ridomil Gold *if* transplants are suspected to be infected with crown rot (*Phytophthora cactorumi*), or when a field has a history of this disease. To aid transplant establishment in October and November, it may be necessary to run the drip system for a few hours every few days during weeks of little or no rainfall. Drip systems are "winterized" in the late fall and are not re-connected until early March (around the time of new leaf development). Water loss from plants is much less during the dormant season (December to early February), and winter rains generally furnish adequate soil moisture through early March. However, in warm periods during mid-March

(pre-bloom) it is not unusual for the crop's water requirement to approach 1 inch/acre/week. On a daily basis this is about 3,880 gallons (1 acre-inch of water = 27,154 gallons). During the bloom, fruit set and harvest period, crop water usage will climb to 1.5 inches/acre/week (0.2 inches/acre/day), and in warm/hot weather it becomes necessary to apply as much as 1.75 inches/acre/week (0.25 inch/acre/day).

Soil erosion and surface water management. Although raised beds encourage water drainage within the soil, plasticulture growers frequently encounter problems with getting rid of excess surface water. Because 50 percent of a plasticulture strawberry field is covered with an impermeable plastic film, the field should have enough slope that surface water drains uniformly and gently from the field after periods of heavy precipitation without causing erosion or leaving puddles. On fields with more than a two percent slope (a two-foot drop over 100 feet), continuous overhead sprinkling for establishment of fresh dug plants may cause severe soil erosion. It is often a good idea to broadcast annual ryegrass at a rate of approximately 50 pounds per acre over the entire field the same day you finish fumigating (before planting holes are punched). Ryegrass will reduce soil washing in the aisles after heavy rains or establishment irrigation on sloping terrain. The ryegrass should be killed or stunted by an application of post-emergence grass herbicide when it is about six inches tall or prior to applying the winter row cover.

2.3 Equipment

A specialized tractor implement is used to lay the drip tape and the plastic mulch at the same time.

*Field preparation***.** Once the soil as been properly amended for pH and nutrient availability, fields must be prepared for transplanting. Since the premise of plasticulture is a raised bed covered with plastic mulch, growers have come to rely on a multi-function tractor implement that reduces the number of passes through the field. Equipment for shaping the beds, fumigating the soil and laying plastic and drip tape, costs approximately $5,500. New growers may consider hiring a contractor who has the necessary equipment. Custom applicators can form beds, inject fumigant, apply plastic and lay drip tape in one operation. As the fumigant is injected, the beds are immediately "tarped" with an *embossed* black plastic mulch film that can be "stretched" by the mulch laying/fumigation unit to give an extra tight fit over the bed. The black plastic film needs to be in direct contact with the soil (for maximum soil warming to occur in the late fall and winter months). If there are "air pockets" between the film and the soil, the black plastic will actually serve to cool the soil, and plant top-growth and root development will be significantly reduced.

Figure 4. Sandy loam and clay loam soils are ideal for building and shaping the 8 – to 10-inch raised beds that are a critical component to success in the *strawberry plasticulture system.* The raised beds are 8-10 in high, and 28 – 30 in wide at the base. These beds are fumigated 3-4 weeks prior to transplanting with a fumigant that is typically shank-injected (the label for some fumigants may also permit injection through the drip system).

Overhead sprinkler irrigation. Strawberry plasticulture requires overhead sprinkler irrigation for establishing transplants, protecting blossoms from cold injury and for evaporative cooling in the event of a spring heat wave that could cause open blossoms to abort. Total cost for overhead sprinkler irrigation would be approximately $2,900 per acre. It is prudent to plan for at least 12 frost and freeze episodes per season. The water requirement for an overhead sprinkler irrigation system is usually estimated on the basis of three consecutive frost or freeze nights. For example, 5.4 acre-inches of water (27,152 gallons equal 1 acre-inch) would be needed for sprinkling at the rate of 0.18 inches per hour (for control down to 24 degrees Fahrenheit), for 10 continuous hours each night over three nights. Furthermore, 1.8 inches per night (10 hours times 0.18 inch) for three nights equals 5.4 acre-inches of water. An irrigation pond would need to hold about 150,000 gallons of water for each acre of plasticulture production under these conditions (5.4 acre-inches times 27,152 gallons per acre-inch equals 146,620 gallons). Several factors should be considered before installing an irrigation system:

Water supply. Water may come from wells, ponds, lakes and municipal lines. An irrigation pond would need to hold about 150,000 gallons of water for each acre of plasticulture production to provide protection for three consecutive frost or freeze nights.

