Appendix 1 – Scientific Names, Common Names, & Abbreviations of BC Conifer Species

Pinaceae family

Amabilis fir	Ba	*Abies amabilis* (Dougl.) Forbes
Grand fir	Bg	*Abies grandis* (Dougl.) Lindl.
Subalpine fir	Bl	*Abies lasciocarpa* (Hook) Nutt.
Noble fir	Bn	*Abies procera* Rehd.
Coastal Douglas-fir	Fdc	*Pseudotsuga menziesii* (Mirb.) Franco
Interior Douglas-fir	Fdi	*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco
Mountain hemlock	Hm	*Tsuga mertensiana* (Bong.) Carr.
Western hemlock	Hw	*Tsuga heterophylla* (Raf.) Sarg.
Western larch	Lw	*Larix occidentalis* Nutt.
Whitebark pine	Pa	*Pinus albicaulis* Engelm.
Limber pine	Pf	*Pinus flexilis* James
Coastal lodgepole pine	Plc	*Pinus contorta* Dougl.
Interior lodgepole pine	Pli	*Pinus contorta* var. *latifolia* Dougl. ex Loud.
Western white pine	Pw	*Pinus monticola* Dougl. ex D. Don
Ponderosa pine	Py	*Pinus ponderosa* Laws
Black spruce	Sb	*Picea mariana* (Mill.) B.S.P.
Sitka spruce	SS	*Picea sitchensis* (Bong.) Carr.
Interior spruce	Sx	*Picea glauca* (Moench) Voss, *Picea engelmannii* Parry ex Engelm and hybrids
Sitka × interior spruce hybrid	SxS	*Picea x lutzii* Little

Cupressaceae family

Yellow-cedar	Yc	*Chamaecyparis nootkatensis* (D. Don) Spach
Western redcedar	Cw	*Thuja plicata* Donn ex D. Don

Appendix 2 – Glossary of Technical Terms

Aflatoxins: Virulent toxin produced by the Hyphomycetes *Aspergillus flavus* and *A. parasiticus*, growing on foodstuffs, especially nuts; highly carcinogenic.

Anatomy: The study of the structure of living organisms, especially of their internal parts by means of dissection and microscopic examination (compare *Morphology*).

Angiosperms: The flowering plants, which are the plants with the most advanced structural organization in the plant kingdom. Monocots with one cotyledon, dicots with two cotyledons (compare *Gymnosperm*).

Ascocarps: A fruiting body of fungi containing asci (singular ascus), a sac-like cell generally containing a definite number of ascospores.

Ascospores: Spores resulting from sexual reproduction borne in an ascus.

Aspiration: A drawing of something in, out, up or through, by or as if by suction.

Asymptomatic: Not showing any clinical manifestations.

Bareroot: The system for growing forest tree seedlings in harrowed fields. Seeds sown directly into soil or plants transplanted to soil for a portion of the crop cycle.

Casehardening: The incomplete opening of cones due to the kilning of very moist cones or caused by fungal or insect activity.

Chlamydospores: Thick-walled asexual resting spores typically formed by many soil-borne fungi.

Conidia: An asexual fungal spore usually formed at the tip or side of a sporogenous cell.

Conidiophore: A fungal hypha bearing conidiogenous cells from which conidia are produced.

Conophyte: Any insect that feeds or develops on or within conifer cones.

Container: Used to describe a system for growing forest tree seedlings. Seeds are sown in media-filled containers that will restrict root growth to the size and shape of the cavity in which seeds are sown.

Convection: The transfer of heat from place to place by the circulation of heated particles of a gas or liquid.

Corrosion cavity: The cavity in the central portion of the mega-gametophyte that forms through cell breakdown. The embryo will grow into this cavity.

Cotyledons (syn. **seed leaves**): The photosynthetic structures of the embryo* found in the seed and emerging during epigeal* germination. They also protect the shoot apical meristem.

Cupressaceae: A family of gymnosperms* characterized by persistent scale-like leaves and cones in which the bracts and scale is wholly fused. Genera present in BC include *Thuja*, *Chaemacyparis*, and *Juniperus*.

Damping-off: The killing of the seedling by micro-organisms before emergence from the soil (pre-emergence) or the collapse of the hypocotyl and/or radical immediately after emergence, usually at the groundline.

