

GROWING DAY-NEUTRAL STRAWBERRIES IN NEW HAMPSHIRE

Variety Selection & Production Tips



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Photograph Credit: Pictures of Oriental Beetle damage (p. 15, images F and G) were taken by B. Sideman. All other photographs were taken by K. Orde. Please credit accordingly.

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Dedication

We dedicate this work to our beloved Farm Manager, John P. McLean, who passed away in early 2019. John enthusiastically managed Woodman and Kingman Research Farms at the University of New Hampshire for many years. He was always there to lend a hand, teach a new skill, or for an interesting and thought-provoking conversation. John's positive spirit was contagious – and his knowledge, wisdom, kind heart and sense of humor, made the UNH farms positive and inclusive places for all.

We thank him for this, and miss him tremendously.



This guide is intended to summarize our experiences with day-neutral strawberry varieties at the University of New Hampshire and to share data from our trials as a benchmark for day-neutral performance in the region.

GROWING IN A CHANGING CLIMATE

In the last 30 years, annual precipitation in the Northeast has increased by 8%, and from 1958 to 2007, the number of days with heavy precipitation increased by 58% (Karl et al., 2009; Walsh et al., 2014). While future climate predictions are highly dependent on the emission levels of greenhouse gasses, even in a rapid emission–reduction scenario, both total precipitation and heavy precipitation events are expected to continue increasing in the next 80 years (Walsh et al., 2014). Wetter weather will pose additional challenges for the Northeastern farmer; including delayed spring planting, fewer days when land is workable, increased soil compaction and erosion, and added crop losses from excessive moisture (USGCRP, 2018). While it is also likely that the frost-free period may become longer, excessive precipitation may prevent farmers from capitalizing on a longer growing season (USGCRP, 2018).

Given these projections, commercial berry producers may need to adopt farming methods that help protect crops from damage caused by precipitation. One approach is to diffuse the risk of crop loss from one poorly-timed weather event by spreading out the production season. June-bearing (short-day) strawberry plants have a concentrated fruiting habit and therefore, a high susceptibility to weather-related damage. Meanwhile, “day-neutral” strawberry plants produce fruit from approximately June until November in New Hampshire, greatly extending the fruiting season and reducing the risk of loss from a single weather event.

Another option for protecting fruit is to establish a barrier between the crop and the environment using high tunnels, caterpillar tunnels, or low tunnels. We have recently written a detailed resource on low tunnel strawberry production that can be accessed online for free:

Low Tunnel Strawberry Production Guide

https://extension.unh.edu/resources/files/Resource007429_Rep10703.pdf



DAY-NEUTRAL vs. JUNE-BEARING

These two plant-types differ primarily in their flowering and fruiting habits. June-bearers are short-day plants, which only initiate flowers in the autumn when temperatures decrease and nights become longer. Flower trusses remain inside short-day plants until the following spring — when they emerge, are pollinated, and produce an intense but rather brief (4–6 week) flush of fruit (Figure 1).

While this traditional strawberry season has historically been met with enthusiasm from consumers, the short fruiting period makes the crop inherently susceptible to significant loss when rain or hail is experienced during this time. Furthermore, local demand for strawberry fruit is strong all year long; therefore, by growing only June-bearing plants, commercial growers are not able to participate in the strawberry market outside of the short June-bearing season.

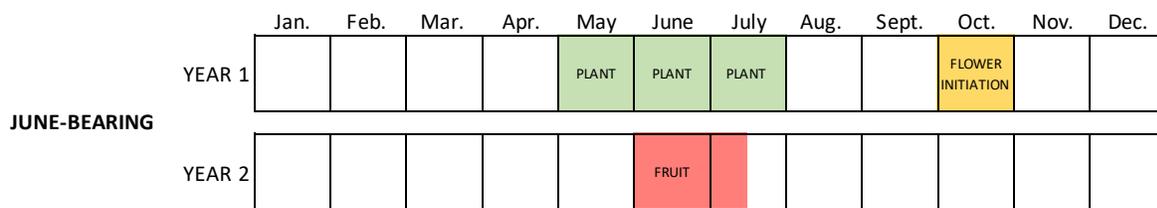


Figure 1. Typical planting and fruiting schedule of June-bearing (short-day) strawberry plants in the northeastern U.S. While month of planting varies among farms, plants require specific conditions in the late-fall to initiate flowers for the following early-summer crop.

