Slide 1 **ONION SEED PRODUCTION**

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Cytoplasmic male sterility (CMS) is a condition under which a plant is unable to produce functional pollen. As the name implies, it is under extra nuclear genetic control. Cytomplasmic male sterility shows non-Mendelian inheritance and is under the regulation of cytoplasmic factors. Since the cytoplasm of a zygote comes primarily from the egg cell, the progeny of such male sterile plants is always male sterile. Therefore male sterility is inherited maternally. CMS systems are a valuable tool in the production of hybrid seed in crops such as sunflower, onions and carrots.

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CMS is maternally inherited, but male fertility can be restored by nuclear-encoded fertility restorer (Rf) gene(s). So, on one hand, sterility results from mitochondrial genes causing cytoplasmic dysfunction and, on the other, fertility restoration relies on nuclear genes that suppress cytoplasmic dysfunction.
Thus, the dominant nuclear genes can override the cytoplasmic male sterility factors.

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Cytoplasmic male sterility (CMS) is used in hybrid seed production. CMS lines must be maintained by repeated crossing to a sister line (known as the maintainer line) that is genetically identical except it possesses normal cytoplasm and is, therefore, male fertile. In genic cytoplasmic male sterility, restoration of fertility is accomplished using restorer lines carrying nuclear restorer genes in crops (Rf). The male sterile line is maintained by crossing with a maintainer line which has the same genome as that of the CMS line, but carrying normal fertile cytoplasm.
In this case, sterility is transmitted only through the female and all progeny will be sterile. This is not a problem for crops such as onions and carrots where the commodity harvested from the F1 generation is produced during vegetative growth.

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In onions and carrots, all lines may be used, because the producers are looking for bulbs and roots. In sunflower, the CMS line cannot be used because there will be no seeds, the commercial product.

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In general, onion hybrid seed production is sensitive to photoperiod and temperature for bulb and seed production, respectively.
Relative moisture is very important because onions are prone to diseases.
Wind can cause the scapes to lodge and make pollen transfer from bees difficult.

Onion crops grow well in soils with a pH between 6 to 6,8.
Weed control must by done in order to avoid competition with the crop. Weeds also increase relative humidity and, therefore, increase the incidence of disease. Finally, two noxious weeds that are difficult to separate from onion seed that must be avoided are *Convulvulus arvensis* and *Sorghum halapense*

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Hybrid onion seed for commercial use is produced either using the bulb to seed method or the seed to seed method. As the name implies, the bulb to seed method begins with mother bulb production during the first year since onion is a biennial crop. The production practices are essentially the same as commercial onion production practices.
Onions are sensitive to photoperiod, i.e. to the length of daylight. In onions, bulb formation is initiated only when the light period exceeds a certain minimum, which varies from one cultivar to the next. The bulb must achieve a minimum diameter of 10 mm to be considered for seed production.

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While day-length provides the stimulus for bulb formation in onions, temperatures also play an important role. The warmer the environment, the faster bulb formation occurs. Bulb formation of any specific cultivar will begin earlier under warmer conditions. Therefore, short-day cultivars are especially suited to regions where temperatures rise more sharply in the spring. Where day-length is sufficient to stimulate bulb formation, but temperatures are too low, a high percentage of bolting can be expected. In this table, the best sowing dates are presented identifying the optimum plant stages to respond to photoperiod and temperature in order to obtain a good bulb mother size.

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Flower induction is sensitive to temperature, photoperiod, number of leaves and bulb development. Cool temperatures play an important role in flowering. Optimum temperatures required for vernalization are 7-12° C. However, this will vary with cultivar. For example, in the tropics, cultivars generally are vernalized even at temperatures as high as 15-21° C. As seen in this graph, the effect of leaf number at the start of vernalization on the number of plants with inflorescense initials after 77 days at 9°C and 18 hours of photoperiod is presented.

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For flower induction,,onion plants must have 5 to 9 leaves. Plants at a younger juvenile stage do not respond to temperature and a bulb diameter from 10 to 15 mm. The larger the bulb size, the more easily it is to induce flowering.

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Bulb size generally plays an important role in seed production. The larger the mother bulb, the greater the seed yield per plant. But, large bulbs do not store well. The dates

on the table show that even with a good bulb size, there may be no flower induction because the plants are not big enough to be stimulated by vernalization.

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Mother bulbs are harvested when the scapes have fallen. In order to increase bulb storage life, they are cured and the tops pruned after the neck has dried.
Mother bulbs are usually planted in autumn prior to the onset of vernalization temperatures.

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During harvest and storage, it is very important to label each line properly. Mother bulbs are stored under similar conditions as the market crop.

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In the seed-to-seed method, sowing dates are before the seed-bulb-seed method in order that plants develop sufficiently to be sensitive to vernalization temperatures. In this case, there is no bulb formation because there is no photoperiod induction.

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Here you can compare both methods.

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The seed-bulb-seed method requires two years. The first year establishes bulb formation just as occurs with commercial production using the same dates of sowing and harvesting. The second year before selection, bulbs are planted in autumn for vernalization during winter and the seed is harvested in the spring. In the seed-to-seed method, sowing dates are earlier in order to have a plant sufficiently developed to be vernalized. But, with these sowing dates, there is no bulb formation and therefore less yield by the plant due to the smaller amount of reserve formation.

The seed-bulb-seed method is more commonly used because of its high seed yield, but 18 months are required to obtain seed. This longer period of seed production and bulb storage means higher cost of production.
The populations used in seed to seed (s-s) are larger because the plants have less vigor and there is no bulb formation. They, therefore, have less plant development, have less scapes (flower stalks) so they produce less yield per plant and per hectare in spite of an increased plant population. High plant density causes less ventilation, drying after irrigation is slow, and heavy dew and moisture make the plants more prone to disease.
The seed to bulb to seed method allows more roguing in the field in the first and the second year between bulb selection before replanting. The seed to seed method requires larger quantities of basic seed and relative basic seed stock because there is only one roguing opportunity.