Deterioration: A general term used to describe the reduction in seed quality. Different physiological mechanisms may be involved.

Disinfected: The removal or killing of fungal propagules or hyphae once the organism has penetrated the seed coat.

Disinfest: The removal or killing of fungal propagules adhering to the surface of materials.

Dormancy (seed): The condition when mature, viable, imbibed and healthy seeds fail to germinate.

Dusts: A pesticide active ingredient mixed with finely-ground particles of inert materials such as talc, clay or volcanic ashes. They are used dry and the concentration of active ingredient is usually low (i.e., 1 to 10%).

Efficiency: A measure of the success (gain*) of a treatment or processing step in relation to the amount of waste material. An efficiency of 95% indicates only 5% of the seed was discarded in producing the achieved gain.

Embryo: The structure in plants that develops from the zygote prior to germination.

Emulsifible concentrates: Contain a pesticide active ingredient, one or more petroleum-based solvents and an emulsifier which allows the formulation to be mixed with water. When the spray mixture is prepared, the pesticide is suspended as minute droplets in the mixture.

Energy curtain: Any cover placed over an object to trap/reflect long wave radiation emitting from it. Used in greenhouses to achieve the above as well as reduce the volume of air requiring heating on cold nights, thereby reducing energy consumption.

Enzyme: A complex protein produced in living cells that speeds the rate of (catalyzes) a chemical reaction.

Epigeal: Describing seed germination in which the cotyledons emerge from the seed and function as leaves. Typical of gymnosperms.

Etiolation: A condition found in plants being grown in the dark or with greatly reduced light intensity. Symptoms include increased stem elongation coupled with poor leaf development and lack of chlorophyll.

Flowables, dry: Consist of a pesticide active ingredient mixed with inert ingredients to form granule-size particles. The particles are added to water, producing a suspension just like a wettable powder. The spray mixture must be continuously agitated. Dry flowables are easier to pour than powders and are less of an inhalation hazard during mixing.

Frass: Particulate insect excrement, similar to dry granular cereal, often mixed with bits of plant material. When found within cones, frass is usually indicative of the feeding activities of conophytic caterpillars.

* Indicates those words found elsewhere in the glossary.

Fungi: (sing. **fungus**) an undifferentiated organism lacking chlorophyll and conductive tissues.

Gain: The improvement in a particular trait (e.g., upgrading a seedlot from 85 to 95% germination is a 10% gain).

Genetic worth (GW): A measure of the genetic quality of a seed or vegetative lot over wild stand material, measured for a specific trait.

Gymnosperm: Any plant whose ovules,* and the seed into which they develop, are borne unprotected, rather than enclosed in ovaries. (The term gymnosperm means naked seed.)

Heteroconophyte (Faculative conophyte): Any insect that has no dependence upon conifer cones but opportunistically feeds upon them when they are available.

Hydrolysis: Chemical decomposition that changes one compound into other compounds by taking up water.

Hyphal: (of **hypha**, pl. **hyphae**) Threads of mycelium produced asexually by fungi.

Hypocotyl: The region of the stem beneath the cotyledons and directly above the root of an embryo. It grows rapidly in seedlings showing epigeal germination and lifts the cotyledons above the soil surface.

Imbibed: Seeds that have become swollen and physiologically active following the movement of water into them. Full imbibition is characterized by all seed contents becoming filled with water. It is critical that water reaches the embryo.

Inoculum: The spores, mycelium, sclerotia, or other propagules of a pathogen that initially infect a host or crop.

Integument: The outer protective covering of a plant ovule.* It is perforated by a small pore, the micropyle. Usually two integuments are present in angiosperms* and one in gymnosperms.* After fertilization the integuments form the seed coat.

Laminar boundary layer: The layer of air in contact and immediately surrounding a surface.

Lipids: An organic compound that is insoluble in water, but soluble in organic solvents.

Macroconidiospores: Conidiospores as distinguished from microconidia. Large asexual spores produced by fungi.

Megagametophyte: Female gametophyte.

Metabolic: Relating to the chemical processes that occur within a living cell or organism.

Microconidia: (sing. **microconidium**) Small asexual spores called conidia, produced by fungi.

