C3. Cultivation

Many factors must be considered and controlled in the cultivation of botanicals, from the choice of farm location through the applications of pesticides and fertilizer. These factors can significantly influence both the quality of the botanicals grown and the economics of the farming operation.

This section outlines recommended practices to ensure the quality and freedom from contamination of the crops produced. In addition, farmers of produce crops such as lettuce are usually (depending on certain exemptions) subject to the additional agricultural practice requirements established in 21 CFR Part 112.

C3.1 Propagation material

i. Seeds and other propagation material (roots, rhizomes, vegetative cuttings, tissue culture explants, spores, etc.) should be obtained from reliable sources such as reputable vendors, seed banks, or harvest from existing plants. Where possible, sourcing propagation material from governmental or other authoritative bodies such as international seed banks,[[1]](#footnote-1) agricultural research stations, or universities may provide additional assurances of identity and quality; however, such sources may be limited in supply, and may be relatively expensive.

ii. Propagation material should be clearly labeled and recorded with the identity, origin, date of collection or harvest, and other relevant descriptors where applicable (such as “organic,” “biodynamic,” “genetically modified,” or patent number).

iii. Growers should take steps to ensure the correct botanical identity of seeds and other propagation material (e.g., through examination of documentation provided by the vendor and/or by morphologic examination of the crop once mature).

iv. Growers should ensure that seed lots are of appropriate purity, health, and cleanliness, either by performing seed testing, by having an outside laboratory perform seed testing, or by requiring vendors to provide appropriate analytical reports for each lot of purchased seed. These tests should examine quality parameters such as:

1. Percent viability.

2. Presence of weed or other foreign seeds.

3. Presence of insects.

4. Presence of fungal contaminants.

v. For each lot of propagation material used, records should be kept of the following:

1. Botanical identity of the lot, with as much specificity as appropriate. See section BQ2.2. for detailed information on botanical identity.

2. Other relevant information such as organic status, genetically modified status, or applicable patent number, if any.

3. Source from which the lot was obtained (even if produced on-site).

4. A copy of any guarantee, certification, analytical report, or other documentation provided by the vendor (where applicable).

5. Results from any testing performed by the grower or an independent laboratory or consultant hired by the grower.

6. Information regarding any treatments applied to seed by the vendor or grower to maximize germination, reduce pests or diseases, and improve yield.[[2]](#footnote-2)

vi. Growers may wish to maintain a retention sample of each lot of propagative material, for future reference if needed. Retention samples should be stored in a manner to protect against insects, microbial growth, moisture, excessive heat, and other sources of degradation. Where fresh plant material is used for propagation, samples should be stored in a frozen or dried state.

C3.2 Cultivation site

i. The field or other setting in which a crop is to be planted should be evaluated to ensure it is suitable for cultivation of food (if applicable) and for the intended crop. Climatic conditions such as the length of day, sun intensity, rainfall (or irrigation) and humidity, air temperatures, and daily temperature cycles will significantly influence the physical, chemical and biological qualities of plants.

ii. Soil characteristics. Soil should be sampled in accordance with appropriate sampling plans,[[3]](#footnote-3) and tested as appropriate; information regarding previous and neighboring land use may help identify relevant tests. Records should be maintained for at least several years of any soil testing performed. Tests to be considered should include:

1. Soil pH. The pH may require adjustment to ensure the optimal range for the intended crop and/or to minimize weeds.

2. Deficiencies in nutrients essential for growth of the intended crop (e.g., nitrogen, calcium, iron, etc.). Appropriate fertilizers may be necessary to provide nutrients at the optimal levels.

3. Excessive levels of contaminants deleterious to either plant health (e.g., boron) or consumer health (e.g., heavy metals or radioactivity), or the presence and levels of any residual pesticides. Some crops will accumulate these contaminants to a greater degree than others. Contaminated soils may require appropriate remediation prior to planting the crop.[[4]](#footnote-4)

4. Other chemical characteristics as applicable, such as salinity, bicarbonate concentration, micronutrients, organic matter, etc.

5. Soil texture (the relative amounts of sand, silt, and clay particles) and structure (the larger arrangements of particles). These characteristics strongly influence soil fertility and drainage, which in turn affect which crops can readily be grown at that location.

