TEXAS AGRICULTURAL EXPERIMENT STATION
A. B. CONNER, Director
College Station, Texas

BULLETIN NO. 651 JULY 1944

HARVESTING AND CURING OF GARLIC TO PREVENT DECAY

H. P. SMITH, G. E. ALTSTATT, M. H. BYROM

Division of Agricultural Engineering
Division of Plant Pathology and Physiology

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
GIBB GILCHRIST, President

D-20-744-4M

[Blank Page in Original Bulletin]

The production of garlic as a commercial crop commenced on a small scale about 1929 in Lavaca and Fayette counties of Texas. Within two or three years production increased until some 20 carloads of garlic were being shipped annually. The crop gave the farmers of that area an annual cash income of approximately $50,000. The planting of poor seed and harvesting before the crop had fully matured caused the garlic to decay badly and resulted in severe losses among shipments in transit.

In 1935 experiments were begun to determine the causes of poor stands and the decay of garlic at harvest and in transit to market.

A total of 25 strains and varieties of garlic were planted to compare the resistance to decay of the bulbs produced. A number of well known fungicides were used to treat garlic cloves (seed pieces) to determine their effect on stand of plants and ultimate keeping quality of the bulbs produced from the treated seed. Five methods of curing garlic bulbs were tested and compared in an effort to find a method that would give a uniform high quality of garlic for the market.

Most of the foreign strains that were tried either gave poor yields due to small bulbs or they matured too late to be of commercial importance. The Mexican and Louisiana Italian strains matured ten to fifteen days earlier than the Texas White variety, but produced small bulbs and lower yields.

Delayed germination, poor stands, and lower yields were generally obtained when fungicides were applied either in the furrow or to the seed piece before planting, as compared to stands and yields obtained with well selected, sound, nearly disease-free seed pieces.

Garlic decayed less during 3½ months storage when cured 10 to 14 days on wire racks either in an open shed or in a barn loft than when cured on floor of barn, left in field, or cured by artificial heat.

These studies indicate that to obtain best yields and a good quality of garlic, sound, disease-free seed pieces should be planted on low ridges, in October and early November and harvested when most of the tops have turned brown, then cured under shelter on open racks from 10 to 14 days.

CONTENTS

HARVESTING AND CURING OF GARLIC TO PREVENT DECAY

H. P. Smith,[1] G. E. Altstatt,[2] and M. H. Byrom[3]

In Lavaca and Fayette counties of Texas, the production of garlic as a commercial crop commenced about 1929 on a small-acreage basis. The acreage was increased until some twenty carloads of garlic were being shipped annually. In this area, garlic was a winter crop that provided cash in early summer when there were no sales of other crops.

Unfortunately, farmers of the area made a practice of selling the best garlic and keeping for seed the poor quality bulbs which were often infested with decay organisms. As a result by 1933, poor stands and low yields were common, much garlic was lost by decay shortly after harvest, and many losses occurred among shipments due to spoilage in transit.

Consequently, in 1935, certain farmers and merchants of this area asked the Experiment Station to investigate the causes of the poor stands and decay in garlic and to work out control measures, in order to save what once had been a profitable crop. A State appropriation was obtained for this work and a cooperative project was set up in 1936 between the Division of Plant Pathology and Physiology and the Division of Agricultural Engineering.

INFORMATION OBTAINED FROM SURVEYS

In June 1935 surveys were made of farms producing garlic and of garlic merchants in Lavaca and Fayette counties. It was learned that the growers made a common practice of selling the best quality garlic and saving for seed the poor, unmarketable garlic which resulted in a decline in quality of succeeding crops and that the farmers were probably increasing and spreading decay organisms as well as decreasing the yields. There was a tendency to harvest garlic before it had fully matured. The produce merchants, therefore, suffered a large portion of the shrinkage or drying loss together with the risk of decay before and after shipment. The merchants became cautious and the market demand declined. It was further found that the general practice of harvesting consisted in plowing the garlic out with a sweep attached to a sweep stock and collecting the garlic into piles along the rows. These piles were often left in the field for a day or two or until the garlic could be removed and spread in windrows on a meadow (Fig. 1). The garlic was then left in the meadow in contact with the ground and exposed to the hot sun for a week or more until it had dried sufficiently to be topped and cleaned. After cleaning, it was usually placed several inches deep on the floor of a poorly ventilated barn loft. If the garlic was fairly green and piled deeply on the floor, it would sweat and create a condition highly favorable for the development of decay organisms.

These surveys indicated a need for research on the causes of the undue amount of decay in the garlic crop, on the improvement of stands, and the prevention of after-harvest deterioration.

---

[1]Chief, Division of Agricultural Engineering.
[2]Plant Pathologist (resigned August 15, 1942).
[3]Agricultural Engineer (resigned May 19, 1942).

Figure 1. This garlic has been pulled and carried to a meadow where it is spread in windrows to dry. This is a method of curing that is frequently used by farmers.