Morphology: The study of the form and structure of organisms, especially their external form (compare *Anatomy*).

Mycelium: (pl. **mycelia**) A mass of hyphae: the thallus of a fungus.

Mycotoxins: A fungal secondary metabolite which is poisonous to man or animals.

Nucellus: The tissue that makes up the greater part of the ovule* of seed plants. It contains the embryo* sac and nutritive tissue. It is enclosed by the integuments* except for a small gap, the micropyle.

* Indicates those words found elsewhere in the glossary.

Nursery-handling factor: The factor used to ensure that nursery equipment has sufficient seed to enable sowing of all cavities. A factor of 0.2 seeds per cavity sown is used consistently for all container types.

Obligate conophyte: Any insect that must spend part of its life feeding or developing on or within conifer cones.

Orthodox: A classification of seed based on storability. These seeds can be dried down to low moisture contents (<10%) and stored under sub-freezing temperatures for extended periods (decades) (compare *Recalcitrant*).

Osmotic potential: Also termed solute potential, it carries a negative sign and refers to the change in free energy or chemical potential of water imparted by solutes dissolved in it.

Osmoticum: A general term for large molecular weight molecules used to regulate water uptake in seeds.

Oversow factor: The factor used to provide a "correction" of the requested number of viable seedlings, to account for non-productive cavities.

Ovules: The part of the female reproductive organs of seed plants that consists of the nucellus,* embryo* sac, and integuments.* The ovules of gymnosperms* are situated on ovuliferous scales of the female cones while those of angiosperms* are enclosed in the ovary. After fertilization, the ovule becomes the seed.

Parenchyma: Roughly spherical relatively undifferentiated cells, frequently with air spaces between them. The cortex and pith* are composed of parenchyma cells.

Parasitic: (of a **parasite**) The action of a parasite, an organism that lives at the expense of another, usually invading it and causing disease.

Photosynthesize: The ability to convert light energy to chemical energy. In green plants it refers to the ability to utilize chlorophyll in the presence of light energy to produce carbohydrate from carbon dioxide and water.

Phototropism: The growth of plant organs in response to light.

Phytotoxic: Poisonous or injurious to plants.

Pinaceae: A family of gymnosperms* characterized by persistent or deciduous spirally arranged leaves, distinct bracts, and scales in a woody cone. Genera present in BC include *Abies*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, and *Tsuga*.

Pith: The cylinder of parenchyma* tissue found in the centre of plant stems interior to the vascular system.

Pneumatic separator (syn. **Aspirator**): A piece of equipment that separates seeds through the use of air currents based on terminal velocity.

Polyethylene: A lightweight plastic resistant to chemicals and moisture and used mainly in packaging.

Polyethylene glycol: A common type of osmoticum* used in seed priming treatments.

Procambium: A plant tissue formed by the apical meristems of shoots and roots. It consists of cells elongated parallel to the long axis of the plant. The procambium subsequently gives rise to the primary vascular tissue.

Pycnidia: A flask-shaped or globose fruiting body of fungi lined inside with conidiophores.

Pycnidiospores: Asexual spores or conidia produced within a fungal fruiting body called a pycnidium.

Qualitatively: Characterization based on a visual and generally subjective assessment.

Quantitatively: Characterization based on numerical assessment (measurement).

Recalcitrant: A classification of seed based on storability. These seeds cannot be dried down to low moisture contents or stored at subfreezing temperatures. Storability is generally short term (months to years) (compare *Orthodox*).

Relative humidity: A measure of atmospheric humidity, RH refers to the amount of water vapour present in a sample of air, expressed as a percentage of how much water vapour that sample can hold (water holding capacity) at its given temperature. Because water holding capacity changes with temperature, two samples of air at different temperatures may have the same RH but different vapour pressure deficits* (VPDs).

Root apical meristem: A region at the tip of each root in which cell divisions occur to produce new root tissue.

Rootcap: A cone-shaped structure that covers the root apical meristem and protects it as it grows through the soil.

Saprophytic: (of a **saprobe**) The action of a saprobe, an organism that utilizes dead organic material for food.

Scalper: A multi-screened vibrational seed cleaner used to separate debris from seeds. Screens will vary in size and shape to remove different types of debris.

