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Edamame in Virginia II: Producing a High-Quality Product

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Introduction

Originally from East Asia, edamame is becoming increasingly popular in the United States owing to its excellent nutritional value and health benefits. Most of the edamame consumed in the U.S. is imported from China as a frozen product (Duncan et al. 2020). The expanding domestic demand — especially for local, fresh edamame — has stimulated interest among plant breeders and growers in producing this crop in the U.S.

Domestic production of edamame is limited because most current varieties do not meet producer and consumer expectations. In addition, U.S. farmers have little experience growing edamame. However, they have been growing grain-type soybeans for decades, so there is an opportunity to increase domestic edamame production. Classified as a specialty crop by the USDA, edamame could provide U.S. and Virginia farmers with an alternative and profitable crop, especially for small-scale or urban agriculture farmers (Garber and Neil 2019).

Farmers can get higher gross returns by growing edamame rather than grain-type soybeans. A report from Mississippi showed that the net return on edamame could be more than twice the return from grain-type soybean production (Zhang and Kyei-Boahen 2007). Moreover, as a legume crop, edamame enriches soil by nitrogen fixation and could serve as a rotation crop. Therefore, if edamame varieties with desirable traits are developed and management practices are optimized, edamame could become a highly valuable and profitable crop for Virginia farmers (akin to green bean [*Phaseolus vulgaris*]) and could help to diversify crop production in the U.S.

Variety Selection

One of the most critical steps in successfully growing and marketing edamame is to select an appropriate variety for production. Soybean researchers have worked with other scientists at Virginia Tech to develop superior edamame varieties with improved bean quality, agronomic performance, suitability for mechanized harvest, and consumer acceptance. Challenges facing domestic edamame production include poor seedling emergence, lodging, plant structures that are difficult for mechanical harvesting, lack of labeled herbicides, and low yield potential of available commercial edamame varieties. In addition, American consumers are looking for products with desirable bean appearance (large, bright-green beans), texture (smooth and firm but not chewy), and distinctive flavors (sweet, nutty, buttery, and beany). Therefore, it is important to consider the requests of both growers and consumers during breeding in order to ensure the profitability of edamame production.

There are a few varieties of edamame available in Mid-Atlantic regions (table 1). The Virginia Tech edamame breeding program recently released ‘VT Sweet’ (Zhang et al. 2022), a mid-maturity group (MG) 5 cultivar (relative maturity 5.6, 125-135 days to harvest) with determinate growth habit. ‘VT Sweet’ has superior characteristics for edamame, such as a large pod size (0.5 ounce per 10 pods, 1 9/16 inches long, 7/16 inch wide, and 5/16 inch thick) and low one-bean pod proportion (15%), as well as low pod hairiness. ‘VT Sweet’ also showed good overall consumer acceptability and favorable tolerance to native pests. When compared with the commercial edamame check ‘UA Kirksey’,

'VT Sweet' yields 2% more and had a higher average field emergence (74.9% versus 68.1%) and comparable consumer acceptability. Therefore, 'VT Sweet' is an ideal variety for growers who are interested in commercial edamame production in Virginia.

Table 1. Commonly available varieties of edamame in the mid-Atlantic region.

Variety	Maturity Group
VT Sweet	M-V
GardenSoy 31	E-IV
GardenSoy 41	L-III — E-IV
Moon Cake	L-V — E-VI
Midori Giant	L-III —E-IV
Besweet 2020	L-III —E-IV
Randolph	VI

Planting and Field Management

Because edamame seeds are larger than grain-type soybeans, they need to absorb more water to germinate. If insufficient water is available, germination will be slowed or completely inhibited (fig. 1). The long germination and emergence period may also make seeds have a higher risk of suffering from chilling injury, insect damage, and soilborne diseases, leading to low emergence. Edamame seeds also encounter more physical resistance from soil to push their large cotyledons above the soil surface than grain-type soybeans do. These challenges with initial stand establishment indicate the importance of practicing proper planting and crop management strategies specific to edamame production, such as minimizing soil crusting.