6. Undesirable organisms. The presence of certain fungi, nematodes, etc. may affect which crops can be grown or may require appropriate control measures.

iii. Water quality. Water should be tested as appropriate to evaluate its suitability for use in cultivation of food, its suitability for the target crop, and the extent to which it may require treatment prior to use.[[5]](#footnote-5) Information regarding previous and neighboring land use, or (where municipal water is used) from annual municipal testing, may help identify relevant tests. Maintain records for at least several years of any water testing performed. Tests to be considered should include:

1. Water pH. Water that is too acidic or alkaline may interfere with cultivation of the target crop.

2. Excessive levels of contaminants deleterious to either plant health (e.g., boron) or human health (e.g., heavy metals or radioactivity), or the presence and levels of any pesticides. Some crops will accumulate these contaminants to a greater degree than others.

3. Other chemical characteristics as applicable, such as sodium absorption ratio, salinity, bicarbonate concentration, etc.

iv. Site location and setting. Information relevant to either improving or damaging the crop or the site itself should be recorded and maintained for at least several years, if not permanently. Factors to consider may include:

1. Annual and seasonal rainfall at the specific location, or at least in the location’s vicinity.

2. Access to water, if the crop requires irrigation.

3. Available sunlight and sun intensity, taking into account the site’s facing in relation to cardinal direction (north, south, east, west), latitude, average annual sun days vs. overcast days, shading from trees or structures, etc.

4. Annual climactic conditions such as USDA zone, average chill hours, humidity levels, etc.

5. Slope, insofar as this affects drainage, the potential for water pooling or flooding, erosion and loss of topsoil, or runoff that may bring contaminants from neighboring properties.

6. Geologic characteristics such as the presence of bedrock, hardpan, or a high water table that will affect water drainage or root growth.

7. Identity (and genetic modification status, if relevant) of crops that will be grown on adjoining sites, if known, and any treatments that may be applied to those crops, if known.[[6]](#footnote-6)

8. Location in relation to potential sources of air- or water-borne contamination, such as waterways, industrial facilities; mine tailings; parking lots; golf courses; underground storage tanks; feed lots; cities; etc. Pay special attention to potential sources of contamination that are upwind from the farm or upstream from the farm’s water supply, where applicable.

v. Site history. A thorough history of prior uses of the crop area should be prepared and maintained to the extent possible. Such records should be maintained for at least several years, if not permanently. Site characteristics to be considered may include:

1. Previous use of the site for housing, commercial, or industrial uses, and any physical or chemical contaminants that may have resulted therefrom.

2. The most recent crop grown on the site, or if possible the crops grown in the past several (3-5) years.

3. Crops recently grown on any adjoining sites, if possible.[[7]](#footnote-7)

4. Any recent (in the past 3-5 years if possible) use or detection of pesticides on the site, if known, including insecticides, herbicides and fungicides. If possible, information about the rates at which any such pesticides break down should be documented.

5. Any recent use of the site as a feedlot, or for any other purpose for which domestic animals have had recent access to the site.

6. Any corrective actions that have been taken to prepare a site where prior environmental contamination is known.

7. Where organic status is desired for the crop, consider previous treatment of the site with pesticides or other disallowed substances that may interfere with organic certification.

C3.3 Fertilizer use

i. Fertilizer use should generally be guided by soil sample analysis to determine what fertilizers may be needed, and what ratios of nutrients are required.

ii. Consideration should be given to the value of fertilizer use in producing better and larger yields, as well as the effects such use may have in the environment.

iii. Federal, state and local regulations may apply to some of the chemical fertilizers used on crops. Furthermore, organic growers must refrain from using chemical fertilizers; instead they should use naturally-sourced amendments when needed.

iv. Fertilizer stocks should be kept away from water supplies and harvested crop materials.

v. For chemical fertilizers:

1. Apply in accordance with federal, state and local regulations that are applicable to the specific fertilizer, if any.

2. Use in accordance with all label directions (e.g., application rates, safe handling, proper disposal, etc.).

3. Store chemical fertilizers properly according to label instructions.

vi. For manure- and/or compost-based fertilizers:

1. Apply in accordance with organic and other regulations as applicable.

2. Do not use manure- or compost-based fertilizers produced with sewage sludge or human feces; these present risks not only to downstream users or consumers of the crop, but also to farm personnel.

