Onion cultivation and seed production

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Introduction

Onion, *Aldrarn cepa* L., cultivars differ substantially with respect to the threshold daylength required for bulbing. Other factors such as temperature many interact with daylength to modify the bulbing response. In all cultivars, bulbing is accelerated with increasing temperature. Temperature extremes not only affect the rate of bulbing, but also affect the bulb shape. Thick and elongated necks are common in plants exposed to 6°C or lower.

The edible part of the onion is the bulb, composed of concentric, fleshy, enlarged leaf bases or scales. The outer leaf bases lose moisture and become scaly and the inner leaves generally thicken as bulbs develop. The green leaves above the bulb are hollow and arise sequentially from the meristem at the inner most point at the base of the bulb. The stem is very small and insignificant during vegetative growth. After vernalization at temperatures below 10°C, the stem elongates rapidly, eventually producing compound u mbels. Bolting has been reported to be related to the length of clay. However, long days do not induce reproductive growth but tend to accelerate development of the seedstalk once it has been initiated by vernalization. Temperature has a major role in inducing bolting.

The onion root system is fibrous, spreading just beneath the soil surface to a distance of 30 to 46 cm. There are few laterals, and total root growth is sparse and not especially aggressive. Therefore, in monoculture, onions tolerate crowding, particularly in loose, friable soils such as peat and muck. Competition from aggressive root systems (as from weed growth) severely limits onion growth.

The ultimate yield of onion is determined by the number of leaves that are formed prior to bulbing. Since bulbing in each cultivar is triggered by a specific daylength, early planting is the most effective method of improving bulb size and is a primary factor contributing toward yield. Spacing also determines the bulb size. If, howeever, early planting coincides with cool air temperature or cool, wet soils, the stand and, ultimately, the maturity of the crop will be erratic. Some cultivars of the Bermuda type also may bolt if substantial growth precedes exposure to cool temperature.

Environment and cultural practices

Soil and climate

Onions can be grown successfully on any fertile, well-drained, non crusting soil. The optimum pH range, regardless of soil type, is 6.0 to 6.8, although alkaline soils are also suitable. Onions do not thrive in soils of pH below 6.0 because of trace element deficiencies or, occasionally, aluminum or manganese toxicity.

Onion is a cool season biennial, tolerant of frost. Optimum temperatures for plant development are between 13 and 24°C, although the range for seedling growth is narrow, 20 to 25°C. High temperatures favor bulbing and curing.

Planting:

Three systems of planting may be employed:

1. direct seeding is preferred and gives excellent results where the season is sufficiently long to provide early prebulbing growth.
2. Transplants normally have three to five well-formed leaves at transplant time. Transplant leaves are pruned during growth prior to field setting, facilitating handling and increasing plant hardiness.
3. Sets are used in some areas to ensure large bulb size and uniform maturity. Sets are small dry bulbs, approximately 12 mm in diameter, produced the previous season by seeding thickly or growing under conditions favoring rapid bulbing.

Any of the above system may be used for early green onion production.

Methods of sowing and spacing

Prior to planting, soils should be plowed and disked sufficiently to eliminate debris and soil clods. In most commercial areas, beds 0.9 to 1.0 m wide are formed, and two to six rows are seeded or planted on the bed. If two rows, they may be two-line (twin) rows with plants staggered to achieve proper spacing and high population density.

Seeds are sown 6 to 18 mm deep in heavy mineral soils, deeper in light mineral soils and mucks. Excessively thick seedings of bulb onions may delay maturity; however, necks tend to be thinner than in sparse seedings, and bulbs are somewhat more globular in shape.

Using coated seed and precision seeding, the seeding rate can be adjusted easily for projected bulb size. For normal storage onions, seeds are spaced 7.5 cm apart. Where small boiling, pickling, or pearl onions are desired, spacing would be reudced to 2.5 cm in the row. Large bulb size is promoted by spacings of 10 cm or more.

Manuring and fertilizer

Onion responds very well to organic manure. Organic manure @ 25 to 40 t/ha is recommended to obtain high bulb yield.