Conversely, day-neutral plants are less affected by daylength than June-bearers and initiate flowers so long as temperatures remain approximately 40–85°F. Another difference between the two plant types is that unlike June-bearers, day-neutrals produce their first fruit in the year of planting, typically within 10 weeks of planting (Figure 2). Even though there is variation among varieties in the fruiting pattern throughout the season, day-neutral plants generally produce fruit from late-June into November in the year of planting (Figure 2; Figure 3).

If plants are overwintered and carried into a second year (please see p. 14: Winter Survival), plants will begin producing fruit prior to June-bearing varieties (before June 1 in Durham NH). The addition of low tunnels and row covers may further promote earliness. Plants typically produce a strong flush of fruit until mid-July, after which, some varieties may continue producing high-quality fruit, but others may not.

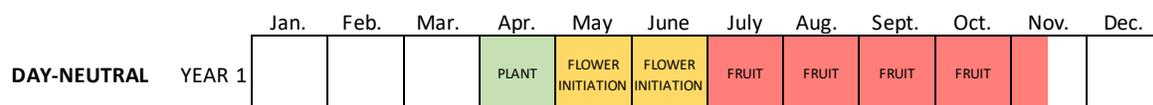


Figure 2. Typical planting and fruiting schedule of day-neutral strawberry plants. In this schedule, dormant bare-rooted crowns are planted in early-spring and begin producing fruit approximately 10 weeks after planting.



Figure 3. Growth progression of dormant bare-rooted plants in the year they were planted. From left to right: May 1, June 16, Aug. 30, and Oct. 6.

YIELD EXPECTATIONS

New England growers report annual yields of 5,900 lbs/acre to the USDA, presumably from June-bearing varieties (USDA, 2017). In our experiments with day-neutral varieties in Durham NH, marketable yields have ranged from 6,534 to 15,682 lbs/acre for plants in their first year (the year of planting). From well-managed day-neutral plantings, commercial growers in New Hampshire and Maine have reported annual yields as high as 1.5 lbs/plant and 25,000 lbs/acre.

Yield is greatly influenced by the conditions of a given growing season, in addition to planting density, mulching approach, and nutrient, pest, and plant management. For example, in our experiments in Durham NH, marketable yields were substantially greater in 2017 than 2018, which was a very wet growing season. We have also found that for the variety Albion, marketable yields have been consistently greater on plastic mulch (black or white) than on raised beds without plastic mulch. **An important note: day-neutrals require on-going and careful attention (runner removal, fertility, pest management, etc.) during the entire growing season to obtain high yields (see p. 12: Crop Establishment + Management Tips).**

DAY-NEUTRAL VARIETIES

The day-neutral varieties outlined in this guide differ from the early “everbearing” types that many commercial growers may remember from the 1980’s. Several of these varieties developed a reputation for being low-yielding and for producing small fruit. The newer day-neutral varieties that we discuss here were developed in California for large-scale production, but have been successfully grown on the East Coast and in the Upper Midwest. Fruit size is impacted by variety, but tends to be comparable to a mid- to large-sized June-bearer fruit (Table 1).

There are a greater number of day-neutral varieties than those described in this guide, and new varieties are currently being released across the country. However, this list includes many of the most well-known varieties and those with which we have experience growing at UNH. **Varieties differ substantially from each other. Thus, we strongly recommend experimenting with multiple varieties to determine those that grow best at your location, are most aligned with your farming practices, and meet your sales needs (shelf-life, etc.).**

Varieties are summarized and pictured below and in Figure 4. Yield data and varietal characteristics are provided in Table 1. Descriptions, data, and recommendations are based on our evaluation of these varieties in replicated studies at the Agricultural Experiment Station in Durham NH. Comments on eating quality are based on fruit sugar content (°Brix), as well as our perceptions of texture and flavor, and are rated as follows: Poor, Fair, Good, and Excellent.

Albion

Albion produced very attractive and deep-colored fruit with a beautiful sheen. Plants were often compact in size. Individual plants tended to produce fruit in flushes, but since each plant had its own pattern, together they provided a consistent fruit supply of fruit throughout the season. Albion has a reputation for being a heavy nitrogen feeder.

Eating quality: Excellent — we consider Albion to be the gold standard among the day-neutral varieties we evaluated. Fruit had a high sugar content, were full of flavor, and consistently juicy.