3. Similarly, do not use untreated manure of any kind for crop fertilization. Use only fertilizers that have been adequately treated through an aerobic process.

4. Monitor for undesirable microbial pathogens using appropriate test procedures. Testing may be performed periodically during composting or may be performed on finished batches of compost. Maintain records of such monitoring for several years.

5. For manure- and/or compost-based fertilizers that are produced or openly stored on-farm:

* Follow proper composting procedures (e.g., balanced carbon to nitrogen ratio; appropriate moisture levels; etc.).[[8]](#footnote-8)
* Monitor runoff from composting and storage sites. Maintain records of such monitoring for several years.
* Do not include sewage sludge or human feces in compost.
* Where possible, avoid composting the seed heads of weedy plants unless the seeds will be killed by the heating of the compost pile.

vii. For all fertilizers:

1. Ensure that packaged fertilizers and containers of diluted or prepared fertilizer are properly labeled at all times.

2. Ensure that only properly trained personnel apply crop fertilizers.

3. Provide adequate safety protection for personnel.

4. Ensure that appropriately clean equipment and supplies are used. Ensure that fertilization equipment and supplies are appropriately decontaminated and/or disposed after use.

5. Apply fertilizers at a sufficiently early phase in the crop’s cycle to optimally promote growth and to ensure the fertilizer has appropriately broken down before harvest.

6. Apply water-soluble foliar fertilizers within 24 hours of preparation. Prompt use optimizes the effectiveness of the application and prevents microbial contamination of the solution.

7. Ensure that water used for mixing any soluble fertilizer is potable or meets established criteria for agricultural irrigation water.

8. Apply fertilizers in a manner that does not contribute to contamination of water supplies.

9. When growing a crop on a contractual basis, use only fertilizers that have been authorized by the buyer, or provide the buyer with an opportunity for review and approval.

10. Maintain records of fertilizers used, including:

* Fertilizer name or description.
* Chemical name where applicable.
* Vendor or other origin.
* Date applied and by whom.
* Quantity and/or concentration applied.

C3.4 Irrigation

Access to water of sufficient quantity and quality is essential to farm operations, and many crops rely on irrigation to supplement water received from normal rainfall.

i. The following steps should be implemented to assure water quality and efficient use in farm operations.

1. Water source. Identify the source of all water used in crop production (for example, on-farm well(s), open irrigation canal(s), reservoir(s), a municipal supply, or other sources).

2. Water monitoring. Establish and follow testing procedures to monitor for contaminants of concern. This may include pathogenic microbes that may be present in water supplies (e.g., *E. coli* and other coliforms), heavy metals, pesticide residues or other contaminants.[[9]](#footnote-9) The frequency of such procedures should take into account the water source(s) and results of previous tests. Analytical reports should be maintained on file for several years.

3. Irrigation type. Choose the irrigation type (e.g., drip system, sprinkler, subsurface, overhead, etc.) based on considerations of cost, water conservation, plant health, and the risk of increased vector-borne diseases (e.g., from snails or mosquitoes).

4. Irrigation systems. Do not use irrigation systems or equipment that may contaminate water or crops, such as those with lead pipes or fittings. Maintain irrigation systems in good working condition (i.e., no leaks or drips) to prevent water waste and to avoid high soil moisture levels that may contribute to mold and fungal problems.

5. Application of irrigation. Apply irrigation according to the needs of the species and in a manner that adequately avoids runoff.

6. Legal conformity. Conform to all rules that are applicable to the local or state water district.

ii. Maintain irrigation-related records for at least several years, including:

1. Records of water sources used in irrigation.

2. Records of water quality testing.

3. Records of irrigation system design, construction, maintenance, and repair.

4. Any records needed to establish conformity with any applicable regulations.

C3.5 Crop maintenance and protection

The growth and development characteristics of individual plants, as well as the plant part destined for use, should guide field management practices. Various strategies can be implemented to protect and maintain the crop and to maximize the success of the harvest.

i. Cultivation techniques. Adapt tilling, mulching, and other cultivation practices to the requirements of the specific crop and to minimize weeds. Consider use of no-till farming to reduce overhead costs (labor, equipment, and inputs such as fuel and irrigation), reduce soil erosion, and improve soil moisture and fertility which can improve yields.