DISEASES, INSECTS, AND ORGANISMS ASSOCIATED WITH BULB DECAY

The various diseases and insect pests encountered in this work are described in Texas Station Circular 98.[1] The diseases include pink root, mosaic, southern blight, and various bulb rots; the insect pests are listed as thrips, white grubs, weevil, and bulb mite. Many of these troubles, however, are found only occasionally. The trouble occurring most consistently has been the decay of seed cloves either before or after planting and the decay of bulbs following removal from the ground at harvest. Most of the research work has involved the identification and control of the organisms causing these bulb decays and the prevention of circumstances in handling the crop that result in the development of favorable conditions for decay.

In studying the causes of garlic bulb decay, many routine laboratory cultures were made of partly decayed bulbs and records were kept of the different organisms isolated. Samples of garlic in various stages of decay were collected from fields, barns, and merchants' warehouses. Beginning of decay was often indicated by a brownish discoloration that started in the neck of the plant and extended into the tissues separating the cloves in the bulb. Once decay begins, the breakdown is rapid and results in badly discolored, partially rotten or often completely spoiled bulbs. Often bulbs were found in which only one of the several cloves was affected while

[1]Alstatt, G. E. and Smith, H. P. Production, diseases and insects of garlic in Texas. Tex. Agr. Exp. Sta. Circ. 98. 1942.

other bulbs were wholly decayed and consisted of only a dry, black, smutty mass. No particular fungous or bacterial species was found with sufficient frequency to associate any single organism with the common types of decay. The fungi most frequently obtained in culture from decaying garlic included species of *Aspergillus, Diplodia, Fusarium, Helminthosporium, Penicillium,* and *Trichoderma,* together with *Sclerotium bataticola* Taub. and *Sclerotium rolfsii* Sacc. Bacterial growth of various types were also common in the cultures; *Bacillus carotovorus* L. R. Jones being the only species readily recognized and identified.

MATERIALS AND METHODS IN FIELD AND CURING EXPERIMENTS

The garlic used in most of these experiments was grown on 2 acres of leased land at the Joe Stary farm about 3 miles south of Moulton, Texas, in Lavaca county. A different part of the field was used each year to avoid residual effects of a single crop. The soil was a black clay of the Houston-Wilson series. Plantings were usually made from October 15 to November 15 and the crop was harvested from May 20 to June 5. The Texas White variety was used almost exclusively in the experimental plantings, although other varieties were also tested. The different methods of handling the crop at harvest are discussed separately under methods of curing.

The bulbs were cleaned by hand. The dry and loose leaf bases covering the bulbs were pulled off with the fingers, while the roots were trimmed off with a knife. A typical garlic cleaning scene and cleaned, ungraded garlic bulbs are shown in Figure 2.

Most of the studies in curing were conducted at Moulton and a part of the cured garlic was brought to College Station for storage tests in a well-ventilated shed during the summer. Final data on the various treatments were taken following the storage period, usually in October.

Since many micro-organisms, both bacteria and fungi, may be transmitted and carried from one year to the next on "seed pieces" used in vegetative propagation, experiments were conducted to determine if the decay of garlic could be controlled by treatment of the seed piece or "clove" (Fig. 3). Several of the well known germicidal and fungicidal chemicals were used in three ways. First, the chemical was placed in the furrow before dropping the seed. Second, they were used to treat the seed piece prior to planting in an effort to kill the decay organism before the seed were placed in the soil. Third, chemicals were used to treat garlic bulbs, as soon after harvesting as possible, to destroy the organisms, which caused decay while in storage and leave the seed piece free of diseases.

Equipment used in the curing experiments consisted of (1) open wire racks (total drying area nearly 600 square feet) under a sheet-iron roof (Fig. 4). The racks consisted of 1-inch hexagonal poultry netting, (2) wire racks in a barn loft (Fig. 5), and (3) a small experimental hot-air drier with a capacity of about 1200 pounds of fresh garlic (Figs. 5-7).

The drier, constructed in the spring of 1936, consisted mainly of a 15-foot vertical chute, 3-feet square inside; a work room, which also housed the furnace and fan; and outside stairways and work platforms. In the

