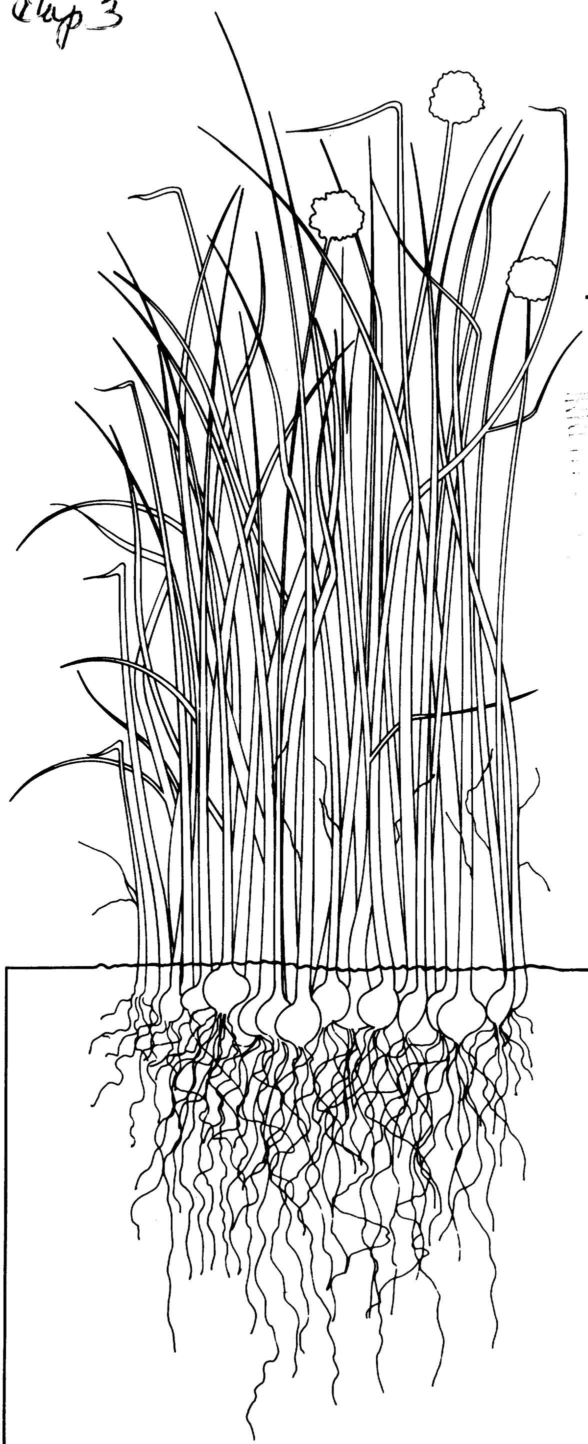

Wild Garlic Life Cycle And Control

United States
Department of Agriculture

Agricultural Research Service

Agriculture Information
Bulletin No. 390

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WILD GARLIC
Life Cycle and Control[1]

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Wild garlic (*Allium vineale* L.) is a troublesome weed in the United States. Significant losses result from the "onion" odor and flavor that wild garlic gives to milk, small grains, and meat products. Other common names that have been used for *Allium vineale* L. are field garlic, meadow garlic, garlic, onion, crow garlic, wild onion, and vineyard garlic (*3,27*)[2]

ORIGIN AND DISTRIBUTION

The geographical origin of wild garlic is difficult to determine. It probably originated in the area of the Mediterranean Sea (*18*).

Wild garlic is found in many areas of the world. It has spread throughout western and central Europe and is found as far north as southern Norway, Sweden, and Finland and east to the Dneiper, Crimea, and Transcaucasian regions of the USSR (*13,31*).

It is rare in Austria; is fairly common in Hungary, Italy, Spain, and Portugal (*12*); and has been reported in North Africa and the Canary Islands (*12*). Wild garlic has spread from Europe to Australia (*2*), New Zealand (*38*), and the United States. It is particularly troublesome in Sweden, England, and the United States (*13,20,27,28*).

Wild garlic was probably introduced into the United States from France in the 17th or early part of the 18th century (*3,15*). After being introduced into the United States, it became a serious weed problem. Pipal cited a report showing that as early as 1754, in Philadelphia, an infes-

[1] Prepared in cooperation with Missouri Agricultural Experiment Station (Journal Series No. 7203).

[2] Italic numbers in parentheses refer to Literature Cited, p. 21.

tation of wild garlic in a wheatfield was so heavy that one garlic head was present for every nine heads of wheat (*28*).

Wild garlic has continued to spread and now infests a large part of the United States. It grows as far south as Georgia, Mississippi, and Arkansas; and as far north as Massachusetts, New York, Ohio, and Michigan (*10*). It is a serious pest on the eastern seaboard and west to Kansas and Oklahoma (*30*). Wild garlic has been mentioned as the cause of garlic-flavored milk in Wyoming (*6*). Infestations also are present in western Oregon and Washington.[3]

PLANTS THAT RESEMBLE WILD GARLIC

In the United States, wild garlic sometimes grows in association with such other bulb formers as *Ornithogalum umbellatum* L., *Allium oleraceum* L., *A cernuum* Roth, *A. mutabile* Michx., *A. canadense* L., *Hemerocallis fulva L.*, and *Zigadenus nuttallii* Gray.

The terms "wild garlic" and "wild onion" are often used interchangeable for many of the bulb formers. In the United States, the species most commonly found with wild garlic are wild onion (*A. canadense* L.) and star-of-Bethlehem (*Ornithogalum umbellatum* L.).

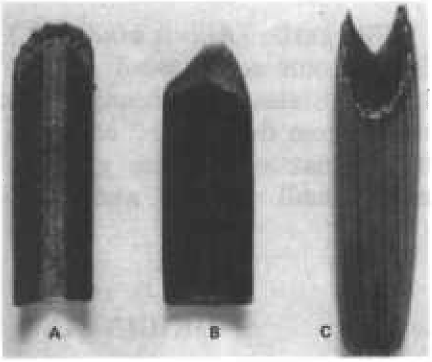

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Figure 1.—**Cross sections of leaf blades of star-of-Bethlehem, wild onion, and wild garlic: A, leaf of star-of-Bethlehem showing white striation at the center of the solid flat leaf; B, flat solid leaf of wild onion; C, round, hollow leaf of wild garlic.**

Wild garlic can be distinguished from wild onion and star-of-Bethlehem by its striate, nearly round hollow leaves (fig. 1, C), which are attached at the lower half of the plant. Wild onion and star-of-Bethlehem have their solid flat leaves attached at the base of the plant. Moreover, wild garlic has underground hardshell bulbs, which are absent on wild onion and star-of-Bethlehem. Also, the old bulb coat of wild garlic is thin and membranous, but the coat of wild onion is fibrous matted. Star-of-Bethlehem does not have the "onion" odor of wild garlic or wild onion.