Seedbed Preparation

Edamame seeds require soil that is warm, moist but well-drained, fertile, and free of weeds. Tilling the soil prior to planting ensures a warm and weed-free soil environment.

Figure 1. Poor seedling emergence of edamame in a field. Photo by Xiaoying Li.

Planting

Edamame is usually direct-seeded with a drill planter (fig. 2). Sow edamame seeds in warm soil after the last frost. The optimum planting date for seedling emergence in most of Virginia is from early May through early June, when soil temperatures have reached 65 F. It is possible to cover soil with black plastic film to increase temperatures during cold periods or for earlier planting (Hosono, Katayama, and Hosokawa 2010). Fungicide seed treatments can prevent disease under cool and/or wet planting conditions. Sow seeds 2-4 inches apart in furrows at a depth of 0.25-1.5 inches (based on soil moisture. Deeper planting depth can increase the physical resistance that seeds encounter and, subsequently, reduce seedling stands (Zhang et al. 2013; Crawford and Williams 2019). Rows can be spaced 15-36 inches apart, with closer row spacing producing higher yields and greater competition against weeds; wider spacing results in larger plants with larger pods (Ogles et al. 2015). Plants should emerge one to two weeks after planting; if not, growers may need to consider replanting.

Figure 2. Edamame is direct-seeded in the field using a research planter. Photo by Bo Zhang.

Edamame can be successfully grown in greenhouses for field transplanting in Virginia (Nolen, Zhang, and Kering 2016). Seeds should be sowed in plug trays and placed in greenhouses during late February and March. Bare-root transplants are more susceptible to transplant shock than plugs. After three to four weeks, germinated seedlings can be transplanted to raised beds in high tunnels or greenhouses in April. Row covers can also be used in field settings prior to May to protect plants from spring frost and cold temperatures. These methods can help establish a uniform stand and shorten field production time for early market availability.

Edamame availability to consumers can be extended by either planting varieties within a maturity group every two to three weeks throughout the growing season or by planting different maturity groups (MG III-VI are recommended in Virginia) for season extension (Lord, Neill, and Zhang 2019). High tunnels can be used to extend fall harvests of late maturity varieties by protecting plants from low temperatures and killing frosts in early November (Nolen, Zhang, and Kering 2016).

Soil Moisture and Irrigation

Edamame seed is sensitive to water stress during establishment, so adequate soil moisture is very important for the early growth of edamame. If the soil is too dry, irrigation might be needed prior to planting. Overhead irrigation after planting can cause soil crusting on conventionally tilled fields if the soil dries completely, preventing seedling emergence if there is little residue cover. Overhead or drip irrigation can prevent crusting after planting if applied regularly so the soil remains moist. However, over-irrigation may favor soilborne pathogens that increase seed and seedling diseases.

Another critical period for irrigation is from bloom through seed fill, when drought stress can cause aborted blossoms, small pods, and shriveled beans (Ogles et al. 2015). During this stage, plants typically require 1-1.5 inches of water per week. During periods of drought, irrigation is necessary to produce high-yielding edamame.

Weed Control

Weeds can directly compete with edamame seedlings for light, water, and nutrients, reducing edamame growth and yields. Currently, weed management depends largely on tillage because fewer herbicides are registered for edamame than for grain-type soybeans (Kaiser and Ernst 2020). Edamame is sensitive to many preemergence herbicides, and a few herbicides are registered for edamame production, such as Satellite (active ingredient is pendimethalin) for preemergence application and Basagran (bentazon) for postemergence use. For more information about herbicide use for edamame, see the Mid-Atlantic Commercial Vegetable Production Recommendations (Reiter et al. 2022).

Living mulches can also suppress weeds. Double-cropping with grains such as wheat can efficiently reduce the interference of weeds on edamame growth. As the season progresses, edamame plant canopies close and eventually cover and shade out most weeds.