Scarification: Degradation of the seed coat by mechanical abrasion or chemical treatment to increase the permeability of water and gases or lower the mechanical resistance.

Seed coat: The protective covering of a seed that develops from the integuments* of the ovule* after fertilization.

Select: Seed and vegetative material having a level of gain greater than zero for some trait of interest. Generally, seedlots registered as select are assigned a genetic worth* for a specific trait.

Shoot apical meristem: A region at the tip of each shoot in which cell divisions occur to produce new stem tissue.

Short-day treatment: Refers to the method of application of photoperiod control to induce flowering in short-day plants. In conifers it is used to induce the shoot apical meristem to set (produce) a terminal vegetative bud, thereby causing the cessation of height growth for the duration of the current growing season.

Solutes: A substance dissolved in a solvent forming a solution.

Sowing factor (SF): The average number of seeds per cavity within a container that should be sown to produce a seedling (e.g., 2.2 seeds per cavity).

Specific gravity: The ratio of the density of a substance to the density of water as a standard. The variable is unitless.

Spores: (sing. **spore**) A general term for a reproductive structure in cryptogams (fungi, algae, mosses, and ferns).

Standard: A reference to seeds that originate from wild stands with no known level of genetic gain (compare *Select*).

Stratification: A technique used to overcome embryo dormancy in seed. Stratification is synonymous with moist-chilling. Seeds are imbibed and then put into cool conditions (2–5°C) for the duration required to overcome dormancy.

Stylar: (of the **style**) Tissues of the style, the thin part of a pistil between the ovary and the stigma on angiosperms.

Symbionts: Organisms living in symbiosis.

Symbiosis: The association of two different organisms living attached to each other or none within the other.

Symptoms: Something that indicates the presence of something else, usually in reference to a condition or pathogen.

Systemic: Entering a plant via the roots or shoots and passing through the tissues.

Vapour pressure deficit: A measure of atmospheric humidity, VPD refers to the difference between the actual vapour pressure and the maximum vapour pressure possible at the temperature of a sample. In horticulture it can be related to the amount of transpirational draw that a plant experiences.

Vascular cambium: A plant tissue consisting of actively dividing cells that is responsible for increasing the girth of the plant (i.e., it causes secondary growth). The vascular cambium occurs in the stem and root; it divides to produce secondary xylem* and secondary phloem. In mature stems the vascular cambium is extended laterally to form a complete ring.

Vigour: A term used to define the relative robustness of a seedlot. A vigourous seedlot will germinate rapidly over a wide range of conditions. The term is also used on **SPAR** to describe the germination value (GV).

Water insoluble: Difficult or impossible to dissolve in water.

Water potential: The chemical potential of water measured in bars or megapascals. A diagnostic tool that enables one to assign a value to the water status in plant cells and tissues. The lower the water potential, the greater the ability to absorb moisture.

Wettable powders: consist of finely-ground pesticide active and inert ingredients. Wettable powders must be added to water and kept in suspension through constant agitation. Wettable powders usually contain 50% or more active ingredient.

Xylem: Woody tissues in vascular plants that give support and conduct water and nutrients.

Zygote: A fertilized female gamete. The product of fusion of the nucleus of an ovule with the nucleus of a pollen grain.

* Indicates those words found elsewhere in the glossary.

Appendix 3 – Cone & Seed Evaluation Form

Registration # _____

Agency: _____

Species: _____

Evaluation Type

Pre-collection: _____

Interim Storage: _____

Receipt at TSC: _____ Date Rec'd: _____

TSC Conditioning:

Embryo

Comments:

- ❒ 90% Yellow
- ❒ 90% + Pale Yellow
- ❒ 90% + White
- ❒ Other

Storage Tissue

Comments:

- ❒ Milky/with shrinkage
- ❒ Firm/with shrinkage
- ❒ Firm/no shrinkage

Seed Wing

Comments

- ❒ Cream/Translucent
- ❒ Tan
- ❒ Brown

Easily released from scale ❒ yes ❒ no

Seed Coat

Comments

- ❒ Cream
- ❒ Tan Brown
- ❒ Dark Brown

Cones

Comments:

- ❒ Green
- ❒ Light Brown
- ❒ Brown
- ❒ Cosed
- ❒ Slight Flex
- ❒ Flexing

Lodgeple Pine: %

Class I _____

Class II _____

Class III _____

Class IV _____

Internal cone colour and condition: _____

Number of filled seed per half cone*: _____

Recommended collection standard: _____

Number of filled seed per cone*: _____

Number of cones sampled: _____

Insect activity/damage*: _____

Mould	Colour	Nil	Trace	Light	Moderate	Heavy
Internal						
External						

Fungal Activity: _____

Other: _____

Remarks: _____

Assessed by: _____ Date: _____

Contact: _____ Date: _____ Phone: _____ Fax: _____

* Indicate results/observations by cone, on reverse.

Appendix 4 – Procedures for Seed Sanitation & Safety

Conifer Seed Sanitation Method Using Hydrogen Peroxide[1]

Non-resin Vesicle Seed: Coastal Douglas-fir and Western Larch

Prior to or following stratification, seeds may be soaked for **one to four hours** in a 3% hydrogen peroxide (H_2O_2) solution. Mix technical grade 30% hydrogen peroxide with tap water to the appropriate concentration prior to contact with seeds. The seeds should be completely immersed in the newly made 3% solution at a ratio of 3:1 peroxide solution to seed volume. Gentle stirring of the seeds and hydrogen peroxide solution should be performed occasionally. Following the sanitation treatment, seeds should be gently rinsed under running water to remove traces of the hydrogen peroxide solution. Seeds may then be surface-dried, stratified and/or sown.

Resin Vesicle Seed Species: Subalpine Fir

The procedure is essentially the same except the high fungal and bacterial levels on some seedlots may lead to very active foaming of the soaking solution. Also, there is the possibility of damage to resin vesicles resulting in handling problems when the seeds are sown. Therefore, soak times prior to or following stratification should be reduced to a maximum of **one hour** to reduce these effects. Choose a container with at least twice the volume of seeds plus solution being used. The foaming action of the solution subsides within minutes of the initial contact between the hydrogen peroxide solution and the seeds but a large container will prevent the loss of seeds. In some cases more 3% hydrogen peroxide solution may need to be added to ensure than all seeds are covered in liquid. Rinsing and surface drying should proceed as described above.

Hydrogen Peroxide

Hydrogen peroxide has the desirable quality of rapidly breaking down into water, thereby reducing concerns over environmental contamination. However, a 30% solution is extremely corrosive and must be handled with extreme caution.

Use the concentration chart that follows to obtain the desired volume of 3% dip solution using 30% technical grade hydrogen peroxide and the appropriate volume of water.

Final dip solution 3% (litres)	Hydrogen peroxide 30% (litres)	Water (litres)
10	1.0	9.0
15	1.5	13.5
20	2.0	18.0
25	2.5	22.5
30	3.0	27.0
35	3.5	31.5
40	4.0	36.0
45	4.5	40.5
50	5.0	45.0

To determine a specific amount of stock solution (i.e., 30% hydrogen peroxide) needed to produce a given volume of final dip solution (i.e., 3% hydrogen peroxide) use the following formula:

$$\textbf{Volume of stock solution} = \frac{\text{volume total of dip solution} \times \text{dip concentration}}{\text{stock concentration}}$$

Total volume of dip solution = volume of stock solution + water

Example: How much 30% H_2O_2 (stock) is required to produce 22 litres of 3% H_2O_2 as a final dip solution.

$$\textbf{Volume of stock solution} = \frac{22 \text{ litres} \times 3}{30} = 2.2 \text{ litres}$$

...add 2.2 litres of 30% H_2O to 19.8 (22–2.2) litres of water.

Precautions – Hydrogen Peroxide

Avoid contact and inhalation. Wear chemical goggles. Avoid the use of contact lenses. Wear a long sleeved shirt, trousers, rubber boots, rubber gloves, and a rubber apron. Hydrogen peroxide is a *corrisive oxidizer*. Keep away from chromium, manganese, silver, platinum, and palladium. Keep away from organics, sodium borate, urea, sodium carbonate, sodium fluoride, and sodium pyrophosate. Provide adequate ventilation and use a multi-gas detector to monitor the air above the rinse tank. The Workers' Compensation Board of British Columbia *Industrial Health & Safety Regulations* permissible concentration for an eight-hour exposure is 1 ppm.