The wild onion, like wild garlic, begins growth in mid-August or early September and matures in

[3] Personal communication from Dr. Marion Ownbey, Dept., of Botany, Wash., State Univ.

late May or early June. Wild onion grows 1 to 2 feet tall. It has flat leaves (fig. 1, B), which arise from the base of the plant.

Star-of-Bethlehem often is planted as an ornamental and then spreads to lawns, gardens, yards, and waste places. It begins growth soon after the ground thaws in early spring. Small, showy white flowers appear, and then the plants mature and disappear before warm weather. Star-of-Bethlehem seldom grows over 8 inches tall. It has flat leaves, which have a white stripe down their center (fig. 1, A). The leaves arise from the base of the plant.

DESCRIPTION AND GROWTH HABIT

Classification

Wild garlic is a bulbous perennial monocot that has classically been included in the Liliaceae family. However, Hutchinson (*14*) includes *Allium* in the Amaryllidaceae family. He considers the umbellate inflorescence to be of greater taxonomic importance for classification than the character of superior or inferior ovary, which is usually used to distinguish Liliaceae from Amaryllidaceae. Other workers support his views (*5,26*).

Five varieties or forms of *Allium vineale* L. have been described in the United States (*15*). These are (a) *forma typicum* Beck, with a loose umbel containing both aerial bulblets and flowers; (b) *forma compactum* Thuill, with a compact head consisting only of aerial bulblets, which are greenish or whitish; (c) *forma fuscenscens* Ascherson and Graebner, with a head containing reddish bulbils; (d) *forma crintium* Jacob, with bulbils on the head tipped with long, green, capillary appendages; and (e) *forma capsuliferum* Koch, with a umbel consisting of flowers only.

Three forms of wild garlic have been identified in England, but their status as varieties has been questioned by Richens (*31*). Transitions between forms are often noted, and they appear to be dependent upon Mendelian allelic genes (*15*). Most *Allium* species have 16 chromosomes, but *Allium vineale* L. has 32 chromosomes, a number that indicates that *A. vineale* L. is tetraploid (*15*). Apogamy is a common occurrence in *A. vineale.*

Iltis (*15*) also observed what he thought to be genetic differences in color of aerial bulblets. Seed from plants with purple bulblets produced plants with purple leaf sheaths and seed from plants with green bulblets produced plants with green leaf sheaths.

Structure of the Wild Garlic Plant

Wild garlic looks much like cultivated onion. Figure 2 shows a clump of wild garlic as seen

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***Figure 2.*—A typical clump of wild garlic in the spring, showing growth habit and plants of various sizes. The larger upright plants are scapigerous and the smaller plants are nonscapigerous.**

in spring. The leaves, two-ranked, have sheathing bases. The leaf blades are circular in cross section and hollow.

The outer layers of a bulb of a growing wild garlic plant are formed from the sheathing bases of the foliage leaves.

Plant Types

Wild garlic consists of two plant types — scapigerous and nonscapigerous. The larger, scapigerous plant bears a scape, which produces aerial bulblets (fig. 3) and sometimes flowers (fig. 4).

The flowers have a greenish to purple perianth with lanceolate to elliptic segments. The segments are obtuse to acutish and about

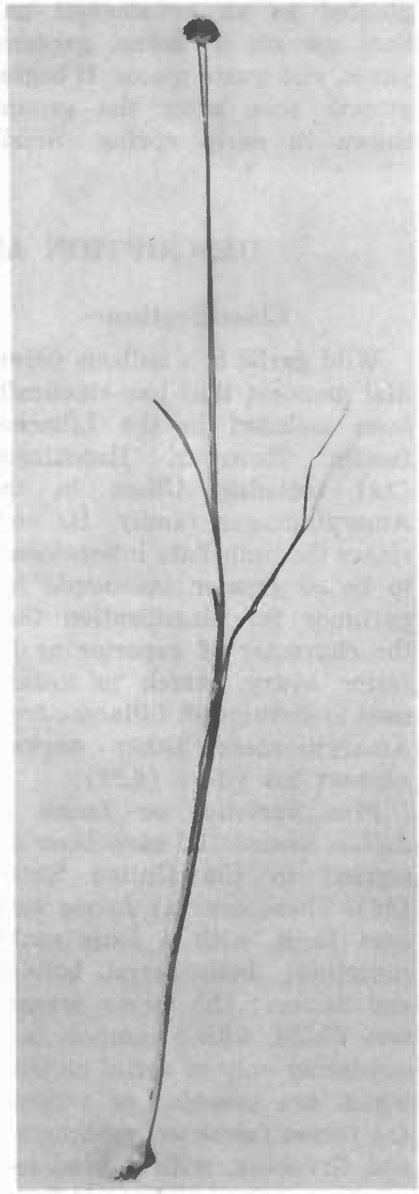

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***Figure 3.*—Scapigerous garlic plant as seen at maturity in June.**

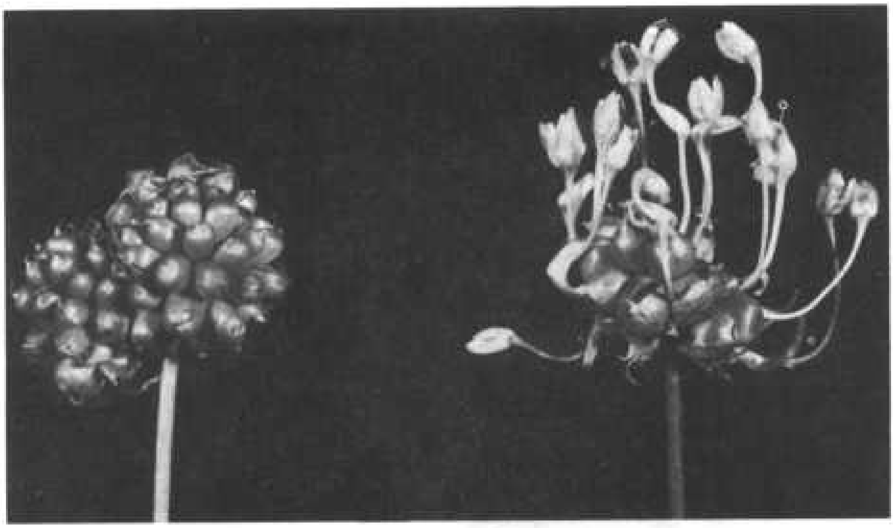

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Figure 4.—**Umbels on scapes of wild garlic. The umbel on the left is a double umbel (single umbels are more common but plants may have as many as three or four) with aerial bulblets only. Umbel on the right contains bulblets and flowers (less common).**

as long as the stamens (*10*). Seeds of the scapigerous plant are black, flat on one side, and about one-eighth inch long.