Fertilizer is applied either as a broadcast or, more commonly, as a band 5 to 10 cm directly below the seed, set, or transplant. Onion plants utilize substantial amounts of nutrients. Based on a yield of 18 t/ha of bulbs, the plants remove an average 66, 11 and 70 kg, of N, P and K respectively. Soils differ widely in fertilizer needs, depending on production history, soil type, and analysis.

Mineral soils on an average contain 90 to 112 kg/ha of N and 56 to 168 kg/ha of $P20_5$ and K. N, P, and K application of 163, 93, and 38 kg/ha, respectively, is recommended for mineral soils. One or two side dressings of nitrogen are applied during a season. These side dressings may be applied through the irrigation system. Fall seeded onions require P_2O_5 only before seeding and require N when active growth starts in the spring and twice thereafter. Insufficient N will induce early maturity and reduce bulb size; high N may increase bulb size and cause large necks and soft bulbs with poor storage quality.

If heavy fertilization rates are indicated by soil tests, the material should be incorporated thoroughly throughout the plow layer or, if banded, placed 15 cm to the side of the row.

Minor element deficiencies, particularly zinc and copper, may be encountered. Suggested corrective rates are 11 kg/ha of zinc or 17 to 28 kg/ha of copper, applied every 2 to 3 years. Relatively high levels of sulfur are utilized by onions, but corrective applications vary widely, according to soils, leaching losses, and presence of sulfur contaminants in the atmosphere. If applied, sulfur will acidify the soil, and therefore, liming rates should be adjusted accordingly.

Similar fertilizer ratios are recommended for green onions; however, due to short growing period, the application rates would be reduced.

As seeds germinate, the cotyledon first appears as an "elbow" or "knee" as the shoot tip remains in the seed testa while the seedling elongates. It then pulls the seed above ground, and the first true leaf breaks through the capillary sheath.

Irrigation and weed control

Onions require uniform moisture throughout the growing season. Fields that suffer a growth retardation may produce excessive numbers of doubles or splits, reducing the number of Grade 1 bulbs. Furrow irrigation is generally used. Light sandy soils are irrigated with overhead systems or by subsurface seep irrigation where the soil profile allows. Onions at the bulbing stage utilize substantial amounts of water, although excessive moisture must be avoided during the growing season.

Onions are not good competitors with weeds. Cultivation, if used, must be shallow to avoid root damage, and growers usually favor chemical control. Pre-emergent broadcast applications of DCPA or one of several organic compounds have been used with some success.

Cultivars

At one time, all onion cultivars were open pollinated, and many of these cultivars are still offered by seed companies. The discovery of male sterility in onion led to a rapid change to F_1 hybrids, possible due to the simplicity and low cost of seed production. Male sterility is a genic-cytoplasmic factor, and male fertility can be restored in plants carrying the sterility factor by introducing a single dominant allele. Any line carrying the sterile trait must be cross-pollinated, and seeds harvested from male sterile plants isolated with a normal pollen-bearing parent will be hybrid seed. Hybrids have higher yield, larger and uniform bulb size than open pollinated cultivars.

The bulb onion cultivars are grouped into short, intermediate, and long-day types. Short-day onions (12- to 13-h threshold) are generally mild, soft fleshed, and unsuitable for storage. Long-tray onions (over 14'/2-h threshold), if grown in the lower latitudes, would not form bulb, and only green onions would be produced. In contrast, short-clay types grown in the higher latitude bulb very quickly and will be little more than sets in size.

Short-day onions include the Bermudas and Grano-Granex types; long-day cultivars include yellow, white, and red globes. The intermediate-day cultivars (13 '/2 - 14-h threshold), also relatively soft fleshed and used primarily for the fresh trade, are grown in areas of mild temperatures (lying between 32 and 38° latitude).

Classification **of onion cultivars**

Daylength	Scale color	Pungency	Representative cultivar
Short	Brown	Sweet	Awahia"
	Red	Sweet	Red Granex
	Red	Pungent	Red Creole', Tropical red varieties
	White	Sweet	White Granex, Crystal Wax'
	Yellow	Sweet	Grano", Granex
	Yellow	Pungent	Yellow Creole"
Intermediate	Brown	Moderate	Cochise Brown"
	Red	Moderate	Stockton Early Red"
	White	Moderate	Fresno white"
	Yellow	Moderate	Rialto
Long	Brown	Pungent	Australian Brown"
	Red	Pungent	Carmen, Southport Red Globe"
	White	Pungent	White Lisbon", Ivory"
	Yellow	Sweet	Fiesta, Sweet Spanish"
	Yellow	Pungent	Autumn Spice, Downing Yellow Globe"

" Open-pollinated cultivar.