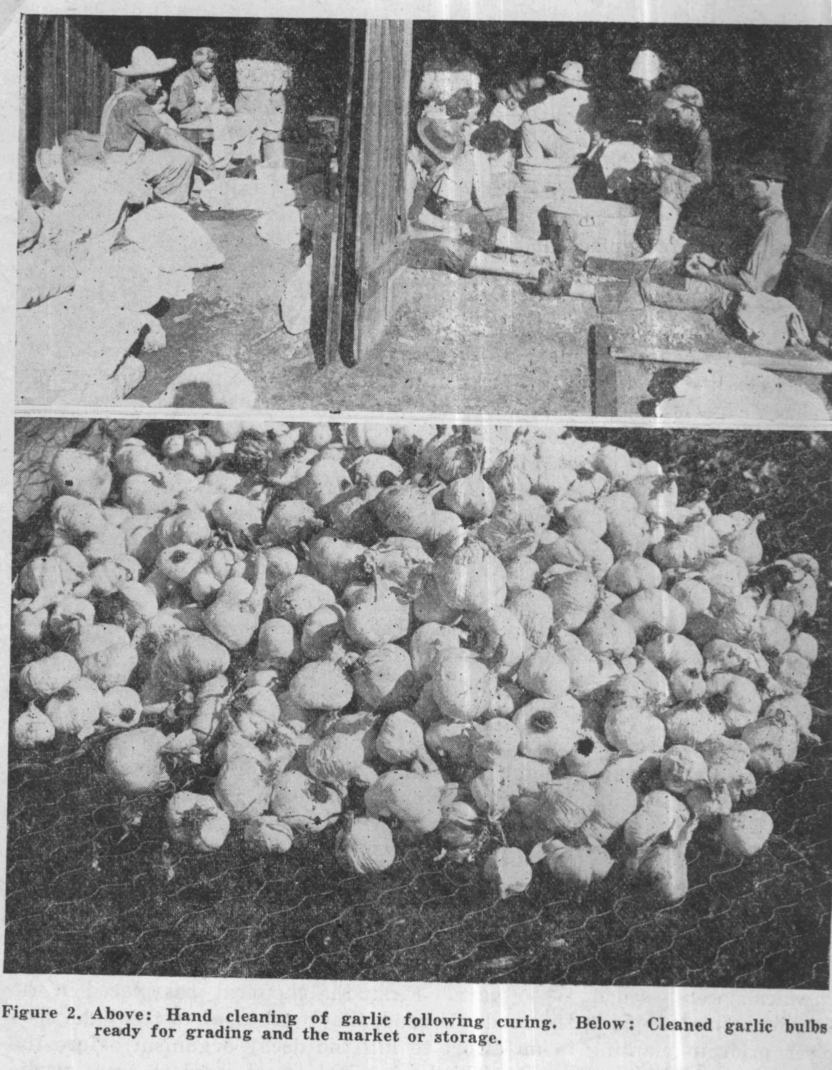

Figure 2. Above: Hand cleaning of garlic following curing. Below: Cleaned garlic bulbs ready for grading and the market or storage.

original construction, three racks of half-inch hardware cloth were built in the upper 12 feet of the chute and spaced 2½ feet apart. With these racks, however, the garlic was placed 18 inches thick and the flow of air through the mass was retarded too much for good drying results. Consequently, for the later experiments, these racks were replaced with a larger number of trays each holding a layer of garlic 1 or 2 bulbs in depth. To support the trays in the chute, two chains with lug links spaced about 3 inches apart, were placed around opposite sides of the chute (Fig. 5). A worm gear was used to raise and lower the lugged chains and trays. The trays were placed on the lugs of the chains at the

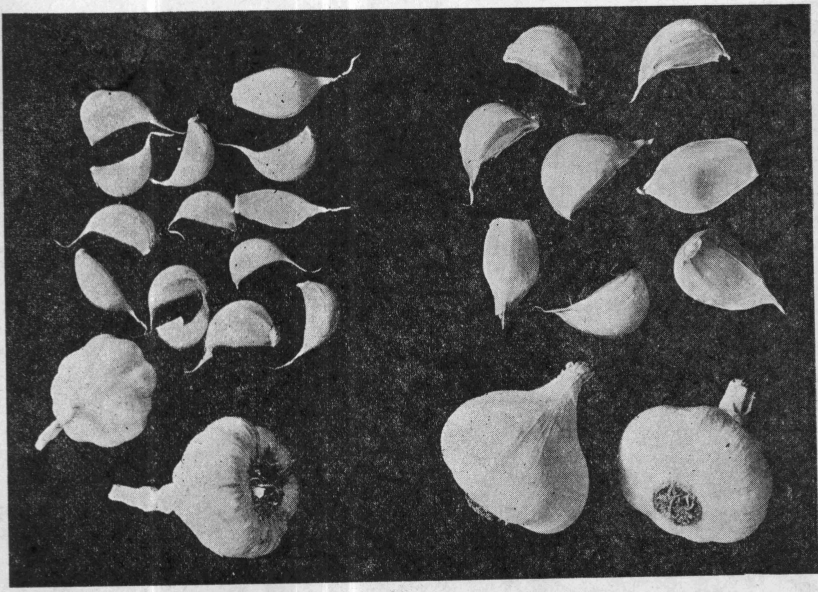

Figure 3. Italian (Louisiana) and Texas White (right) strains of garlic showing cured and cleaned bulbs ready for market, also the cloves separated from single bulb of each strain. These separated cloves are the parts used for planting and are referred to as "seed-pieces" or "seed" cloves.