The number of scapigerous plants varies in a wild garlic stand. Under conditions in the British Isles, Richens observed that about 30 percent of the wild garlic population consists of scapigerous plants in any one season (*31*). The rest of the population was made up of nonscapigerous plants (fig. 5), which are shorter and less conspicuous than the scapigerous plants.

Nonscapigerous plants have slender foliage and fewer leaves and do not produce a scape at the end of the growing season.

Bulb Types

Four types of bulbs can be found on wild garlic at the end of a season's growth in late spring. In naming bulb types, the system of nomenclature suggested by Davis and Peters (*7*) will be used in this publication.

Aerial bulblets

As many as 300 aerial bulblets (fig. 6, A) may be formed on the scape of a scapigerous plant (fig. 3).

The bulblets develop within a spathe (a large, dry, thin, membranous bract) at the top of the scape. The spathe contains no green color and remains closed until near maturity in late spring.

PN–4412

Figure 5.—**The nonscapigerous plant as seen at maturity in May. These plants usually mature about a month earlier than the scapigerous plants.**

Then the spathe bursts, exposing aerial bulblets and flowers.

The aerial bulblet consists of a fleshy, cone-shaped scale containing a growing point at its base. The fleshy scale is a bladeless storage leaf. Surrounding the storage leaf is a protective scale consisting of two or three cell layers. The protective scale is a bladeless leaf in most cases, but it may include a blade, which was referred to by Iltis (*15*) as an appendage.

Iltis (*15*) describes three forms of aerial bulblets found in Virginia, each form appearing in a separate head. One form of bulblet is whitish or yellowish with pointed, greenish, or purple tips that are bent slightly to one side. The second form is dark purple without appendages. The third form of bulblet has green appendages that are 2 to 3 inches long. The appendages, or leaf blades, are usually fully developed within the spathe before it bursts.

Barnes[4] showed that the formation and length of appendages could be altered by temperature. When wild garlic plants were grown continuously at 70° F under a 12-hr daylength, the outer protective leaf of the aerial bulblet developed a long appendage that continued to grow and the aerial bulblet developed roots and became an independent plant. If the plants were grown continuously at 50° under a 12-hr daylength, no appendages developed. But when plants were exposed to temperatures of 50° or lower and then grown at 70°, short appendages developed, but these dried up as the plant matured.

Hardshell bulbs

The second most numerous type of bulb is the hardshell bulb (fig. 6, B). Larger than aerial

[4] Barnes, Donald L. Effects of Environment and a Growth Substance on Development of Wild Garlic (*Allium Vineale* L.). (Ph.D. Dissertation, University of Missouri. 1970.)

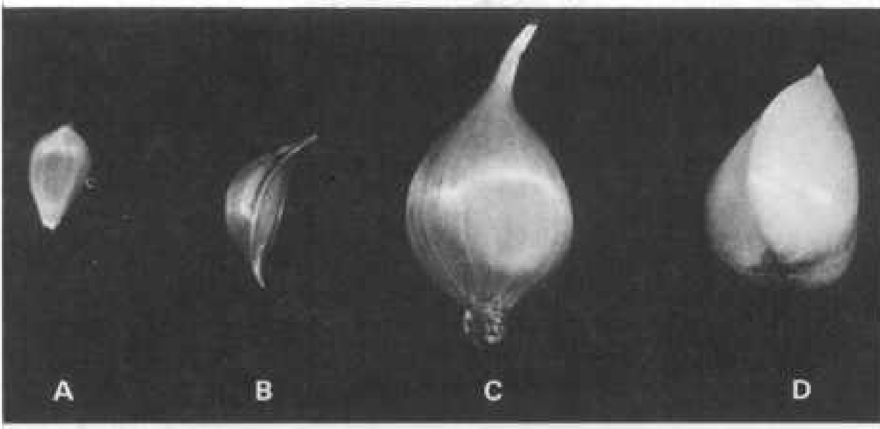

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Figure 6.—**The four bulb types of wild garlic: A, aerial bulblet; B, hardshell bulb; C, central bulb; and D, soft offset bulb.**

bulblets, hardshell bulbs have a single bladeless storage leaf that contains a growing point at its base. The storage leaf is surrounded by a bladeless leaf that forms a hard protective shell.

Hardshell bulbs are formed underground in the axils of the outer leaves of scapigerous and nonscapigerous plants (fig. 7).

The hardshell bulb is the only bulb type that is produced by the scapigerous and nonscapigerous plants.

Central bulb

The central bulb (fig. 7, B) is formed underground by nonscapigerous plants and is conspicuous at the end of a season's growth. It is formed around the main axis of the plant. The central bulb, circular in cross section (fig. 6, C), varies from the small size of an aerial bulblet up to that of a soft offset bulb.

The structure of a central bulb is similar to other bulb types. However, it sometimes does not have an outer protective scale and is surrounded only by the withered bases of foliage leaves. When the outer scale is present, it is prolonged into a sharp terminal point.

Soft offset bulb

The soft offset bulb (fig. 7, D) is formed underground in the axil of the innermost leaf of the scapigerous plant. It is similar in structure to the other bulb types and usually is the largest of the four types. It is ovate in longitudinal section and has a convex abaxial face and a flat adaxial face, which form two distinct ridges where the faces meet (fig. 6, D). The ridges tend to clasp the sides of the flattened scape to which they are attached.