Aromas

Aromas fruit had a long conical shape, a unique and attractive fluffy calyx, and a beautiful deep magenta color. The variety was notable for producing high late-season yields in our 2017 experiment. Plants were very vigorous and produced high numbers of runners. Aromas may be more difficult to obtain than other varieties, and the plant phenotype has varied among plant sources. Thus, growers should ensure plants are purchased from a reputable nursery.

Eating quality: Fair to good — sugar content was low compared with other varieties we evaluated, but fruit quality improved as the season progressed into fall, with fruit being quite flavorful during late-fall harvests.



Cabrillo

Cabrillo is a relatively new variety that has not been widely evaluated on the East Coast, but we were able to evaluate it at UNH from 2018 to 2019. Fruit were quite round, very shiny and smooth, and had an attractive deep-red color. Fruit and plant size were incredibly consistent from plant to plant. Plants produced a flush of high yields during the mid-summer. In year 1 during the warm summer months, fruit tended to crack following rain; yet this tendency was not observed late in the fall or for plants overwintered into a second year.

Eating quality: Fair — sugar content was low compared with other varieties, and fruit lacked sweetness and flavor.



Monterey

Monterey fruit were medium to large in size, and ranged from slightly-orange to dark-red in color. Fruit tended to have a dull sheen, especially compared to Albion, but were still very attractive. Plants produced long flower trusses and had an open growth habit, making the variety easy to pick. Like Albion, Monterey was a consistent producer throughout the season.

Eating quality: Good to excellent — sugar content was high and fruit were flavorful.



Portola

Portola fruit were light-red to deep-orange in color and were often too soft (mushy) in texture. Portola did not establish well in 2017 or 2018, when plants remained small and stunted in their first year of growth. However, after plants overwintered, they became vigorous and produced large fruit during the spring season in the second year. Poor first year establishment has not been widely reported, and the variety has actually produced remarkably high yields in NY, MN, and PA in recent years.

Eating quality: Poor to fair — fruit had a low sugar content compared with other varieties and tended to be too soft, and lacking structure, sweetness, and flavor.



San Andreas

San Andreas fruit were large with a rounded tip. Fruit tended to appear ripe when they were actually slightly under-ripe. Thus, it is important to teach harvesters to be patient with this variety, and wait until the underside is fully ripe before harvesting. Flower trusses were long, making San Andreas an easy variety to pick; thus, quickly filling a container. San Andreas was an excellent mid- to late-season producer. At UNH, plants (especially runners) occasionally displayed calcium deficiency when grown under low tunnels.

Eating quality: Good — sugar levels and flavor were moderate. Fruit may be too firm (even crunchy) if not allowed to fully ripen.



Seascape

Seascape is a popular early-season variety that produced very attractive fruit with a deep-red color in our location. Fruit were large during the early and late-season, but the variety tended to produce high numbers of small fruit during the middle of the season. While not observed in all locations across the Northeast, prominent achenes gave the fruit an attractive “seedy” appearance at our site. Plants established very well and had vigorous vegetative growth in the early season compared with other varieties.

Eating quality: Good to excellent — fruit contained a high sugar content, and were juicy and flavorful.



Sweet Ann

Sweet Ann produced large fruit that were very shiny and had a light-red color. Plants were large, vigorous, and produced high numbers of small tender runners. Flower trusses were long, making the variety easy to pick. Sweet Ann had substantially higher marketable yields under low tunnels than open beds in Durham NH in 2018, likely due to the fact that fruit were soft and fragile and thus, easily damaged by precipitation. Therefore, this variety may be better suited for protected culture than open field culture.

Eating quality: Good to excellent — fruit contained a high sugar content, and were juicy and flavorful.





Figure 4. Day-neutral plants approximately five months after planting on Sept. 28, 2018 (Albion, Cabrillo, Monterey, Portola, San Andreas, Seascape, and Sweet Ann) and Oct. 7, 2017 (Aromas).

Table 1. Attributes of eight day-neutral varieties. Data are from a two-year study at the University of New Hampshire using dormant bare-rooted crowns that were planted by early-May and grown on open beds covered by black plastic mulch. Runners were removed monthly. Data are for the year of planting on open beds only, and do not include/are not representative of second-year production or low tunnel production.