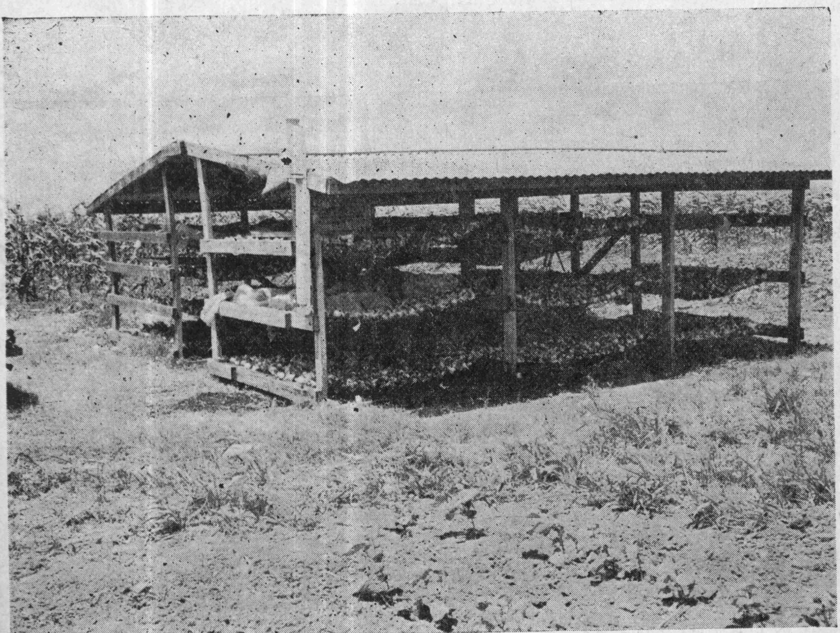

Figure 4. Open shed with wire poultry netting racks loaded with garlic bulbs. Note that air may circulate above, below, and around the bulbs, hastening curing and drying.

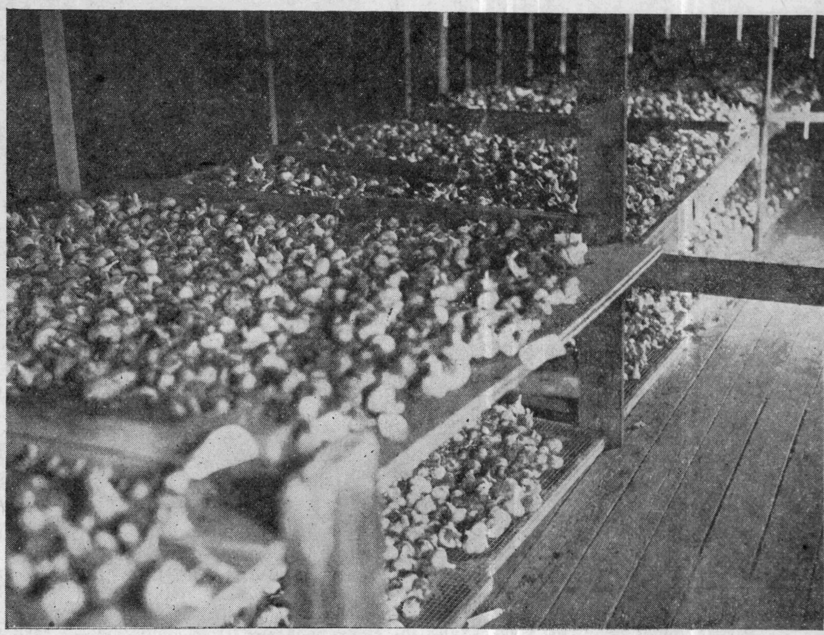

Figure 5. Garlic bulbs drying on wire racks in loft of barn. The garlic on the trays on the floor also cured well and did not sweat.

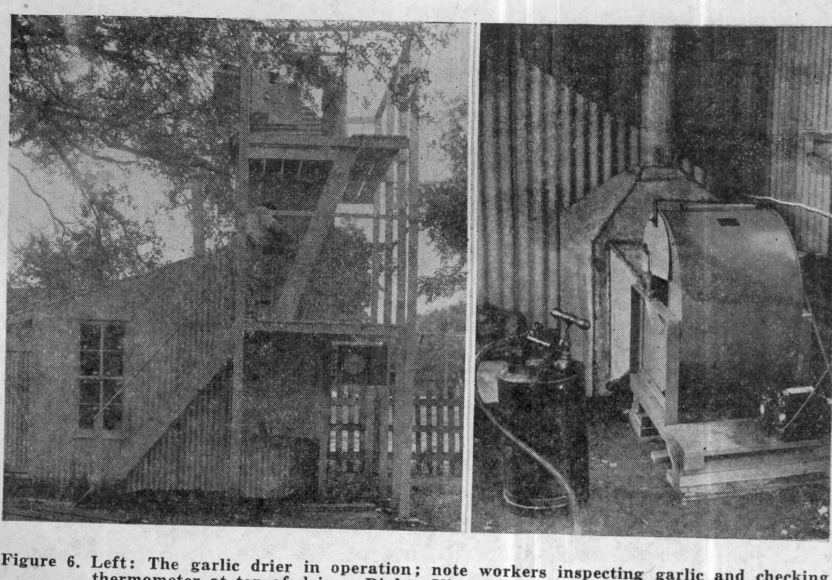

Figure 6. Left: The garlic drier in operation; note workers inspecting garlic and checking thermometer at top of drier. Right: View of inside of work room showing fan in foreground and furnace in background.