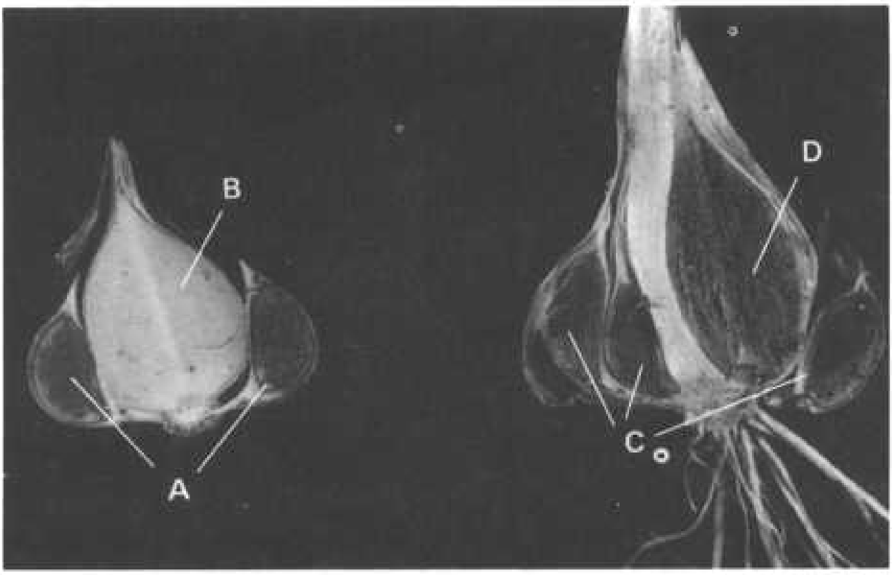

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Figure 7.—(Left) **Longitudinal section of the base of a mature nonscapigerous plant showing (A) the hardshell bulbs and (B) the central bulb.** ***(Right)*** **Longitudinal section of the base of a mature scapigerous plant showing the positions of (C) hardshell bulbs and (D) a soft offset bulb.**

REPRODUCTIVE CYCLES

Figure 8 shows the reproductive cycles of wild garlic.

Each type of bulb is capable of producing either a scapigerous or a nonscapigerous plant. The nonscapigerous plant produces one central bulb and sometimes one or two hardshell bulbs at maturity. The scapigerous plant produces seed and aerial bulblets above ground plus one soft offset bulb and one to six hardshell bulbs below ground.

Production of seed is insignificant in most garlic habitats, except near the southern limits of its range in the United States where wild garlic may produce abundant viable seed (*15,34*). In Virginia and Delaware, for example, seed production is common (*1,15*). When seeds are produced, they usually are viable (*13,15*). Garlic seeds are produced in the spring and germinate the following fall. Seedlings evidently are nonscapigerous; they develop only one small bulb during the first year (*15*).

Wild garlic is usually spread by bulbs rather than by seeds. Aerial bulblets are more numerous than other bulb types, and therefore, are responsible for most of the dispersion of wild garlic.

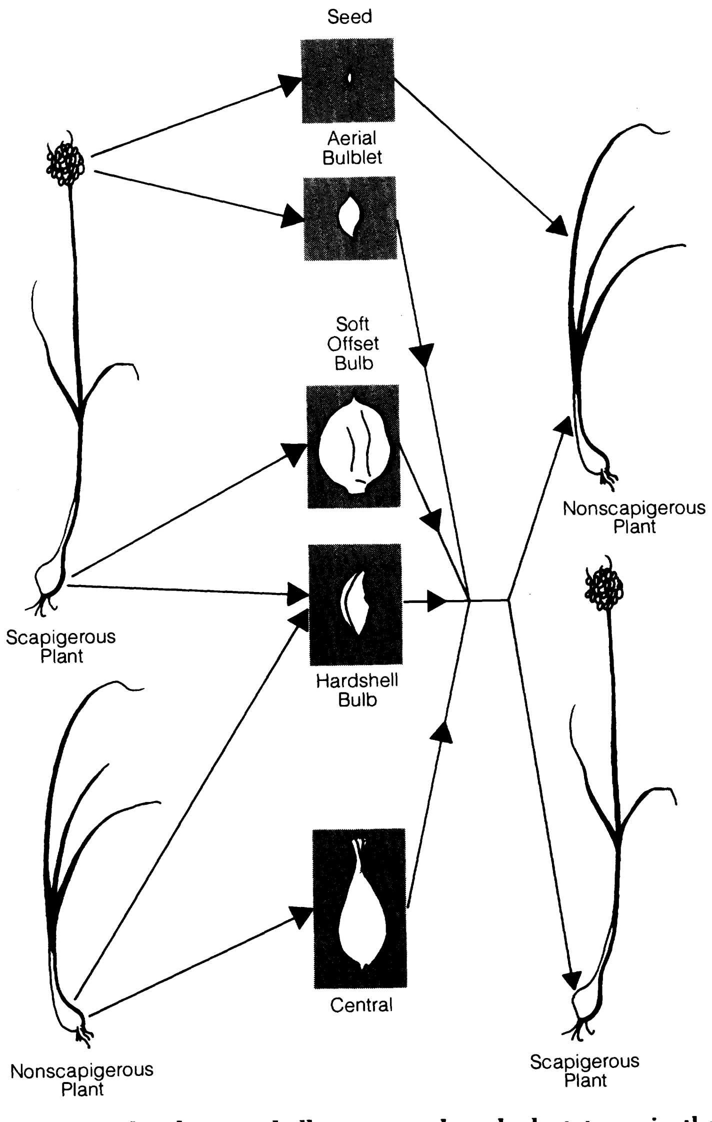

Figure 8.—**Relationship between bulb types, seed, and plant types in the reproductive cycles of wild garlic. The bulb types will give rise to either a scapigerous or nonscapigerous plant. Seed will give rise to a nonscapigerous plant the first year and give rise to either type of plant later. Refer to figure 7 for location of the underground bulbs for each type of plant.**

Aerial bulblets that complete growth in spring (May and June) sprout the following fall. Plants developing from aerial bulblets may produce scapes (*19*), but they usually produce nonscapigerous plants that develop only leaves above ground.

The growth of the nonscapigerous plant is unique because it terminates a season's growth with the formation of one central bulb containing a stem apex and sometimes two hardshell bulbs in the axils of the foliage leaves (fig. 7). In Missouri, development of central bulbs first becomes apparent in early winter and development of hardshell bulbs usually becomes apparent in February or March. Figure 9 shows a longitudinal section of the basal portion of a growing nonscapigerous plant examined in April.

Plants developing from aerial bulblets may, in some instances, produce a scape, a soft offset bulb, and hardshell bulbs in one season. Freeman (*11*), in Kentucky, found that about 33 percent of the plants from aerial bulblets produced scape the first year.