True pearl onions are classified as *Allium mnpeloprasum* (Ampeloprasum Group) because they form just one storage leaf. In practice, short-day onion cultivars, such as `Grano', `Crystal Wax', and others, grown in northern latitudes, will develop pearl-size bulbs and be marketed as such. Most- are used in pickling or in frozen mixtures of peas, broccoli, and other vegetables.

Green onions, scallions, and multiplier and bunching onions are all used in the immature stage. Green onions generally are bulbing type white cultivars harvested at the miniature bulb stage. Scallions are white cultivars of *A. cepa* that do not form bulbs. Multiplier onions are cultivars of *A. cepa* of Group Aggregatum with white flesh and yellow or brown scales. These are distiguishable from the shallot by the latter's red scales and supposedly delicate flavor. The shallot can be used both in the immature stage and as a dry bulb. A cross of shallot, susceptible to pink root, with resistant *A..frstu/osun:* gave rise to the tetraploid cultivar `Beltsville Bunching'. *A. fstuloszmr* includes the bunching onions, termed as Japanese bunching onion or Welsh onion.

Management of disease and insect pests

Diseases: Both field and storage diseases reduce profitability. Field diseases include Stemphylium blight, purple blotch, anthracnose, smut, downy mildew, pink root, smudge, leaf blight and several basal rots. Storage diseases include some of the common field rots, black mold, botrytis neck rot, and bacterial soft rot.

Purple blotch: Purple blotch *(Alternaria porn)* attacks onion, garlic, shallot and other *Althorn* crops. Initially, small white sunken spots develop on the leaves. These enlarge, become zonate and under moist conditions, turn purple. These are also prominent on the inflorescence stalks. Infection can cause a semi-watery rot of necks of bulbs which turn yellow-red in color, bulb tissues eventually become papery. This pathogen is wide spread. The optimum temperature for disease development is 21 to 30°C. Therefore, it is most serious in hot humid climate where severe crop losses, of upto 50% in seed crop yield have been reported.

The fungus is seed-borne, but the relevance of this phase in initiating disease out breaks in hot climates is not well documented. Infected onion debris was implicated as an infection source.

Host-plant resistance is yet to be exploited. Some cultivars appear to be less susceptible e.g. cv. Red creole. Taliana Red in Hungary is reported to be resistant.

Cultural control methods include long rotations with unrelated crops and good drainage. Lowering the density of transplanted crops reduced infection, as did the application of high rates of calcium superphosphate and potasium fertilizer. Nitrogen fertilizer at low and high rates increased disease. Routine (7 —d interval) field sprays with dithiocarbamate fungicides, particularly mancozeb and chlorothalonil have been reported to be effective.

Stemphylium leaf blight: This disease is caused by *Stemphylium vesicariarm,* and has been reported from Europe, Africa, North and South America and Asia. Foliage losses of 80 to 90% have been reported. Disease symptoms are very similar to purple blotch. Lesions are light yellow to brown, water soaked, and progress from the tip to the base of leaves. As conidia develops lesions turn light brown to tan and blacken. The conidia have upto six transverse septa, besides several vertical septa. Wet and warm conditions favor the disease spread. Control measures are similar to purple blotch.

Collectotrichuzn blight: It is caused by *Colletotrichum gloeosporioides.* The disease favors hot (24 to 29°C) and wet conditions.

The disease overwinters in sets and soil, and spores are spread by wind, splashing water and tools. The leaves become twisted due to infection.

Downy Mildew: Downy mildew *(Peronospora destructor)* also attacks young plants, appearing as white specks, usually confined to the oldest leaves of young plants. A white mold develops rapidly in cool clamp weather and progresses down the sheath, and plants eventually fall over and dry up. The fungus overwinters in bulbs and sets and on plant debris. Spores are carried long distances by air currents. For control, young plants can be treated with mancozeb at weekly intervals until bulbing begins.