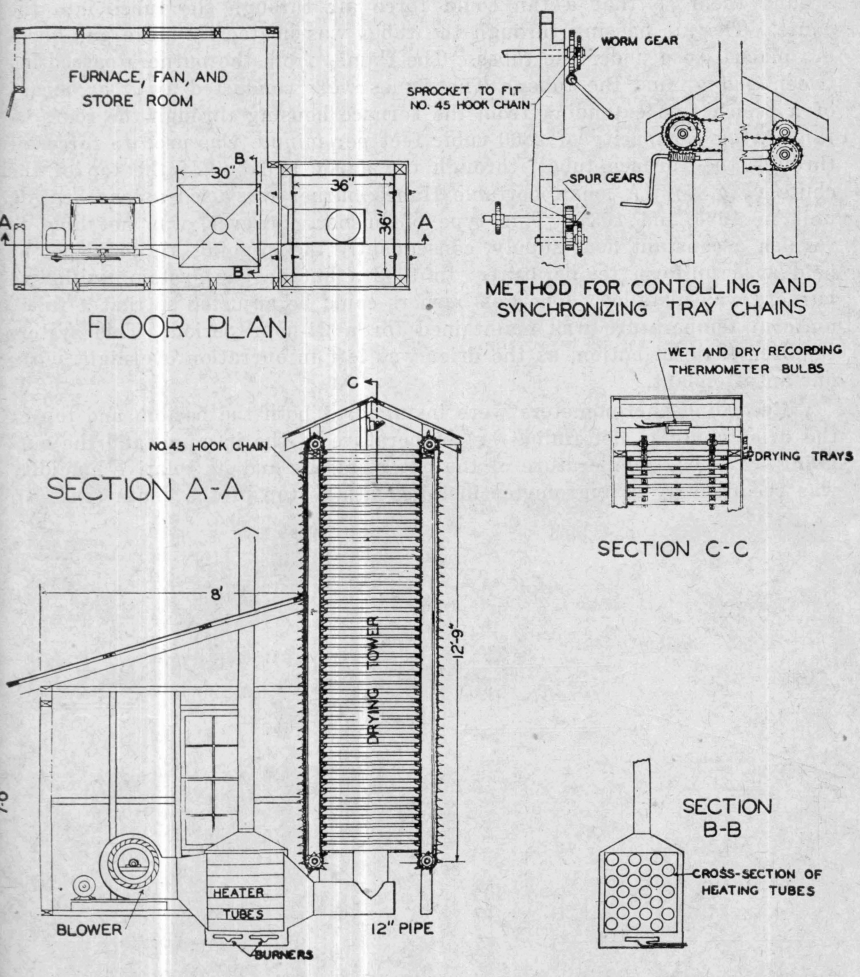

Figure 7. Cross-sectional view of experimental garlic drier, showing fan, furnace, lugged chains supporting trays in chute, and method of controlling and synchronizing tray chains.

top of the drier. In loading the trays, some 25 pounds of garlic were spread on each tray and lowered with the chains by turning the handle on the worm gear, until the lugs were in position for another tray. This procedure was continued until the chute was filled with about 48 trays.

After studying the various types of furnaces available for drying vegetable crops a satisfactory furnace was designed and constructed from sheet metal (Figs. 6 and 7). A total of 24 tubes were made from 18-gauge sheet metal. These tubes were approximately 2 feet long and 4 inches in diameter. End plates, to hold the tubes in position, were made by cutting 24 holes, in a staggered arrangement, in two pieces of sheet metal. After the tubes were welded to the end plates, a housing was built around them so that a fan could force air through the tubes into the chute. The air passing through the tubes was heated by large gas burners placed close under the tubes. The flames from the burners passed between and around the tubes. The fumes were conducted away by means of a 6-inch flue extending from the furnace housing through the roof. A fan having a capacity of 2800 cubic feet per minute was used to force air through the furnace tubes, through the garlic and out of the top of the chute (Fig. 7). A small portable Hauck burner was used as the heating unit in 1936 and 1937. This type of burner, however, was not able to furnish a constant heat supply, consequently the in-going air could not be held at a uniform temperature. In 1938 a butane gas system* with two burners was installed. The gas burners could be adjusted so that a fairly uniform temperature was maintained for a 24-hour period. This system required little attention, as the drier was left in operation overnight without an attendant.

Recording thermometers were installed at both the bottom and top of the drier chute to determine the temperature of the in-going and the outgoing air. The temperature of the out-going air and its relative humidity was recorded by a hygrometer installed at the top of the chute (Fig. 8).