Iltis (*15*), in Virginia, and Pipal (*28*), in Indiana, have reported that plants growing from aerial bulblets develop secondary bulblets at the base of primary bulblets in the fall, and the secondary bulblets grow into separate plants during the winter.

A development similar to this was described, but was shown to be growth from two bulblets located close together within the same covering leaf (*13*). Observation in Missouri has shown that frequently two bulblets can be found within the same covering leaf, giving the impression that only one bulblet is present.

Figure 10 shows the developmental stage of a growing scapigerous plant in April.

The first bulbs developed in the scapigerous plant are the hardshell bulbs, which form in the axils of the outer foliage leaves. Growth of the scapigerous plant is terminated with the formation of the spathe on the plant axis and the formation of one soft offset bulb in the axil of the innermost foliage leaf (fig. 10, B).

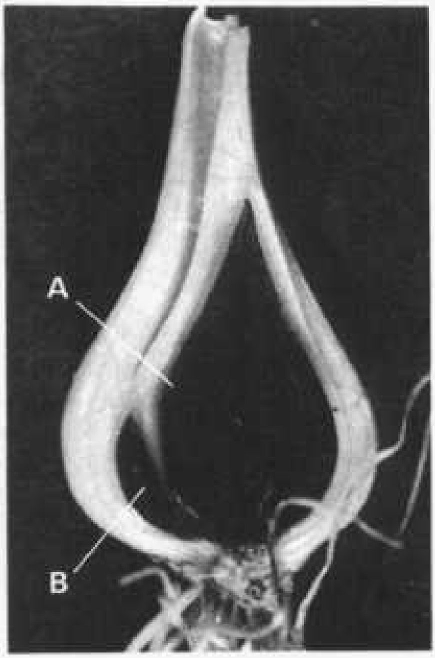

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***Figure 9*.—Longitudinal section of the base of a nonscapigerous garlic plant on April 15 showing the origin of the central bulb (A) and the hardshell bulb (B).**

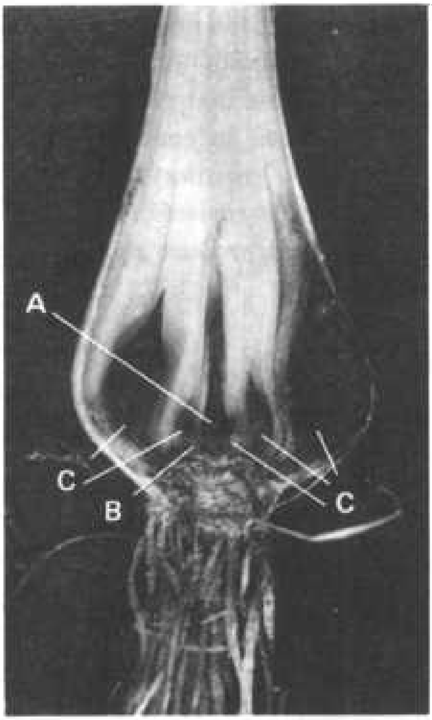

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Figure 10.—**Longitudinal section of the base of a scapigerous garlic plant on April 15 showing the origin of the scape (A), soft offset bulb (B), and hardshell bulbs (C).**

Central bulbs and soft offset bulbs start sprouting in early fall. These bulbs usually produce large plants, three-fourths of which produce scapes (*11*).

All types of wild garlic bulbs have a short after-ripening period following scenesence of the parent plant (*32*). In aerial bulblets, central bulbs and soft offset bulbs, anatomical changes occur during the after-ripening period which appear to be a maturation process similar to that occurring in seeds with immature embryos (*33*). During this after-ripening period from early June to late July, the root and leaf primordia elongate slowly. At the conclusion of the after-ripening period, primordia elongate rapidly. In hardshell bulbs, little or no elongation occurs during the after-ripening period until late August when about 20 to 35 percent of the hardshell bulbs break dormancy and sprout. Leaf and root growth in the remaining dormant hardshell bulbs essentially ceases, and these bulbs break dormacy slowly and some may remain dormant up to 6 years (*35*).

Sprouting of hardshell bulbs starts in mid-August or early September and nearly ceases by October or November. Studies in Missouri showed essentially no sprouting after November. However, many shoots of sprouted bulbs did not emerge from the soil until spring. Freeman and Kavanaugh (*12*) and Mitchell and Sherwood (*25*) reported that wild garlic was observed emerging from the soil in March and April.

Freeman (*11*) found that about two-thirds of the plants produced from hardshell bulbs were nonscapigerous the first year.

The mechanism that determines whether a bulb produces a scapigerous or a nonscapigerous plant is not known. Richens thought plant type is determined in the early development of the plant (*31*) and that it is associated with food reserve in the bulb. Planting of soft offset and central bulbs at depths of 4 inches or more reduces the number of scapes formed from these bulbs (*21*). All plants from bulbs planted 2 inches deep produced scapes, but only 76 percent of the plants from bulbs planted 4 inches deep produced scapes. Increasing the depth of planting to 8 inches decreased the percentage of scape-producing plants to 52 percent. This indicates that food reserves are consumed in emergence and that plants growing from great depths cannot replenish their food reserves and produce scapes.

WILD GARLIC: A PEST

Wild garlic contains allyl sulfide that has a disagreeable odor and imparts a garlicy flavor to agricultural products tainted with it.

Wild garlic is a poor competitor, and therefore, generally does not reduce crop yields, but it often persists under row-crop culture.

Because wild garlic is drought hardy, cold hardy, and tolerant to wet soils, it is found on poorly drained land along rivers and creeks, as well as on hillsides (*28,31*). Wild garlic grows in many types of soil (*17*), but it is best adapted to heavy soil (*31*).

Pest in Small Grains

Wild garlic is a pest of fall-planted crops and is especially troublesome in small grains, which have a similar growing season.

Aerial bulblets are present when small grains ripen and often are harvested with the grain. Harvesting bulblets with wheat that is used for flour is particularly objectionable because the bulblets taint the flour. Products made from garlicy flour usually retain the garlicy flavor.

Wheat is graded garlicy when two or more green aerial bulblets, or an equivalent of dry or partially dry bulblets, are present in 1,000 grams of wheat (*37*).

Aerial bulblets also have a high moisture content and when present in wheat, their moisture adds to the problems of milling the wheat.

Because wheat kernels and aerial bulblets are similar in size (fig. 11), the fresh bulblets cannot be removed from the wheat with conventional grain-cleaning equipment.

A garlicy odor remains in wheat even when the bulblets are removed.