For a complete list of safety precautions and disposal recommendations refer to the manufacturer's material safety data sheet. Observe all federal, provincial, and local waste disposal laws and regulations.

[1] Modified from Neumann (1997) and Peterson (1991).

Equipment Cleaning Methods[2]

Sanitation Method Using Ivory® Dishwashing Liquid and Hot Water

Ideally, cleaning should occur weekly, especially during times of high use. However, as this may not always be possible, cleaning every two weeks would be beneficial as this will help to reduce the build-up of *Fusarium* spp. inoculum levels. Tank cleaning should begin just prior to the beginning of the seed preparation season and continue until the end of the season.

A 5% solution of Ivory®, dishwashing soap and very hot water (200 ml Ivory, and 3800 ml hot [50°C] water) should be made up just prior to use. Seed processing containers or tanks should be scrubbed with special care being given to the corners and bottom surface since that is where most of the contamination is present. Container/tanks should be rinsed thoroughly with cold water. To ensure complete removal of soapsuds, the container/tank should be filled partially with water to dilute the soap and to speed its removal.

Precautions – Dishwashing Soap

Care should be taken to avoid eye contact with the soap product. Splash-resistant safety goggles/glasses should be worn. Spillage of soap solution onto floors may cause them to be slippery temporarily. Thorough rinsing of tanks will ensure that disposal of soap occurs with a minimum of foam.

Screen Cleaning Method Using Bleach, Buffer, and Water

A 0.5% bleach and buffer solution should be made up with cold water of a sufficient volume to soak and completely cover seed-soaking screens. The solution should be made of equal parts of buffer to bleach (12%) and made up with enough cold water to produce a 0.5% solution of the required volume. A typical solution would contain 160 ml of 12% industrial sodium hypochlorite, 160 ml of buffer (75% phosphoric acid, 50% sodium hydroxide); and 3840 ml of cold water. Screens should be soaked for 3 to 4 hours and then rinsed thoroughly for at least 30 minutes in running tap water. For maximum efficiency, screens could be cleaned every two weeks but monthly will reduce inoculum loads as well.

Bleach

A 0.5% bleach solution is a more effective sanitising agent when buffered to a pH of 7.0. Either household bleach (6% available chlorine) or industrial bleach (12% available chlorine) can be used. The pH of the bleach solution can be assessed with pH paper or a pH meter. The pH should be close to 7.0.

If the pH is above 7.0, slowly add buffer.

If the pH is below 7.0, slowly add bleach.

Use the concentration charts below to obtain a 0.5% dip solution at the volume desired by adding **equal parts buffer to bleach (12%)** with the appropriate volume of water.

Final dip solution (litres)	Bleach 12% (litres)	Buffer (litres)	Water (litres)
10	0.4	0.4	9.2
15	0.6	0.6	13.8
20	0.8	0.8	18.4
25	1.0	1.0	23.0
30	1.2	1.2	27.6
35	1.5	1.5	32.0
40	1.7	1.7	36.6
45	1.9	1.9	41.2
50	2.1	2.1	45.8

Use the following chart to obtain a 0.5% dip solution at the volume desired by adding **one part buffer to two parts bleach (6%)** with the appropriate volume of water.

Final dip solution (litres)	Bleach 6% (litres)	Buffer (litres)	Water (litres)
10	0.8	0.4	8.8
15	1.3	0.6	13.1
20	1.7	0.8	17.5
25	2.1	1.0	21.9
30	2.5	1.2	26.3
35	2.9	1.5	30.6
40	3.3	1.7	35.0
45	3.8	1.9	39.4
50	4.2	2.1	43.8

Precautions – Bleach

Inhalation of fumes or mists causes respiratory tract and mucous membrane irritation. Liquid and mists will irritate the skin or damage the eyes. Wear chemical goggles. Avoid the use of contact lenses. Wear long-sleeved shirt, trousers, rubber boots, rubber gloves, and rubber apron.

The chlorine concentration in the atmosphere above the rinse tank can be monitored using a multi-gas detector. The Workers' Compensation Board of British Columbia I*ndustrial Health & Safety Regulations* permissible concentration for an eight-hour exposure is 1 ppm.