Botrytis Leaf Blight: Leaf blight, commonly termed blast, is caused by several.Botytis species. The disease first appears as white specks on leaves, expanding to cause a dieback from the leaf tips. Tops may be killed completely within a week, and entire fields may be affected. Frequently, blight follows previous damage from insects, disease, mechanical damage, or air pollution. Control is achieved through mancozeb sprays at approximately 7-day intervals.

Bulb Rots: Several rots may occur either in the field or in storage. Basal rot, caused by *Fusarium* species, results in a breakdown of inner scales. Outwardly, the bulb may appear normal. It eventually becomes soft, however, and will develop a water rot under moist conditions or a dry shriveled bulb in a dry environment. The disease is most severe in warm areas with poor soil drainage. *f3onytis* neck rot is an extension of the leaf blight disease and can become serious in storage.

Thrips *(Thrips /abaci)* are minute insects that cut or "rasp" the epidermis of leaves or stems and suck the plant sap, resulting in white blotches on leaves. Severe infestations result in leaf blasting and collapse. Bulbs become distorted and undersized. Infestations are more severe in dry seasons than in moist, and entire fields may be destroyed. The insect has many host plants, and adults and nymphs overwinter on plants or plant debris or in weeds bordering the field. Most of the insects are female, which can reproduce without a male. Eggs are thrust into the leaves and will hatch in 5 to 10 clays.

Diazinon spray at 7-10 clay intervals is recommended to control thrips. Up to six applications may be necessary, and good coverage is essential.

Harvesting and preparation for market

Onions are ready for harvest when the leaves collapse. For storage, onion tops should have broken over before harvest and the necks should collapse and dry. Storage bulb maturity can be accelerated by withholding irrigation water or by pruning the root system. Bulbs for storage may be harvested when 50 percent or more of the tops have broken over, but the bulbs must be cured and dried thoroughly before being placed in storage. Bulbs intended for immediate use can be undercut when 15 to 25 percent of the tops are down.

To harvest, first a knife or lifter is drawn under a bed or row, cutting roots and loosening the soil. Then the bulbs may be dug or allowed to cure further before digging. Under dry conditions, bulbs may be left to cure in the field, either in place or in windrows. To avoid damage from direct sunlight, however, onions normally are placed in field containers and moved to a dry, shady location for subsequent curing.

Curing

The purpose of a curing period is to allow natural dormancy to develop and to dry the onion sufficiently. A properly cured onion will have a dry shrunken neck and dry outer scales. The respiration rate of cured bulb is lower than that of an uncured bulb. Fully mature bulbs are harvested and cured by exposure to temperatures up to 35°C in low (less than 50 percent) relative humidity. Air movement must be provided at the rate of 1 ft'/min per cubic foot of onions (60 m^3/h per cubic meter of onions). Immature onions require twice the rate of air exchange.

Following curing, the temperature of stored onions is lowered gradually to 0°C, or slightly higher, with the relative humidity at 60 to 70 percent. Air exchange in the storage facility is important to prevent any condensation on the bulbs. Also, when the bulbs are removed from storage, they should be conditioned for several days at 20°C and 50 percent relative humidity.

The tops and roots are removed during harvest. When this is not possible, they should be removed after curing, before storage or sale.

Storage

Freshly harvested onions are dormant and will not sprout for a variable period of time (depending on cultivar). Storage will prolong this dormancy. Sprouting will increase in storage temperatures above 4.4°C, decreasing again as temperatures exceed 25°C. To reduce the frequency of sprouting after the rest period, onions may be field treated with maleic hydrazide (MR-30) at 2.2 to 3.4 kg/ha when the tops are still green but beginning to senesce.

Cultivars intended for long-term storage should be firm with a thin dry neck, free from greening, root growth, sunburn, or freeze damage, and well covered with dry scales. Bulbs with fleshy, soft necks are susceptible to persistent rot, especially if storage humidity exceeds 70 percent.