However, when wheat containing aerial bulblets is stored for 6 months, the bulblets generally will be dry enough to remove with a fanning mill (*27*).

Artificial heat also has been used with some success for drying bulblets harvested with wheat (*28*).

Aerial bulblets float when wheat containing them is immersed in water, but the wheat then has to be dried. Drying makes the large-scale use of the

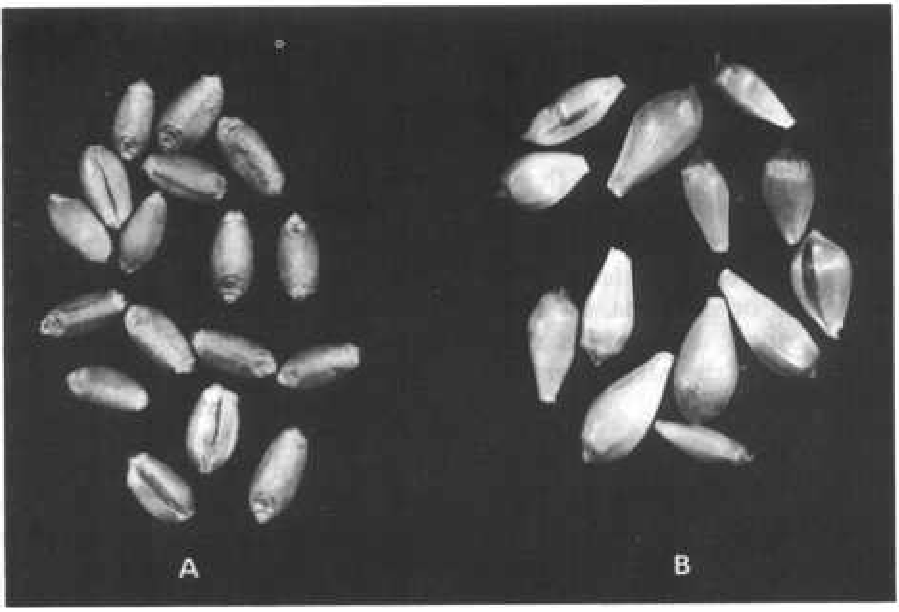

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Figure 11.—**Showing the similarity in size of A, grains of wheat, and B, aerial bulblets of wild garlic.**

immersion technique of removal impractical (*27*).

Investigations have been made to determine the effects of storage on germination of wheat containing aerial bulblets (*16*). Germination of wheat is not adversely affected by 7 months of storage and then most aerial bulblets are no longer viable In one test, however, some aerial bulblets remained viable for about 2 years (*16*).

Attempts to destroy the viability of aerial bulblets in wheat by rolling (crushing) also have been made (*16*). One rolling did not affect sprouting and two rollings only slightly reduced sprouting of aerial bulblets.

Pest of Pastures and Hay Fields

Losses from wild garlic probably are greatest in the dairy industry. Milk from cows grazed on garlic-infested pastures develop the garlicy flavors. Also, a small amount of garlic in the ration of dairy cows taints the dairy products made from such milk.

Arbuckle (*4*) stated that garlic was the main cause of off-flavor in milk in Maryland.

Many authorities believe that removing cattle from garlic-infested pastures for 3 or 4 hours before milking reduces or eliminates the flavor in milk (*4,6,27*). But Pipal (*28*) stated that off-flavor persisted in milk for several days after dairy cows were removed from garlic-infested pastures. He also reported that cattle grazed on wild garlic had garlic-flavored meat. In one case, the garlic flavor persisted in the meat of a cow that had been removed from a garlic-infested pasture 10 days before slaughter. Because of garlic infestations, many pastures cannot be used in fall or spring when the garlic is growing.

Pest Around Homes and in Noncrop Areas

Wild garlic is unsightly around homes and gardens, on roadsides, and in noncrop areas.

It also gives lawns a disagreeable odor. When heavily infested lawns are mowed, garlic odor becomes intense in the general area of the lawn, on the mower, and on the clothes of the person mowing the lawn.

Populations of wild garlic build up in lawns, gardens, and waste areas where they serve as sources of infestations to adjoining areas.

Wild garlic spreads from one place to another mainly through movement of bulblet-infested small grains, hay, straw, and manure. But all types of bulbs can be spread in soil moved during construction of buildings, ponds, terraces and roads.

Garlic infestations in lawns most often are the result of planting infested sod, but infestations may also result when infested soil is used for fill or when building is done on a garlic-contaminated site.

Spread of wild garlic seed and aerial bulblets by wind is of minor significance. Spread of aerial bulblets by water, on the other hand, probably accounts for widespread infestations on lands subject to flooding.

CONTROL AND ERADICATION

Where a few plants of wild garlic are found, eradication can be obtained by removing the plants and all underground bulbs. Because garlic bulbs are not killed by uprooting, they should be burned or destroyed by some other method that will kill the growing points.

Where wild garlic infestations are extensive, eradication is difficult. Central bulbs, soft offset bulbs, and aerial bulblets will germinate during the fall of the year in which they are formed, and most of these plants can be killed by repeated tillage or with several applications of herbicides. However, hardshell bulbs that remain dormant in the soil for as long as 5 or 6 years will continue to reestablish the garlic stand (*8*). This means that tillage or herbicide treatments may have to be continued for as long as 6 years or more to eradicate wild garlic.

Cultural Control

Wild garlic is not easily killed by tillage because it possesses a great deal of food reserves and reestablishes itself and resumes growth after tillage. Lazenby (*23*) evaluated the effects of tillage and disturbance on wild garlic growing in England. He found that plants with large bulbs remained green for 7 weeks when allowed to lie on dry soil exposed to high temperatures. The more frequently the plant was disturbed, so the roots were broken from the soil, the more the size of the plant was reduced.

Repeated pulling and replanting of growing plants reduced the number and size of underground bulbs (*23*). Plants that had originated from aerial bulblets were stimulated by one pulling in mid-March and increased in size. Uprooting the plants every 2 weeks and immediately replanting them over a 4-month period did not kill the plants, but yields of the underground structures were reduced.

The date on which a disturbance took place influenced the ability of the plant to recover (*23*). When disturbed on March 15, plants originating from aerial bulblets remained green for 4 to 5 weeks before death; but during this time, food reserves were exhausted in the production of new bulbs. Plants disturbed in April or June immediately transferred their food reserves into a small bulb varying from one-half to three-fourths of the size of the original bulblet.