Day-neutral variety	Year of study	Total yield (lbs/plant) [†]	Marketable yield (lbs/plant) [‡]	Percent marketable yield [¶]	Avg. fruit wt. (g/fruit) [*]	Fruiting period	Fruit sugar content (°Brix)	Runnering tendency	Suggested in-row spacing	Notable susceptibilities
Albion	2017 → 2018 →	1.1 0.8	0.9 0.5	77% 63%	13.5 g 12.1 g	Early, Mid, Late	High	Low–Moderate	12–14"	Fruit anthracnose
Aromas[‡]	2017 →	1.1	0.7	67%	12.6 g	Early, Late	Low	High	14–16"	
Cabrillo[‡]	2018 →	0.5	0.3	64%	12.2 g	Mid	Low	Moderate	12–14"	Cracking; fruit damage from precipitation
Monterey	2017 → 2018 →	1.2 0.8	0.8 0.4	71% 53%	13.4 g 11.7 g	Early, Mid, Late	High	Moderate	12–14"	Leaf spot; fruit anthracnose
Portola	2017 → 2018 →	0.9 0.6	0.6 0.3	67% 47%	11.8 g 11.4 g	Early, Mid, Late	Low	Low [¶]	12–14"	Leaf spot; fruit anthracnose
San Andreas	2017 → 2018 →	0.9 0.7	0.7 0.5	75% 65%	14.9 g 16.0 g	Mid, Late	Moderate–High	Moderate	14–16"	
Seascape	2017 → 2018 →	1.2 0.7	0.7 0.3	62% 46%	10.9 g 9.8 g	Early, Late	Moderate–High	Low	12–14"	Powdery mildew
Sweet Ann[‡]	2018 →	0.6	0.4	60%	13.6 g	Mid	Moderate–High	High	14–16"	Fruit damage from precipitation; fruit anthracnose

[‡]Based on one year of data only. Data for all other varieties are for two years.

[†]Total yield is marketable + unmarketable yield.

[‡]Marketable fruit were >7 g/fruit.

[¶]Low tunnels may significantly increase the % marketable yield. See our guide: https://extension.unh.edu/resources/files/Resource007429_Rep10703.pdf

[‡]Plants did not establish or perform well in the year of planting in Durham NH and thus, presented yields may be low.



*Visual illustration of the relationship between fruit weight (g) and size.

CROP ESTABLISHMENT + MANAGEMENT TIPS

In the Northeast, day-neutrals are typically planted in the early-spring as dormant bare-rooted plants (pictured right). To encourage plant establishment after planting, the first flush of flower trusses can be removed. Several other tips:



- **Order plants early.** We recommend placing your plant order as soon as possible. Some nurseries will take orders up to one year in advance.
- **Use a reputable plant source.** Plant establishment, disease incidence, and subsequent yields are highly affected by plant quality. Varieties can be off-type when purchased from a questionable supplier. Cornell University keeps an up-to-date list of nurseries in North America and the varieties they offer: <https://blogs.cornell.edu/berrynurseries/strawberries/>
- **Plant early.** Studies show that delaying planting by even a few weeks can significantly reduce annual yields. In Durham NH (zone 5B) we aim to plant by the end of April, but warmer and earlier springs may allow for even earlier planting in the coming years.
- **Use plastic mulch and drip irrigation.** The varieties outlined in this guide were developed for plasticulture production. In our experiments, marketable yields of Albion have been greater on plastic-mulched beds (black or white) than unmulched beds. Plastic mulch warms the soil (especially black mulch), improves drainage, retains soil moisture, and reduces weed pressure. Raised beds should have a slight peak to encourage the shedding of water, and should be equipped with a drip irrigation line for the application of fertilizer.
- **Plant at a high density.** Day-neutrals were developed for high-density plasticulture production. Plants should be installed in double staggered rows approximately 12" apart with an in-row spacing that is tailored to the variety (see Table 1). Bed spacing (center-to-center) and in-row spacing will determine the number of plants per acre (Table 2).
- **Fertilize weekly.** Since day-neutral plants continue to initiate flower trusses and develop fruit for up to 20 weeks each year, they will require continuous fertility throughout the season. The current recommendation is 5 lbs nitrogen per week through the drip irrigation system, but this may vary by site. Furthermore, since several methods are used for calculating the area that should be fertilized (e.g. total field area vs. bed area) and planting density may impact nutrient availability, foliar testing should be conducted to gauge plant nutrient levels and allow for the adjustment of a fertility regime. Foliar testing is easy and tissue samples are processed by a number of private and public laboratories, including UNH Cooperative Extension: https://extension.unh.edu/resources/files/Resource002488_Rep3658.pdf