Flavor in onion is associated with pungency (propyl disulfides and other disulfides) and with sugars (glucose, fructose, sucrose). Both sugar content and pungency are related to percentage dry matter. Short-day and long-day types differ in their flavor. Pungency and dry matter content are important quality attributes in onions for processing.

Marketing

Onions normally are shipped in 22.7 kg mesh bags. The bulbs are graded by size, with jumbo and pearl sizes frequently used by processors. Those intended for international trade are packed in 25 kg bags.

Green onions are pulled before bulbing, when the basal diameter exceeds 6 mm, and the roots are trimmed near the base. They should be washed free of soil. Discolored stalks are discarded. The green onions are bunched and packed in ice to preserve crisp texture and quality. Vacuum cooling is possible but requires prevvrapping in ventilated polyethylene bag to retard wilting. Storage life of green onion is limited to approximately 1 week at 0°C and 90 to 95 percent relative humidity.

Shallots are harvested by hand when the bases are at least 6 mm in diameter. The outer leaf is stripped off and the roots are trimmed before washing and bunching. If grown for dry bulbs, they are handled in a similar manner as onion bulbs.

SEED PRODUCTION IN ONION

Introduction

The seed producing area should have low humidity, mild cool temperature during initial growth, followed by increase in temperature at later stages of the crop. While onion is in flower, clear, bright days are necessary to ensure insect activity for pollination.

For seed producton, the onion bulbs are harvested, stored for sometime and then replanted in proper season for seed production. Mother bulbs are grown in the same way as the crop for market and are stored in well ventilated storage houses. Generally medium sized bulbs are selected for planting for seeds. About 1500 kg of bulbs are required for planting one hectare area for seed crop. Bulbs are planted in the month of October. The spacing depends on the size of bulbs, however, the ideal spacing is 50 cm between the rows and 20 cm within the rows. Fertilizer doses and plant protection measures are same as in bulb crop.

Isolation distances

Onion being a highly cross pollinated crop, having insects as main pollinating agents, needs large isolation distances to maintain purity of the variety. About 2 km distance between cultivars gives fair isolation. Cultivars of different colors should be planted at least 3 kin apart.

Harvesting and seed extraction

Although all the seed heads do not mature simultaneously, there is usually only one cutting. This should be made sufficiently early to avoid shattering of seeds but on the other hand sufficiently late to obtain well ripen seeds. The seed heads are cut 10-15 cm of stem attached. The cut seed heads are dried in the sun. When the seed heads are completely dry these are threshed and seeds are collected after cleaning.

Seed yield

Seed yield generally vary with the cultivation season, soil type, location, pollinating insect activity and production methods. A yield of 500 kg to 600 kg seeds/ha is considered as average. But under favourable conditions yields upto 2000 kg/ha can be achieved.

Production of hybrid seeds

(i) Male sterility

Utilization of Gene-cytoplasmic male sterility has been a great help in the hybrid seed production in onion.

Gene-cytoplasmic male steility: In onion gene-cytoplasmic male sterility is being used extensively for the production of hybrid seeds. In this male sterility system there is an interaction between nuclear and cytoplasmic genes. The nuclear sterility is governed by single recessive allele `ins ms' while its dominant allele 'MsMs' is for male fertility. Similarly there is a sterile cytoplasm, `S' and the normal cytoplasm, N. The genetic constitution of male sterile plant is Smsms, having sterile cytoplasm `S' and recessive allele `msms' for sterility. The other genotypes like SMsMs, SMsms, N MsMs, NMs ms and Nmsms are all male fertile.

Development of parental lines: Three parental lines namely A, B and C are needed for hybrid seed production. The line A, used as female parent is male sterile having the genetic constitution of Smsms and used for the production of hybrid seed. The line B with the genotype N msms, is a male fertile and used as the maintainer line for the line A. Line C is the fertile pollen parent or inbred which is genetically diverse from the lines A and B. The lines A and B are genetically identical except that the former is male sterile while the latter is male fertile. The male sterile line A is maintained by crossing with the line B. Hybrid seed is produced by crossing line A and C.

(ii) Developing **lines A and B**

Four different methods.can be used for the development of lines A and B.