ii. Growth controls. The timely application of measures such as thinning, topping, bud nipping, pruning and shading may be used to control the growth and development of the plant, thereby improving the quality and/or quantity of the plant material being produced.

iii. Crop rotation. Consider adjusting crop rotation plans to maintain soil fertility (e.g., through periodic planting with nitrogen-fixing crops) and to minimize pest and disease problems.

iv. Companion plants. Consider companion planting strategies such as interplanting with crops that repel damaging insects or attract predatory insects; separately planting trap crops to attract insects away from the target crop; or interplanting to provide necessary shade, support, or humidity. Certain combinations of companion plants are reported to improve flavor and/or vigor. Conversely, some combinations of plants are known to stunt growth and should be avoided.

v. Weeds. During crop growth and immediately prior to harvest, monitor fields for undesirable weeds and control them as appropriate. Any weeds containing tropane or pyrrolizidine alkaloids (see also Appendix 8) should be appropriately eliminated before harvesting.

vi. Integrated pest management.[[10]](#footnote-10) Minimize pest and disease infestations through appropriate selection of resistant varieties, appropriate choice of sowing time, appropriate seed treatments, removal of dead or diseased plants or tissues, applications of beneficial bacteria and fungi (e.g., mycorrhizae; compost tea), etc. Where insects reach unacceptable levels, evaluate alternatives to insecticides such as use of beneficial insects, physical insect barriers and traps, vacuuming, etc. Check with state agricultural agencies for guidance.

vii. Pesticide use. Pesticides (insecticides, herbicides, fungicides, etc.) from either natural or synthetic sources must be carefully controlled.

1. Pesticides should be applied to crops at the minimum effective rates, and only by properly trained personnel with the proper application equipment and personal protective equipment.

2. All pesticides must be approved for use on the specific crop by both local and U.S. federal governments. Application levels must ensure that established tolerance levels for the crop are not exceeded, except for pesticides for which no tolerance is required to be established by U.S. regulation.[[11]](#footnote-11)

3. Application and storage must be in accordance with label instructions and all regulations.

4. Keep pesticide stocks away from water supplies and harvested crop materials.

5. Pesticides must be applied sufficiently in advance of harvest to comply with label instructions and any relevant regulations.

6. Records of pesticide use should be kept for at least several years, including:

* Pesticide name or description.
* Chemical name where applicable.
* Vendor or other origin.
* Date applied and by whom.
* Quantity and/or concentration applied.

viii. Records.

1. In addition to the pesticide-related records discussed above, maintain other records of crop planting, cultivation, maintenance, and protection as appropriate. Activities may be recorded in a Daily Farm Log that combines all this data into the same document, or in activity-specific documents such as a Fertilizer Application Log, Pesticide Application Log, etc.[[12]](#footnote-12)

2. All records with relevance to a particular cycle of cultivation and harvest should preferably be retained past the time when the harvested crop is no longer in the marketplace, which may be several years or more.[[13]](#footnote-13)

C3.6 Other considerations

i. Genetically modified materials. If genetically modified seeds or vegetative stock are used as propagation material, conform to all relevant federal and regional regulations, both at the agricultural location and in the countries in which the material may be sold. Also, disclose the use of genetically modified propagation material in records and crop labeling to ensure that downstream recipients of materials produced from these crops are informed of such use. If the crop is intended to receive non-GMO certification, follow the applicable requirements (e.g., with respect to seed sources, manure- or compost-based fertilizers, etc.).

ii. Organic materials. If the crop is intended to be certified organic per the USDA National Organic Program,[[14]](#footnote-14) conform to all relevant federal and regional regulations governing organic certification. Disclose the organic status of the crop in records and labeling to ensure that downstream recipients of materials produced from these crops are informed of the organic status.

iii. Environmental stewardship. Growers should take steps to protect and improve the stability and quality of the topsoil that is essential to their farms’ longevity. Farm water should be used resourcefully and in a manner that protects the immediate water supply, as well as all downstream supplies. To the degree possible, growers should maintain and enhance the biodiversity of their farms, and minimize the deleterious effects of fertilizers and pesticides on groundwater and surrounding areas.

iv. Produce crops. If the crop being grown meets the definition of “covered produce” in 21 CFR Part 112, comply with the requirements of those regulations.[[15]](#footnote-15) Certain elements of Part 112 will require more stringent, more specific, or more extensive standards than what is suggested herein, for example with respect to agricultural water quality, exclusion of animals, etc.