Soft offset bulbs and central bulbs lying on the soil surface for 2 weeks began to shrivel, but some of these bulbs were still viable after 2 months (*23*). Hardshell bulbs attached to the dried soft offset or central bulbs seemed to persist.

Wild garlic bulbs are also able to tolerate deep planting; and soft offsets and central bulbs often emerge from a depth of 16 inches (*21*). Deep planting, however, reduced the number of offsets and scapes produced on all bulbs. All plants from soft offsets and central bulbs planted at a depth of 2 inches or less produced scapes, but the percentage of scapigerous plants that were produced decreased as depth of planting increased. Deep-planted hardshell bulbs had fewer scapes and offsets than shallow-planted bulbs, but, in addition, length of dormancy of hardshell bulbs increased as the depth of planting increased. Nearly all hardshell bulbs left on the soil surface or planted ½ inch deep sprouted after 2 years, but when planted at depths of 8 and 16 inches, half of them remained dormant (*21*).

Because aerial bulblets are smaller than other bulbs, they do not have the food reserve to emerge from great depths. There was a large reduction in the number and weight of reproductive structures on plants developed from bulblets planted at a depth of 4 inches or more (*21*).

Experiments show that time of tillage is important and that tillage should be repeated each time new growth appears. Repeated tillage is necessary to reduce reproduction of bulbs because the wild garlic plant, even when disturbed, is able to translocate material to new bulbs. Deep plowing is only partially effective because wild garlic can sprout and grow from great depths.

Tillage should be done after emergence because tillage before plant emergence merely redistributes bulbs and does nothing toward control. This principle was recognized by Tinney (*35*), who recommended an annual plowing in November for 6 years followed by frequent cultivations in spring. Frequent tillage gradually exhausts food reserves and if continued, eventually prevents reproduction of underground bulbs.

An immediate effect of tillage is preventing the production of scapes bearing aerial bulbs.

Deep plowing in fall to completely bury garlic plants followed by shallow plowing in the spring has been recommended in Illinois and Indiana (*27,28*). Clean tillage during spring and summer following plowing was then recommended.

Talbot (*34*) recommended the growing of row crops that could be tilled to cut off the garlic plants.

Lazenby (*22*) showed that time of tillage for planting cereals had important effects on garlic. Tillage for spring cereals reduced the number of plants, the number of hardshells, the number of plants bearing scapes, and the size of central bulbs and soft offset bulbs compared with tillage for fall-planted grains.

The effects of competition on wild garlic was studied by Lazenby (*19,20*). Ryegrass (*Lolium multiflorum* and *L. perenne*) sown with aerial bulblets did not affect the establishment of wild garlic, but competitive effects of the ryegrass later reduced the growth rate of wild garlic and reduced the weight of its underground parts to one-fifth of those grown alone (*19*). Competition from wheat reduced the size of garlic plants and the weight of their underground parts (*20*). After 7 years of competition from *Phalaris tuberosa,* wild garlic lost its vigor, and the plants grew only 3 inches tall and failed to produce scapes (*3*).

Frequent mowing, beginning in April, reduced the size of garlic plants and the weight of their underground parts (*24*). Close cutting was more injurious to garlic than high cutting. Cutting in April was more effective than cutting in June.

Chemical Control

Because of the difficulty of controlling wild garlic with cultural methods, much attention has been given to the possibility of chemical control. Control of wild garlic with chemicals has been attempted for about 60 years. In the early 1900's crankcase oil, carbolic acid, sulfuric acid, fuel oil, orchard heating oil, sodium chloride, and sodium arsenite were tried on wild garlic (*28*). These materials were unsatisfactory because they killed the associated crop.

Although the effects of tillage

have not been directly compared with the effects of modern-day herbicides, the nature of herbicide activity indicates that herbicides are more effective than tillage (*9*). Plants of wild garlic treated with 2,3,6-TBA (2,3,6-trichlorobenzoic acid), or 2,4-D [(2,4-dichlorophenoxy)acetic acid] were killed, and the hardshell and soft offset bulbs attached to the plants usually showed growth modifications and often were killed (*9*). Central bulbs were more frequently killed than other bulb types. Herbicides were translocated through the plants to the underground reproductive parts.

Many herbicides have been evaluated for use on wild garlic. Dalapon (2,2-dichloropropionic acid), TCA (trichloroacetic acid), MCPA ([(4-chloro-*o*-tolyl)oxy]-acetic acid), amitrol (3-amino-*s*-triazole), 2,4,5-T ((2,4,5-trichlorophenoxy) acetic acid), MH (1,2-dihydro-3, 6-pyriadzinedione), 2,4-DB (4-(2,4-dichlorophenoxy) butyric acid), and dicamba (3,6-dichloro-*o*-anisic acid) have given some control. The rates and effectiveness of herbicides vary from location to location.

None of the herbicides that were available through 1974 eliminated wild garlic in a single application. Even when tops of garlic plants were killed completely, viable hardshell or soft offset bulbs often remained in the soil and the garlic stand was not eradicated (*8*). Raleigh (*29*) reported germination of soft offset bulbs after 3 successive years of top kill with 2,4-D.

Davis and others (*9*) evaluated a number of herbicides and showed that 15 pounds per acre of dalapon, 6 pounds per acre of MH, 6 pounds per acre of amitrole, 4 pounds per acre of 2,3,6-TBA, and 2 pounds per acre of 2,4-D gave reasonable control of wild garlic. In this study, the ester of 2,4-DB at 4 pounds per acre gave fair control of wild garlic.

Because of low rates of application needed for control (1 to 2 pounds per acre) and relatively low cost, 2,4-D has been investigated extensively. The esters of 2,4-D have been more effective than the amines, perhaps because the esters penetrate the wax on wild garlic leaves better than do the amines.

Time of herbicide treatment influences the amount of kill obtained on wild garlic. More garlic plants receive treatment when herbicide is applied after March 15 than when applied earlier, because wild garlic begins to emerge in late summer and continues to emerge until March (*11*). However, early treatments will kill wild garlic plants before new bulbs have been developed in the axils of the lower leaves. Formation of new bulbs usually becomes apparent sometime in February.

In the case of 2,3,6-TBA and dicamba, time of application may not be as critical as with 2,4-D because they remain in the soil for some time and are probably absorbed over a period of time by the root system of the garlic plants; thus plants that are not up at the time of a fall application will not receive a foliage application but the herbicides may be absorbed by the roots of the garlic plant.

Herbicides can be used to keep wild garlic under control. State extension personnel should be consulted regarding herbicides for specific problems.