(1) The most common and simplest method is by back crossing the male sterile plants (Smsms) to the male fertile plants of the genotype Nmsms of the variety from which the lines A and B needs to be developed. The male sterility genes have been found widespread in onion cultivars collected from many parts of the world. In many cultivars, plants of Nmsms types can be detected by a suitable test cross. For this purpose 10 plants are selected at random in the population of a particular cultivar and each of them is crossed with male sterile plant. The progenies of some of these crosses will be male fertile while some others will be male sterile. The plants which produced male sterile progeny should have the genetic constitution of Nmsms. Such Nmsms type should be selected and selfed for maintenance. By repeated back crossing of male sterile plants to Nmsms plants, it will be possible to develop a male sterile line of the desired cultivar. After 5 or 6 backcrosses the line A (Smsms) will become genetically identical to line B (Nmsms) except for the male sterility.

(2) When all the plants in a cultivar has the genetic consititution of NMsMs, ms allele can be incorporated. The plants of Nmsms genotypes can be developed by using following method.

(a) Cross these male sterile plants (Smsms) with the fertile plants (NMsMs). F_1 plants will be fertile with the genotype SMsms.

(b) Cross these male fertile F_1 plants (SMsms) with fertile NMsMs using SMsms as pollen parent. The progeny of the cross will be male fertile, and will have two genotypes NMsMs and NMsms, which can be detected by progeny test. Cross some of these plants with male sterile plant and test their progeny. There will be two types of progenies, one in which all the plants will be male fertile, while in the other, half of the progeny will be male fertile and half male sterile. In the former case the plants are of NMsMs genotype and in the latter they are of NMsms.

(c) On selling the NMsms plants three types of progenies are observed i.e. NMsMs, distinguished by a progeny test after crossing with the male sterile plant. The Nmsms plants can be easily detected as only these will produce all male sterile progeny when crossed with male sterile plant (Smsms).

(d) After obtaining the require B line (Nmsms) through backcrossing genetically identical A & B lines could be developed differing only in male sterility trait.

(3) Naturally occurring male sterile plants in the commercial fields can be crossed with the fertile plants of the same cultivar to test and develop the plants of genotype Nmsms. After obtaining the plants of genotypes Nmsms, they can be backcrossed with male sterile plants (Smsms) to produce A and B lines by backcrossing.

(4) A and B lines can also be developed from the seeds of commercial cultivars (F_1 hybrids). The F_1 hybrid plants are checked for fertility. If the F, plants are all male sterile it can be presumed that the F_1 hybrid was obtained by crossing the lines A (Smsms) and B (Nmsms). If the F_1 hybrid plants are fertile it indicates that F_1 hybrid was produced from a cross of A (Smsms) and C (NMsMs), and the genetic constitution ofF_1 hybrid will be S Msms. On selling it will produce the ratio of 3 male fertile and one male sterile plants (Smsms). The male sterile plant can be used for developing plants are checked for fertility. If the F_1 plants are all male sterile it can be presumed that the F_1 hybrid was obtained by crossing the lines A (Smsms) and B (Nmsms). If the F_1 hybrid plants are fertile it indicates that Fl hybrid was produced from a cross of A (Smsms) and C (NMsMs), and the genetic constitution of F_1 hybrid will be S Msms. On selfing it will produce the ratio of 3 male fertile and one male sterile plants (Smsms). The male sterile plant can be used for developing A and B lines by backcross.

(iii) Development of `C' line

The pollen parent or C line can be developed by inbreeding of plants in a promising cultivar for some generations to achieve uniformity. The C line is genetically diverse from A and B line, and it is necessary to test the combining ability of the C line before producing F_1 hybrids.

(iv) Production of hybrid seeds

The hybrid seed is produced in the open in an isolated field. The bulbs of A (male sterile) and C (Pollen) lines are planted alternately in a ratio of four rows of A line to one row of C line. Sometimes 8 rows of A lines are alternated with 2 rows of C lines. The flowering in A and C lines must synchronize. If it does not, it can be accomplished by adjusting planting dates of-line A and C. In large fields it is useful to keep about 3 or 4 bee-hives per 0.40 ha to ensure good pollination. Gene-cytoplasmic male sterility has been used successfiillly in onion; carrot, radish, cabbage and pepper.