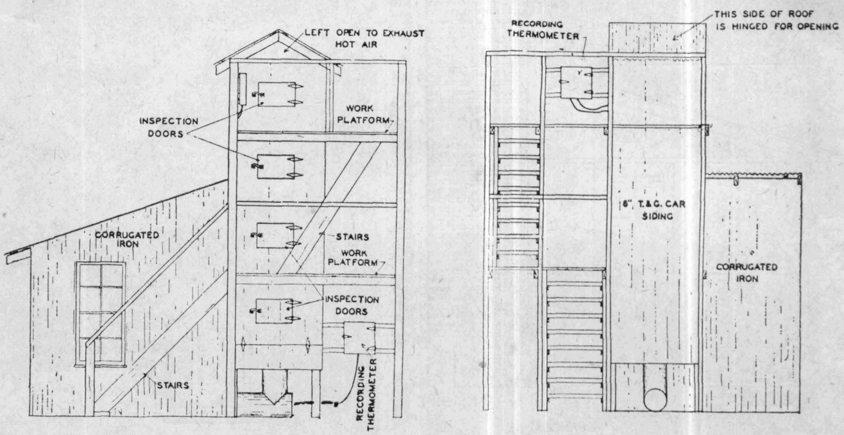

Figure 8. Front view (on left) of experimental garlic drier, showing work room, chute, inspection doors, location of thermometers, stairways ,and work platforms. On right: Side view of garlic drier, showing underside of stairways, chute, and work room.

Both the dry and wet bulbs of the hygrometer were mounted over the center of the chute, where the expelled air could flow around them. When the garlic and the chute became thoroughly heated, and reached a constant temperature, there was a difference of about 14 degrees between the ingoing and the out-going air.

STUDIES WITH GARLIC VARIETIES

In order to compare the keeping qualities of different kinds of garlic, a collection of strains and varieties was obtained through the cooperation

*This equipment was leased to the Experiment Station by the Edward's Gas Appliance Company, San Antonio, Texas.

of the California Agricultural Experiment Station.* Some of these types of garlic came from China, India, Bulgaria, Algeria, Germany, Egypt, Yugoslavia, and Italy. In addition, other strains were obtained such as the Louisiana Italian, Creole, Mexican, and the Texas White. Most of the foreign strains either gave poor yields due to small bulbs, or they matured too late to be of commercial importance. A Manchurian strain, even though it produced a small bulb, matured two to three weeks earlier than the large-bulb Texas White. The Mexican and the Louisiana Italian strains also matured 10 to 15 days earlier than the Texas White variety but they produced small bulbs. The Texas White garlic (possibly a strain of the Creole variety) is the most commonly grown variety in Lavaca and Fayette counties of Texas.

Certain of the small bulb varieties appeared to decay less readily than some of the larger-bulb types but they usually produced low yields under the conditions at Moulton.

Figure 9 shows a close-up view of the thick stemmed, Texas White garlic together with the slender, narrow-leaved Louisiana Italian variety. The Louisiana Italian garlic with slender stalks was ready for harvest much earlier than the Texas White variety with the thick heavy stalk.

Figure 9. Two strains of garlic: Texas White on left and early Italian (Louisiana) strain on right. Photograph taken about 2 weeks before harvest of the earlier strain.

EFFECTS OF FERTILIZERS ON YIELD

Some experiments were conducted in 1937 and 1938 with fertilizer applications to garlic planted on black-land soil near Moulton. In 1937, three different fertilizer formulas were used and applied in the furrow before

*Varieties of garlic grown in California are described in California Agricultural Extension Service revised circular No. 84.

planting at the rate of 300, 600, and 900 pounds per acre. Each fertilizer and rate was replicated four times. The highest yield of 1689 pounds per acre was obtained when the 4-12-4 fertilizer was applied at the rate of 900 pounds per acre. This was only slightly better than the yield obtained when 600 and 300 pounds per acre were applied. With 6-12-6 fertilizer, the 300-pound application gave the highest yield while the 900-pound rate gave the lowest yield, 1672 and 1276 pounds per acre, respectively. The 6-18-6 fertilizer applied at the rate of 600 pounds per acre gave the highest yield of 1628 pounds of garlic per acre as compared to 1381 for the 300-pound rate and 1221 for the 900-pound rate. Plats that received no fertilizer yielded 1601 pounds of garlic per acre—only 83 pounds per acre less than the highest yield obtained for any of the fertilizers and rates of application. This slight increase in yield was not enough to justify the cost of the fertilizer and the labor required for the application.

Table 1. Effect of fertilizer on yield of garlic.

1937			1938			
Fertilizer	Rate lb. per acre[1]	Yield lb. per acre	Fertilizer	Placement	Rate lb. per acre	Yield lb. per acre
Check	None	1601	Check		None	1438
4-12-4 4-12-4 4-12-4	300 600 900	1533 1670 1689	4-12-4	2″ to each side and 1½″ below seed level[2]	800	1646
6-12-6 6-12-6 6-12-6	300 600 900	1672 1502 1276	4-12-4	Mixed in soil 1½″ below seed[2]	800	1382
6-18-6 6-18-6 6-18-6	300 600 900	1381 1628 1221	6-16-6	Side dressed 5″ to each side and 1″ below seed level[3]	1000	1502

[1]Applied in furrow, by hand, before planting November 23, 1936.
[2]Fertilizer applied with special machine at time of planting October 28, 1937.
[3]Side dressed February 11, 1938.