For a complete list of safety precautions and disposal recommendations refer to the manufacturer's material safety data sheet. Observe all federal, provincial, and local waste disposal laws and regulations.

[2] Modified from Neumann (1997) and Peterson (1991).

Seed Handling and Safety

Other Seed Contaminants

Depending on the source and species, seed screening assays may find a variety of other fungi and bacteria associated with a particular seedlot. These organisms are primarily moulds that are facultative saprophytes and generally have little host specificity. Most of the species belong to the genera *Aspergillus*, *Chaetomium*, *Mucor*, *Penicilium* and *Rhizopus*. In particular, *Penicillium* and *Aspergillus* are occasionally connected with health effects when found in high concentrations in homes, office buildings and schools. *Aspergillus* produces aflatoxins that are toxic to humans. *Penicillium* may also cause health consequences, especially in individuals who have allergic reactions to the drug penicillin. Another candidate is *Stachybotrys*. In recent years, it has been a source of concern in chronically wet buildings that have considerable amounts of cellulose-based materials.

Some of these fungi may cause allergies. An allergic reaction occurs when a substance provokes formation of antibodies in a susceptible person. These substances that cause an allergic reaction are termed *antigens or allergens*. Rashes, hay fever, asthma (tightness in the chest, difficulty in breathing), and runny noses are common allergic reactions.

Occupational Hazardous Fungi

Aspergillus

A genus of fungi with over 100 species of which approximately 15 are commonly encountered in dwellings. Most naturally occurring *Aspergilli* are toxigenic or allergenic. Among several toxigenic species of this genus, the most important are, *A. parasiticus*, *A. flavus*, *A. versicolor* and *A. fumigatus*. Aflatoxins are among the most extensively studied mycotoxin.

Penicillium

Some *Penicillium* species are fairly common indoor fungi, even in clean environments. These particular species of fungi can proliferate in sub-basement offices and rooms, in libraries, auditorium, storage room of paper materials and also in ventilation systems. Some *Penicillium* species can produce small, non-descript conidia and complex mixtures of metabolites that are more or less toxic. Like all other moulds, spores have the highest concentrations of mycotoxin, although the vegetative portion of the mycelium can also contain the material.

Stachybotrys

It is a genus of moulds (Hyphomycetes) characterized by having a high moisture requirement so it grows in chronically wet areas. This mould has a very low nitrogen requirement, and can grow on water-saturated cellulosic materials such as paper, wallpaper, ceiling tiles, carpets, insulation material, wood-derived building materials and even general debris.

Control Strategies

Most of these associated organisms are either benign or in insufficient numbers to affect people working with seed sources. Yet it is prudent to implement some simple procedures to ensure the safety of any individuals working in the seed processing area:

- Designate an area in your production facilities as a seed processing lab.
- Use water/chemical resistant materials on the benching and floor.
- Reduce relative humidity. Use a chemical or mechanical dehumidifier.
- If you find mould or mildew in your seed processing area, try to find and eliminate sources of moisture.
- Clean mould and mildew growth from bench surfaces, walls, floors with water mixed with chlorine bleach, diluted to 0.5% solution bleach (see table on previous page). Commercial products can also remove mildew and mould. Follow product instructions carefully. This should be done on a regular basis. Very mouldy items should be replaced.
- Vent to the outside.
- Change heating and cooling system filters monthly.
- Vacuum air return covers or screens regularly.
- Check air conditioners for mould before each cooling season and have coils cleaned as needed.
- Have heating/cooling system ductwork checked for loose insulation, leaks, or signs of condensation where the system enters the building. Insulate ducts on the outside.
- Consider installing air cleaners and filters. Electronic and hePA (high efficiency particulate absolute) cleaners and filters are best at taking mould, mildew, and dust out of the air.
- Use simple personal protection such as latex gloves, eye protectors, lab coat and if necessary, wear an appropriate respiratory filter.