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Onion is an insect-pollinated crop. As a result, complete isolation in a field grown crop is practically impossible since pollination is entirely by insects which carry the pollen from field to field over long distances. The greater the distance between onion fields, the less the amount of outcrossing. The isolation distance from other onion seed fields should be at least 1,000 m for hybrid production and 1,500 m for parental lines.
In the seed-bulb-seed method, roguing is conducted at the bulb stage before replanting as well as at flowering. In the seed to seed method, roguing is accomplished before and after flowering. Parameters used in both methods during roguing are foliage type, flower color and seed height. Bulbs are selected by shape, size and color.

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Downy mildew (*Peronospora destructor*) is the most serious disease in onion seed crops in Chile and other countries. The seed stalk can be seriously infected during prolonged periods of leaf wetness. The susceptible period is longer and low ventilation in the field also results in a high incidence of weeds. Chemical control measures recommended for commercial bulb crops are generally followed for seed crops.

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Onions are insect pollinated and require bees to carry the pollen from one plant to the other. To ensure successful pollination, it is not recommended to place all the hives in the field at one time. A few hives should be placed when 50% of the umbels have opened flowers. The optimum population of bees is 8 to 10 hives per hectare. High potassium concentration in the flower nectar has been associated with reduced attractiveness of flowers to bees.

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Depending on the cultivar, seed maturity takes approximately 30-50 days after anthesis. Onion seed may be harvested either manually or mechanically. Seed is hand harvested when about 25% of the umbels show a few open fruits and the seeds are black. However, mechanized harvesting is recommended when ripe (black) seeds are visible in 1-3% of the umbels. The best seed quality is obtained when seed moisture content is between 50 and 65%. Below 50% and lower, umbel shattering occurs. In addition, under 50% seed moisture content results in lower germination and seed weight.

Slide 22 **Carrot seed Production**

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Botanically, the carrot is an herbaceous biennial. During the first year, it produces a rosette of leaves and a fleshly taproot. The seed stalk develops in the second year growing to a height of 1-2 m or more.

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The inflorescence is a compound umbel, usually called a head. The appearance of umbels is not uniform. The primary or king head is the first and largest umbel to flower and it is in the top on the main flowering stalk.

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Secondary umbels are formed at the terminus of branches from the main flowering stem and flower in a sequence from the top to the bottom inflorescence. There may be third- and fourth-order branches and heads during later development.

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Seed-root-seed and seed to seed are the two distinct methods of producing carrot seeds. The seed-root-seed method is the most commonly employed procedure in the seed trade in Chile as well as other countries with low paying laborers. This method is expensive, but often results in high seed quality. The seed-to-seed method is first sown direct in late summer providing sufficient time to allow the plants to enter winter when most of the roots have attained their widest minimum diameter. In the next spring, blooming is initiated and the seeds are harvested in summer. The seed-root-seed method is planted in summer on slightly raised beds. Before replanting, small, diseased, cracked or injured or off-type stecklings are removed and disinfected in order to prevent diseases. Stecklings are planted in autumn for vernalization during winter. Finally, harvest occurs in summer. Only stock seed of the highest quality should be sown with the seed-to-seed method.

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Carrots are cross-pollinated because their flowers exhibit protoandry and hybrid seed production is possible using cytoplasmic male sterility. The common planting pattern is 2 males per 4 or 6 female rows. Hybrid carrot seed production has two problems: reduced plant vigor because of intense inbreeding and male flowers producing small petals that are unattractive to bees. As a result, hybrid production often has low yields that results in higher seed costs.

In order to assure successful nicking, the male is planted twice at 15 and 30 days before the female. The entire umbel may take 7 to 10 days to complete flowering depending upon plant size and production environment. Flowering on a single plant may continue for about 4 weeks.

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Carrots must be isolated from wild carrots because of the potential for pollen contamination. Volunteer carrots must also be controlled in the field. For hybrids, the isolation distance is 2000 m between fields. For open-pollinated cultivars, the isolation distance is 1500 m. Pollination is accomplished by honey bees, usually 5 hives/ha and sometimes by alkali bees.

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Carrot stems may grow 1.5 m. As a result, to avoid physical contamination, an empty row is often left between the male and the female rows.

Female rows are staked and stringed to ensure that the parents remain separated.

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In carrot seed production, high plant density increases yields per hectare. However, this diminishes the seed production per plant and the higher proportion of primary umbels, thus resulting in a more uniform period of seed maturation. – I DON'T UNDERSTAND THIS SENTENCE

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(31) Harvesting can be problematic in carrots because of the three economically important umbel orders. These umbel orders mature at different times. The primary or king umbel matures first, the secondary umbel next, and the tertiary umbels last. (32) For this reason, in Chile, the primary and early secondary umbels are harvested by hand. (33) The umbels are dried in the field (34) and the crop is threshed using a stationary thresher. The remaining secondary and tertiary umbels are harvested with combines at a seed moisture content of 7%.

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Debearders are used to remove spines from the seeds. Seeds are then cleaned with an air-screen cleaner and gravity table. An indent cylinder is used to remove remaining stems. Some conditioners use size graders to improve germination, but this is not always helpful.

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Germination is low in some years and is often accompanied by increased abnormal seedlings. Early harvest may contribute to this problem when the seeds are brown in color and appear to be mature, but the embryos remain immature.