1. For example, members of the International Seed Federation are required to meet special requirements such as recording the seed treatment rate used per line of seed. (This equals quantity of treatment material per quantity of seed). Accreditation is given to applicators based on certain criteria such as equipment calibration, record keeping, knowledge of factors affecting seed loadings, etc. [↑](#footnote-ref-1)
2. Seed treatments are used to initiate germination, promote good seedling establishment, minimize yield loss, maintain and improve quality, and avoid the spread of harmful organisms. Seed treatments may be chemical or physical. [↑](#footnote-ref-2)
3. Information on soil sampling can be found from various organizations, such as <http://www.fao.org/docrep/003/t0234e/t0234e01.htm>and<http://animalrangeextension.montana.edu/forage/documents/soil%20sampling%20stratgeies.pdf>; an example plan is available at <http://www.waterboards.ca.gov/rwqcb4/water_issues/programs/401_water_quality_certification/Newhall/Workplan%20Soil%20Sampling%20for%20Pesticides%20March%202013.pdf>. [↑](#footnote-ref-3)
4. If soil contaminants occur at levels high enough to be potentially problematic, a risk analysis, testing, or additional research should be performed to determine whether or not crops grown in the soil will meet established contaminant specifications. This also applies to contaminants found in water or air. The correlation between contaminants in the environment and their presence in the plant should be evaluated on a case by case basis. [↑](#footnote-ref-4)
5. Procedures for various testing methods and parameters to test are available at https://www.epa.gov/cwa-methods and http://www.fao.org/docrep/003/t0234e/t0234e01.htm. [↑](#footnote-ref-5)
6. Information regarding adjoining fields may be difficult or impossible to obtain, and may not be relevant depending on the nature of the crops to be grown, the purpose for which the crops will be used, the application method of any pesticides used in neighboring property (e.g., spray by airplanes or fogging vs. more targeted application methods), the potential for airborne or waterborne drift from the neighboring property, etc. A risk assessment may be appropriate. [↑](#footnote-ref-6)
7. As mentioned above, information regarding adjoining fields may be difficult to obtain and may not be relevant; a risk assessment may be appropriate. [↑](#footnote-ref-7)
8. Additional information on composting procedures can be found at North Carolina State University extension services <https://content.ces.ncsu.edu/large-scale-organic-materials-composting>; USDA Alternative Farming Systems Information Center <https://www.nal.usda.gov/afsic/compost-and-composting>; and from organizations such as the Composting Council (<http://compostingcouncil.org/>). [↑](#footnote-ref-8)
9. Procedures for various testing methods and parameters to test are available at <https://www.epa.gov/cwa-methods> and <http://www.fao.org/docrep/003/t0234e/t0234e01.htm>. [↑](#footnote-ref-9)
10. Integrated pest management (IPM) involves the careful consideration of all available pest control techniques and the use of appropriate measures to discourage the development of pest populations and to reduce the use of pesticides to the extent possible. IPM emphasizes the growth of a healthy crop with the least possible disruption to ecosystems by encouraging the use of natural pest control mechanisms. [↑](#footnote-ref-10)
11. See for example 40 CFR Part 180.900-180.1325 and 180.2000-180.2020. [↑](#footnote-ref-11)
12. An example of such a log is available at <https://www.ccof.org/documents/sample-farm-activity-log>. Alternately, software is available to manage and record farm activities. [↑](#footnote-ref-12)
13. Even when the harvested crop is sold in fresh form (i.e., a perishable form that might be expected to leave the marketplace quickly), downstream companies may process (e.g., by drying or extracting) the material into a shelf stable form that remains in the marketplace for years. [↑](#footnote-ref-13)
14. In the US, only crops grown and certified under the USDA National Organic Program or that are recognized as organic crops through USDA international agreements are permitted to be called “organic.” See <https://www.ams.usda.gov/services/organic-certification/international-trade>. [↑](#footnote-ref-14)
15. See Appendix 1 for a discussion of “covered produce.” [↑](#footnote-ref-15)