Pumping capacity. A pumping capacity of as much as 90 gallons per minute (gpm) or 0.2 inches per hour is recommended for severe frost and freeze conditions.

Pump. An electric pump is recommended for reliability so long as a reliable electric power service is available.

Sprinkler type. Low-impact sprinklers are preferred.

Sprinkler spacing. A 40-foot by 40-foot triangular spacing will greatly improve the

sprinkling distribution pattern under higher winds as compared to matted-row spacing of 60-foot by 60-foot.

Overhead sprinkler irrigation is essential for establishment, frost protection and evaporative cooling.

Drip irrigation. The deep 8- and 10-inch beds require drip irrigation because capillary movement of water is poor. Drip irrigation provides the most efficient use of water and fertilizer. Many deep wells are fairly clean and require only a screen filter to remove particles. However, the presence of precipitates or other contaminants in the water should be determined by a water-quality test before considering the well for a drip system. Any surface water source, such as a stream, pond, pit or river, will contain bacteria, algae or other aquatic life, making sand filters or other special filters a necessity. For strawberries, drip tape is used to wet a continuous strip along the center of the row. A 12-inch emitter spacing is recommended for sandy loam and clay soils. For coarse sands, 8-inch emitter spacing is recommended. Drip emitter discharge rates are generally expressed in gallons per minute (gpm) per 100 feet of length for the selected emitter spacing. A common tape selection for plasticulture strawberries on sandy loam or clay soils uses 0.40 gpm emitters: 24 gallons per hour (gph) per 100 feet. To determine field water requirements in gpm per acre, simply multiply 24 gph times 87.12 (the number of 100-foot row units per acre on five-foot bed spacing) and divide by 60, which yields 35 gpm. The cost to install a drip irrigation system to these specifications is approximately $1,000 per acre. An additional cost of approximately $170 per acre will be required annually for the drip tape used in the rows. Because strawberries grown on plastic mulch are considered annuals and are grown for only one season, thin, disposable drip tape (8 mils thick) is commonly used. Once a drip irrigation system is installed, the crop can be fertilized via the drip system (fertigation).

2.4 Plant Material

Strawberry plant material is utilized in three forms in North Carolina depending on the strawberry producing region. Plants may be acquired as plugs, fresh dugs and cutoffs. Approximately 55 percent of the strawberries grown in North Carolina are grown from plugs, while 35 percent start as fresh dugs with the remaining 10 percent grown from cutoffs. The mountains, foothills and Piedmont primarily use plugs. In fact, the mountains are restricted to using plugs since the fresh dugs are not available until after their last acceptable planting date. Growers in the coastal plains primarily use fresh dugs. A most southeastern region of the coastal plains can also use cutoffs. These types of plant material are all “fresh” as opposed to dormant. Fresh dugs and cutoffs are bare-root plants, while plugs are runner tips that have been rooted in a peat-based media and feature an intact root-ball. The distinction between fresh dugs and cutoffs is that fresh dugs retain the vegetative foliage while the foliage of cutoffs has been mowed prior to digging from the propagation bed. Plugs are the most expensive type of plant material, while cutoffs are the least expensive.

Figure. 5. From left to right: plug plant, cutoff and freshly dug bare-root plant (far right).

Conclusion:

I am not as familiar with the potential for strawberry plasticulture production in upstate New York, but I have worked with the North American Strawberry Growers Association on a *Strawberry Plasticulture Workshop* that was offered just two years ago in Michigan, and the bulk of my slide presentation in this talk will incorporate information from that program. I will be commenting on opportunities to carry the plasticulture planting into a second season and also some of the issues I see with not being able to fumigate the planting.

As far as day-neutral strawberry varieties, we are now doing quite a bit of work with Albion (day-neutral) for the so-called June bearing season (which starts in mid-late April for growers in North Carolina - we prefer the term *short day*). There is an interesting progress report that you may wish to review on our preliminary experiences with growing and marketing Albion as a spring season berry:

http://www.smallfruits.org/Newsletter/Vol11-Issue3.pdf