In 1938, the 4-12-4 fertilizer was applied by mixing it with the soil 1½ inches below the seed and also by applying it two inches to each side and 1½ inches below the seed level, at the time of planting. It may be seen in Table 1 that the side application at the rate of 800 pounds per acre produced 1646 pounds of garlic per acre. When mixed in the soil below the seed the yield was 1382 pounds per acre as compared with 1438 pounds for the check (no fertilizer). Fertilizer (6-16-6) was applied in another test as a side dressing on February 11, 5 inches to each side and one inch below the seed level at the rate of 1000 pounds per acre. Fertilizer applied in this manner gave a yield of 1502 pounds of garlic per acre. These results indicate that better results were obtained when the fertilizer was applied to the side and below the seed level, either at the time of planting or as a side dressing. However, the increase of 208 pounds of garlic per acre by the application of fertilizer was not enough to justify the extra expense at the prevailing price that year.

These results cannot be taken as conclusive as the tests on the effects of the different fertilizer formulae and rates of application and the effects of the placement of fertilizers were based on one year's work.

APPLICATION OF FUNGICIDES IN FURROW

In 1936, sulphur and Cuprocide were applied as separate treatments in the furrow at rates of 400 and 800 pounds and 200 and 400 pounds per acre respectively. After these chemicals were distributed by hand in the furrow, the garlic cloves were dropped in the same furrow in direct contact with the chemical. A sweep was used to fill the furrow and cover the seed and chemical. Plant counts showed that these furrow treatments delayed germination, reduced the stand materially, and caused lower yields.

PRE-PLANTING TREATMENT OF GARLIC CLOVES

Experiments were begun in the fall of 1937 to determine the effects of treating the garlic cloves (seed pieces) with chemical disinfectants or fungicides on the stand of plants and possible benefits following harvest of the crop. The chemicals used included sulphur, Cuprocide, Ceresan, mercuric chloride, formaldehyde, Semesan, malachite green, and Phemernite.

The bulbs were first separated into individual cloves which were then dusted with sulphur, Ceresan, Semesan, and Cuprocide, or dipped for about 1 minute in solutions of mercuric chloride (1:1000), formaldehyde (1 pt. per 15 gal.), malachite green, and Phemernite, and dried before planting.

The treatment of garlic cloves for seed appeared in most cases to retard and reduce stands as compared with stands obtained with non-treated seed pieces (Table 2). Semesan was the only treatment that gave, on the average, better stands than the checks. When the various treatments were inspected at the time of emergence it was observed that plants from the Cuprocide, sulphur, mercuric chloride, and formaldehyde showed somewhat slower emergence indicating that these treatments retarded germination. The data in Table 3 show that the treatment of the seed-piece did not increase the average yield over that of the checks, although during the period 1938-1940 some treatments showed slightly higher yields than the check. This was apparently due in part to the poor seed stocks that were used before selected seed was available. For the period 1941-1943 none of the treatments gave yields as high as those obtained with non-treated cloves. It was observed that the mature bulbs from the mercuric chloride treatments had a yellowish tinge and that the outer scales of the bulb were loose, somewhat shriveled, partly disintegrated and crumbly. The

Table 2. Effect of chemical treatment of garlic seed (cloves) on number of plants per 100 feet of row.

Treatment	1939	1940	1941	1942	1943	Av.
Check	143	131	150	——	133	139
Sulphur	144	80	——	——	——	112
Cuprocide	125	101	——	——	——	113
Cuprocide 54	126	114	——	——	——	120
Ceresan 2%	145	123	——	——	——	134
Mercuric chloride	134	127	126	——	147	134
Formaldehyde	141	60	133	——	——	111
Semesan	158	141	152	——	170	155
Malachite green	148	116	——	——	——	132
Phemernite	——	141	137	——	——	139

highest average yields were obtained with mercuric chloride, Ceresan, and Semesan (2246, 2183, and 2158 pounds per acre, respectively). The average acre yield for the check, non-treated seed was 2344 pounds per acre, or 98 pounds per acre more than was obtained with the best chemical treatment.

Table 3. Effect of treatment of garlic seed (cloves) on yield—pounds per acre.

Treatment	1938	1939	1940	1941	1942	1943	Av.
Check	2303	1932	1281	2722	2379	2722	2344
Sulphur	2149	1978	641	——	——	——	1816
Cuprocide	2031	1620	644	——	——	——	1645
Cuprocide 54	2029	1469	819	——	——	——	1653
Ceresan 2%	2432	1995	1355	——	——	——	2183
Mercuric chloride	2540	1912	1246	2369	2332	2273	2246
Formaldehyde	——	1866	380	2440	——	——	1562
Semesan	——	2363	1274	2295	2175	2681	2158
Malachite green	——	2165	1176	——	——	——	1670
Phemernite	——	——	1250	2457	——	——	1854

Samples of the garlic produced in the various seed-piece treatments were cured in the drier and on racks in the open shed previous to the usual 3½ months' storage period. Table 6 shows that there was a higher percentage of decay for all treatments when the bulbs were dried with hot air than in curing in the open shed. This is attributed to the fact that there was more moisture remaining in the neck of the bulb and in the thin partition skins of the bulbs in the hot air treated lots, a condition more favorable for the development of decay organisms. The lowest percentages of decay, following curing in the open shed were found in the mercuric chloride and Semesan treatments and in the non-treated check. Only the mercuric chloride treatment gave a lower percentage of decay than the check and this difference was not great. It appears from the results obtained, therefore, that chemical treatment of the seed-piece did not increase the stands, plant growth or yields and little effect on decay in storage was noted when the seed (cloves) were taken from selected bulbs.