Chemical Control in Turf and Pastures

Several herbicides, at rates tolerated by one or more species of turf plants, will control or suppress wild garlic.

Either 2,4-D or 2,4-DB applied at 1 to 2 lb/A two times a year will control wild garlic. The addition of a surfactant to the spray solution usually increases the effectiveness of the treatment. Treatments made in November or early December and repeated in February or March have usually been more effective than treatments applied on other schedules. Neither chemical will provide good control if top growth of the wild garlic has been removed by recent mowing or grazing. Also, mowing or grazing during the first week after treatment may decrease the effectiveness.

Good control has seldom occurred in less than 2 years of treatment. Because hardshell bulbs may continue to sprout for as long as 5 years, annual treatments would be necessary until eradication is achieved. Wild garlic is controlled more effectively by 2,4-D than by 2,4-DB, but 2,4-DB is not as likely to kill desirable turf legumes, such as white clover, as is 2,4-D. Most established grasses will tolerate treatment with either of these two herbicides at 1 to 2 lb/A, but either herbicide may kill or injure seedling grasses.

Many species of trees, shrubs, flowers, and vegetables may be injured or killed if contacted by small amounts of 2,4-D or 2,4-DB. The hazard to nontarget plants is much greater if spraying is done when wind is blowing, or when highly volatile esters of the herbicides are used.

Dicamba or 2,3,6-TBA are often more effective than 2,4-D for control of wild garlic. Dicamba and 2,3,6-TBA, however, persist in the soil longer than 2,4-D and are more likely to injure or kill woody ornamentals by contact and entry through roots in the soil. Both of these herbicides are likely to injure or kill nongrass plants if the herbicides are applied to the soil surface over the root zone of susceptible plants. Turf legumes are usually killed or severely injured by rates of dicamba or 2,3,6-TBA that will control wild garlic, but established grasses will tolerate rates that control wild garlic.

Treatments discussed for control of wild garlic in turf will also control wild garlic in pastures. There are differences, however, in the situations that need careful consideration. For example, legumes are more likely to be present as desirable plants in pasture than in turf. Registrations for uses of herbicides in pastures often differ greatly from registrations for use in turf where grazing animals are not involved.

Chemical Control in Small Grain Fields

Application of a low-volatile ester of 2,4-D at ½ to ¾ lb/A will often prevent small grains from being graded garlicy. This rate of 2,4-D will not consistently kill wild garlic, but it does reduce production of aerial bulblets and knock down tops of wild garlic so that the grain combine will gather few, if any, bulblets during harvest.

Fall-planted small grain will be injured by application of 2,4-D in the fall. Application of 2,4-D in the spring after the grain has tillered but before rapid elongation or jointing of the stems occurs seldom causes significant injury to small grains. Treatment before tillering or when the grain crop is in the boot stage usually reduces grain yield. Oats are more susceptible than barley, and barley is more susceptible than wheat, to 2,4-D damage.

Chemical Control in Waste Areas

The vegetation that is to remain on the site is a crucial factor in selecting herbicides for control of wild garlic in such waste areas as ditchbanks, drainageways, and other noncrop areas.

Grasses will generally tolerate low-volatile esters of 2,4-D at 2 lb/A, 2,3,6-TBA or dicamba at 2 lb to 4 lb/A, or MH or amitrole at 3 to 6 lb/A. Of these herbicides, dicamba, MH, or amitrole would be the most likely to cause slight to moderate injury of grasses. Dicamba or 2,3,6-TBA would often kill or injure trees or shrubs with roots growing under the area to be treated.

Dalapon at 4 to 8 lb/A effectively controls wild garlic, but will injure or kill grasses growing at time of treatment.

Precautions

Some herbicides are poisonous to man and animals. Read and follow the directions on all herbicide labels and heed all precautions.

Keep herbicides in closed, well-labeled containers in a dry place. Store them where they will not contaminate food or feed, and where children and pets cannot reach them.

Avoid repeated or prolonged contact of herbicides with the skin. Avoid spilling herbicides on your skin, and keep them out of the eyes, nose and mouth. If any is spilled on skin or clothing, wash it off the skin and change clothing immediately.

To protect fish and wildlife, do not contaminate lakes, streams, or ponds with herbicide. Do not clean spraying equipment or dump excess spray material near such water.

Avoid drift of herbicide sprays to nearby crops and other desirable plants.

Empty containers of poisonous chemicals are particularly hazardous. Burn empty bags and cardboard containers in the open or bury them. Crush and bury bottles or cans.

PARASITES AND DISEASES

Although wild garlic is grazed readily, it is not seriously injured by animals. We have found that aerial bulblets on the soil surface or other bulbs growing near the soil surface may be eaten by field mice when this rodent population is high. Richens (*31*) reports that bulb tissue may be eaten by slugs (*Agriolimonx agrestis* L.), millipedes, and nematodes (*Anguillulina dipsaci* Kuhn). Widespread damage from insect pests has not been reported on wild garlic, but Freeman [5] reported damage to soft offset bulbs from the cabbage maggot.

At the Missouri Agricultural Experiment Station, much damage to soft offset bulbs was found during the summer of 1964 from insects tentatively identified as the cabbage maggot (*Hylemya brassicae* Bouche) and onion maggot (*H. antiqua* Meigen).

Several fungi have been reported to attack wild garlic. Infestations of *Botrytis allii* Munn. have been observed in Missouri. Richens (*31*) also reports *Botrytis* present in the British Isles. The disease causes deterioration and decay of the central and soft offset bulbs and sometimes may attack immature hardshell bulbs. The hard coat of the hardshell bulb may be a factor in preventing invasion of the fungus. At points of fungi infection, a dark bluish color is apparent.

Richens (*31*) states that rotting of young bulbs can sometimes be caused by *Penicillium* and *Fusarium* species. *Sclerotium cepivorum* Berk also attacks the central and soft offset bulbs of garlic as well as immature hardshells (*31*). Fine white mycelium covering the surface of the bulb characterize the infection. Later in the season, black sclerotia fill the cavity left by the rotting bulbs. Both *Botrytis* and *Sclerotium* may attack the plant at the same time. Leaf spot (*Heterosporium allii* Ell. and Mart.) has been reported on wild garlic in Delaware, Illinois, and New Jersey (*36*).

The diseases cause serious damage to garlic plants in small localized areas, but the diseases do not become epiphytotic.

[5] Personal communication from J. F. Freeman, Kentucky Agricultural Experiment Station.

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