Fertilization

Normally, if sufficient nutrients are present within the field for other vegetable crops, edamame should grow well. Conduct a soil test prior to planting to determine nutrient levels (table 2). If some nutrients are inadequate, apply the corresponding fertilizer at planting in a band (for efficiency of fertilizing) approximately 2 inches to the side and 2 inches below the seed. Edamame is a legume that can fix nitrogen from the atmosphere. Therefore, it is usually not necessary to apply nitrogen fertilizer or inoculate seed with a nitrogen-fixing bacterium if the field has recently been planted with soybeans. Still, edamame seeds can be inoculated with *Bradyrhizobium japonicum* strains, which are recommended for soybean inoculation. Inoculant for soybean is not the same as bean or pea inoculant (Miles, Lumpkin, and Zenz 2000). No fertilizer is required beyond the initial seedbed preparation.

Table 2. Recommended nutrients based on soil tests Disease and Pest Control

		Soil Phosphorus Level				Soil Potassium Level				
		Low	Med	High (Opt)	Very High	Low	Med	High (Opt)	Very High	
Edamame	N (lb/A)	P_2O_5 (lb/A)				K_2O (lb/A)				Nutrient Timing and Method
	0	100	60	20	0	120	100	80	40	Pre-plant incorporated
	25									At planting
	25									Side dressed

Note: This table is cited from 2022/2023 Mid-Atlantic Commercial Vegetable Production Recommendations.

Plant diseases and pests observed on edamame are similar to those on grain-type soybeans. However, since edamame is harvested while immature, late-season diseases and pests are less of a problem (Kaiser and Ernst 2020). Most early-season diseases are caused by soilborne fungal and oomycete pathogens such as *Fusarium* sp., *Phytophthora* sp., *Pythium* sp., and *Rhizoctonia solani*, which all cause seed and root rot and seedling damping-off, leading to poor edamame stands. Wet and poorly drained soils increase these diseases; therefore, overwatering should be avoided. These diseases can be severe if they previously occurred in the same field. Seed treatment with fludioxonil + mefenoxam has been reported to control soilborne diseases to improve edamame seedling emergence (Williams and Bradley 2017). Fungicide recommendations can be found in the 2022-2023 Mid-Atlantic Commercial Vegetable Production Recommendations (Reiter et al. 2022). Currently, there are no edamame varieties that are resistant to soybean cyst nematode or root-knot nematode; therefore, grow edamame in nematode-free fields and rotate away from legumes and nematode-susceptible crops.

Foliar diseases affecting edamame grown in Blacksburg, Virginia, in 2021, include one bacterial disease (Xanthomonas bacterial pustule) and four fungal diseases (frogeye leaf spot, Cercospora leaf spot, Septoria brown spot, and downy mildew), although the appearance of these vary widely from year to year. Some of these diseases (such as Cercospora leaf blight) also occurred in Painter, Virginia. These diseases could reduce edamame pod quality. For example, severe infections cause early defoliation, leading to sun-scalded pods. In addition, Cercospora leaf blight produces red spots on edamame stems and pods, which reduce marketability. Since pod appearance is an important quality attribute of edamame, foliar diseases need to be controlled before they cause severe damage.

Edamame varieties vary widely in their susceptibility to foliar diseases; however, these differences have not been fully documented. Many foliar diseases (e.g., bacterial pustule and frogeye leaf spot) are seedborne, so planting pathogen-free seed will reduce its occurrence. Cultural control practices include rotating with a nonhost crop (e.g., corn), avoiding overhead or over-irrigation, and planting in areas that receive full sun. Applications of fixed copper can offer some suppression of bacterial disease as well. For more information about copper fungicide products, see Copper Fungicides for Disease Management, available at vegetables.cornell.edu/pest-management/disease-factsheets/copper-fungicides-for-organic-disease-management-in-vegetables. Moreover, there are some fungicides labeled for edamame to control foliar fungal diseases, including anthracnose, cercospora, diaporthe, and septoria. A list of fungicides labeled for edamame is in the 2022-2023 Mid-Atlantic Commercial Vegetable Production Recommendations (Reiter et al. 2022).