Appendix 5 – General Nursery Guidelines for Germination Stages 1 & 2

	Stage 1	Stage 2
Temperature at seed level	15–25°C – optimum >20°C – no day/night differential required	15–25°C – optimum >20°C – day/night differential photoperiod dependent
Light intensity	≤50% full sun	≥50% full sun – depends on time of year – depends on latitute – depends on GH cover
Photoperiod	20+ hour extended day	20+ hour extended day
Moisture	– even, moist to wet – media not saturated – maintain media aeration porosity	– moist
Fertilization	– 10–30 PPM NO_3 based – starter/grower formulation – acts as seed primer when watering	– 20–50 PPM NO_3 based – starter/grower formulation – radicle may be taking up
Grit cover	– maintains constant °C and RH – helps orient emerging radicle – reduces moss and algae growth – 3 mm forestry sand	– maintains constant °C and RH – helps orient emerging radicle – reduces moss and algae growth – 3 mm forestry sand
RH	95%+	85–95% – light dependent
pH	4.5–6.0 4.5–6.0	
Air circulation	– minimal	– increase
$C0_2$ injection	– no	– minimal if desired – wait until green is evident – include air circulation – light dependent to 800 PPM
Monitor EC	<0.5 mmhos/cm^3	≤0.5 mmhos/cm^3

Appendix 6 – Conversion Table of Metric & English Units

Distance

Metric		Imperial
1 millimetre [mm]		0.0394 in
1 centimetre [cm]	10 mm	0.3937 in
1 metre [m]	100 cm	1.0936 yd
1 kilometre [km]	1000 m	0.6214 mile

Imperial		Metric
1 inch [in]		2.54 cm
1 foot [ft]	12 in	0.3048 m
1 yard [yd]	3 ft	0.9144 m
1 mile	1760 yd	1.6093 km
1 int nautical mile	2025.4 yd	1.852 km

Area

Metric		Imperial
1 sq cm [cm^2]	100 mm^2	0.1550 in^2
1 sq m [m^2]	10 000 cm^2	1.1960 yd^2
1 hectare [ha]	10 000 m^2	2.4711 acres
1 sq km [km^2]	100 ha	0.3861 $mile^2$

Imperial		Metric
1 sq inch [in^2]		6.4516 cm^2
1 sq foot [ft^2]	144 in^2	0.0929 m^2
1 sq yd [yd^2]	9 ft^2	0.8361 m^2
1 acre	4840 yd^2	4046.9 m^2
1 sq mile [$mile^2$]	640 acres	2.59 km^2

Volume/Capacity

Metric		Imperial
1 cu cm [cm^3]		0.0610 in^3
1 cu decimetre [dm^3]	1000 cm^3	0.0353 ft^3
1 cu metre[m^3]	1000 dm^3	1.3080 yd^3
1 liter [l]	1 dm^3	1.76 pt
1 hectolitre [hl]	100 l	21.997 gal

Imperial		Metric
1 cu inch [in^3]		16.387 cm^3
1 cu foot [ft^3]	1728 in^3	0.0283 m^3
1 fluid ounce [fl oz]		28.413 ml
1 pint [pt]	20 fl oz	0.5683 l
1 gallon [gal]	8 pt	4.5461 l

USA measure		Metric
1 fluid ounce	1.0408 UK fl oz	29.574 ml
1 pint (16 fl oz)	0.8327 UK pt	0.4731 l
1 gallon	0.8327 UK gal	3.7854 l
1 bushel		35.239 l

Mass

Metric		Imperial
1 milligram [mg]		0.0154 grain
1 gram [g]	1000 mg	0.0353 oz
1 kilogram [kg]	1000 g	2.2046 lb
1 tonne [t]	1000 kg	0.9842 ton
1 kg/hectare		0.892 lbs/acre

Imperial		Metric
1 ounce [oz]	437.5 grain	28.35 g
1 pound [lb]	16 oz	0.4536 kg
1 stone	14 lb	6.3503 kg
1 hundredweight [cwt]	112 lb	50.802 kg
1 ton	20 cwt	1.016 t
1 pound/acre		1.12 kg/hectare

Temperature

To convert from	To	Substitute in formula
Degrees Celsius	Degrees Fahrenheit	(degrees C × 9/5) + 32
Degrees Celsius	Kelvin	(degrees C + 273.16)
Degrees Fahrenheit	Degrees Celsius	(degrees F - 32) × 5/9
Degrees Fahrenheit	Degrees Rankin	(degrees F + 459.69)