- **Remove runners.** In the plasticulture production system, runners are not permitted to root and are removed periodically (at least monthly). To save on labor costs, it is best to remove runners when they are young and tender, and easily removeable.
- **Monitor for pests + pathogens.** As with June-bearing varieties, it is important to monitor for pests and pathogens throughout the season. At UNH, we have encountered our fair share of pest challenges! See Figure 5.

Table 2. The number of strawberry plants per acre at different bed and row spacings. The in-row plant spacing indicates the distance between plants in each of the double staggered rows on beds. Table adapted from *Season-long Strawberry Production with Everbearers* by Lantz et al. (2010).

In-row spacing	Bed spacing (bed center)			
	5 feet	6 feet	7 feet	8 feet
12 inches	17,424	14,520	12,446	10,890
14 inches	14,935	12,446	10,668	9,334
16 inches	13,068	10,890	9,334	8,168
18 inches	11,616	9,680	8,297	7,260



Figure 5. (A) Aphids on young strawberry plant; (B) fruit anthracnose; (C) powdery mildew on the underside of leaves and fruit; (D) an Oriental Beetle on a leaf; (E) wilting associated with Oriental Beetle feeding; (F–G) Oriental Beetle grubs found in the soil around roots.

WINTER SURVIVAL

Outside of the Northeast, day-neutrals are typically grown as an annual crop, but it is feasible to overwinter plants in the Northeast and harvest a spring crop in the second year. Some commercial growers have even reported keeping plants into the fall of the second year. Winter survival is affected by the weather conditions of a given winter and mulching approach. In Durham NH, plant survival rates have ranged from good (80–90%) to excellent (90–100%) for most varieties. For Monterey, winter survival was very poor (<50%) for the 2017-18 winter, but it was excellent the following year.

We have used both straw mulch and a single layer of 1.25 oz/yd² row cover (separately, not at once) to overwinter day-neutral plants successfully in Durham NH (Figure 6). Recommendations for row cover thickness vary substantially depending on location and who you ask. Some suppliers will recommend a single layer of 0.9 oz/yd², while others will strongly suggest a double layer of 1.0–1.25 oz/yd², with one layer removed in the early-spring. We do not have good research-based information upon which to inform recommendations at this time.



Figure 6. Left: 1.25 oz/yd² row cover. Sand bags are used to keep row cover down. Right: straw applied over plastic mulch. Low tunnel hoops are also visible, which were left in the field for the winter.

SECOND YEAR FRUIT PRODUCTION

We are in the process of finishing a two-year study on spring yield from overwintered day-neutral plants. This guide will be updated once the study has been completed. Fruit pictured to the right were harvested from this experiment on June 18, 2019.



VALUABLE RESOURCES

Season-long Strawberry Production with Everbearers for Northeastern Producers.

By: Willie Lantz, Harry Swartz, Kathleen Demchak, and Sherry Frick

<https://www.sare.org/Learning-Center/SARE-Project-Products/Northeast-SARE-Project-Products/Season-Long-Strawberry-Production-with-Everbearers-for-Northeastern-Producers>

Low Tunnel Strawberry Production Guide. By: Kaitlyn Orde and Becky Sideman

https://extension.unh.edu/resources/files/Resource007429_Rep10703.pdf

Growing Strawberries. By: Becky Sideman

https://extension.unh.edu/resources/files/Resource006095_Rep8605.pdf

Extending Local Strawberry Production Using Day-Neutral Cultivars and Low Tunnel Technology.

By: Marvin Pritts and Laura McDermott

<http://hort.cornell.edu/fruit/pdfs/low-tunnel-strawberries.pdf>

New England Small Fruit Guide

<https://ag.umass.edu/fruit/ne-small-fruit-management-guide/strawberries>

Berry Soil and Nutrient Management Guide for Educators and Growers

By: Marvin Pritts, Cathy Heidenreich, Laura McDermott, and Jeff Miller

<https://www.sare.org/Learning-Center/SARE-Project-Products/Northeast-SARE-Project-Products/Berry-Soil-and-Nutrient-Management>

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