Several insects can attack edamame, including stink bugs, caterpillars, soybean aphids, leafhoppers, spider mites, and beetles (Japanese beetle, Mexican bean beetle, and cucumber beetle). The prevalence of specific insect pests can vary by location and year. Caterpillars and Mexican bean beetles can chew holes in edamame pods, resulting in unmarketable product (Lord et al. 2021). Most insecticides labeled for use on soybeans are registered for use on edamame to control beetles, caterpillars, leafhoppers, aphids, stink bugs, thrips, and whiteflies. A list of insecticides labeled for edamame is in the Mid-Atlantic Commercial Vegetable Production Recommendations (Reiter et al. 2022).

Finally, it is important to prevent deer, birds, and other wildlife from feeding on edamame plants. Fencing (including portable electric fencing), repellants, and scare devices are necessities for edamame fields.

Harvest

Harvest Time

The optimum harvest time is 25-30 days after pod set (R4), when seeds fill 85%-90% of the pod cavity and pods are still bright green. Harvest timing depends on the planting date, the variety's maturity group, and the production systems, so pod harvest can take place from early July through the end of September or early October in Virginia (Nolen, Zhang, and Kering 2016). The harvest window is usually seven to 10 days. By the time pods show any yellowing, the optimum time for harvest has passed and the beans have become starchy, losing their sweet and nutty flavor. Thus growers must closely monitor edamame pod fill so they are ready to harvest when the pods are ready.

Methods for determining optimal harvest time of edamame are visible changes, touch, or taste. Such methods can be quite subjective and can pose a major obstacle for relatively inexperienced or new edamame growers. The lower quality associated with edamame harvested outside of the optimal window can cause significant economic losses. Yu et al. (2022) found that pod/bean weight and pod thickness peaked when edamame is harvested at early full seed stage (R6), when the pod contained a green seed that fills the pod cavity at one of the four uppermost nodes on main stem with fully developed leaf and remained stable thereafter. Sugar, starch, alanine, and glycine also peaked at early R6 and then declined.

Harvest edamame early in the morning, shortly after sunrise when pods are cool. Fresh edamame pods have a high metabolism rate due to their high moisture content, and pods are prone to degradation of quality parameters when harvested in the heat of the day. Sugar and amino acids in edamame beans will deteriorate within three to 10 hours after harvest and will affect flavor unless beans are cooled during harvest, storage, and sale (Konovsky, Lumpkin, and McClary 1994). In Taiwan, harvesting began at 3 am to avoid high daytime temperatures. Edamame should remain refrigerated if processing is delayed in order to maintain product taste, freshness, and quality.

Harvest Method

A green bean harvester can be used to harvest edamame (fig. 3). Home gardeners can manually pick the green pods from plants or cut the whole plant at the base of the stalk using a knife, clippers, or scythe when the majority of pods are ready. Hand-harvesting takes longer but allows the pods to be handled more gently, reducing damage to the pods. Hand-harvesting also allows the field to be harvested flexibly according to the maturity of the plants and pods since they usually mature at slightly different rates (compared to a once-over destructive harvest by machine) (Garber and Neil 2019). However, limited harvest time and labor availability may reduce the option of hand-harvesting for many growers. According to Garber and Neill (2019), if harvest damage can be maintained below 20%, mechanical harvest should be profitable for commercial harvest.

Figure 3. An edamame pod harvester exhibited at the Eastern Virginia Agricultural Research and Extension Center's 2021 Field Day in Warsaw, Virginia. Photo by Xiaoying Li.

Conclusions

Edamame is an alternative crop for farmers in Virginia. To improve domestic edamame yield and quality to meet the high demand for edamame in U.S. markets, researchers are developing new varieties, optimizing agronomic practices, determining best harvest timing, extending the harvest window, and optimizing mechanical harvesters. These improvements can potentially increase domestic edamame production and supply, which will ultimately improve the economic sustainability of the Virginia vegetable industry.

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