VARIOUS METHODS OF CURING GARLIC

In an attempt to find a method of curing that would give a uniformly high quality of garlic for the market, experiments were undertaken using several methods of curing. Heating and drying of the bulbs was at first tried. Later, less expensive methods of curing that would be available to farmers were tried, such as that of drying the bulbs on wire racks either in an open shed or in a barn loft (Figs. 4 and 5). For comparison, untopped garlic bulbs were left in windrows in the field, as was commonly practiced by many growers.

Data were collected to show the effects of these methods of curing on the percentage loss by shrinkage in drying, cleaning, and decay in storage.

Field Curing of Garlic

Certain growers in the Moulton area have made it a practice to leave the garlic plants in piles in the field for a few days following pulling, then hauling them to a meadow or barnyard where the untopped plants were spread in windrows and left until dry enough to top and clean. Under these conditions, the garlic did not cure uniformly, as the bulbs underneath were in contact with the damp ground and partially covered, while those on top were exposed to the hot sunshine and subject to scald. Data were collected on the percentage loss through shrinkage and decay in cleaning and storing of garlic handled in this fashion as compared with the other methods of curing. No data were obtained on the loss of weight during curing as the tops were left on the bulbs until they were ready to be cleaned. The garlic was left in the field from 8 to 14 days (Table 4). As

Table 4. Average curing time for different treatments of garlic.

Year	Method of curing				
	On ground in field (days)	On floor of barn loft (days)	On wire racks in shed (days)	On wire racks in barn (days)	In hot-air drier (hours)
1937	—	—	—	—	20
1938	—	—	32*	—	14
1939	8	—	8	—	18
1940	10	—	15	—	24
1941	14	12	13	12	29
1942	14	—	14	14	24
1943	—	—	13	13	24
Av.	11.5	12.0	12.6	13.0	21.9

*Garlic was placed on wire racks without removing tops and therefore required more time to dry

shown in Table 5, the loss in cleaning garlic that was left in the field averaged 12 per cent for the 4-year period 1939-1942. This was 5 percent more than the loss sustained when the garlic was dried in the drier and 6 percent more than the open-shed curing. This higher loss in cleaning of garlic left in the field can be attributed to at least three factors: First, considerable damp soil that could not be shaken off clung to the roots. Second, the husks (or shucks) and roots of the bulbs in contact with the ground were damp. Third, more of the shuck or sheath of the bulb was removed in cleaning because of the damp and stained condition. Many bulbs were often "soil-stained" so deeply that the most careful cleaning did not remove the discoloration. Exposure to damp soil, rains or dew caused the bulbs to become stained and dark brownish in color. The stems were often partially decomposed and ragged under these conditions. In general, a poor quality of marketable garlic resulted from this method of curing.

When garlic was left on the ground to cure, the average shrinkage loss after 3½ months of storage was 24 per cent for the No. 1 grade and 22 per cent for the No. 2 grade (Table 6). The average loss by this method of curing was almost identical to that of the hot air method, but approximately 2½ to 5 per cent more than occurred with either the open shed racks or barn rack methods. This indicates that the garlic left in the field was not dried as thoroughly as comparable lots that were cured in the shed or barn on racks before being placed in storage.

In Table 6, it may be seen that there was an average of 9 per cent decay during storage with the No. 1 grade and 6 per cent with the No. 2 grade, when garlic was left in the field to cure. This amount of decay was slightly less than that which occurred with the hot air treatment but

Table 5. Percentage loss in weight and in curing and cleaning of garlic as affected by different methods of curing.

Year	On ground in field		On floor of barn loft		On wire racks in shed		On wire racks in barn		In hot-air drier	
	Cure	Clean	Cure	Clean	Cure	Clean	Cure	Clean	Cure	Clean
1937	—	—	—	—	—	—	—	—	13	7
1938	—	—	—	—	—	—	—	—	11	10
1939	—	11	—	—	7	6	—	—	7	10
1940	—	10	—	—	25	6	—	—	20	8
1941	—	15	18	8	24	6	23	5	25	6
1942	—	10	—	—	19	5	20	5	19	5
1943	—	—	—	—	18	6	18	7	15	5
Av.	—	12	18	8	19	6	20	6	16	7

it was considerably more than occurred when the garlic was cured on racks either in an open shed or in the barn. The high percentage of decay in 1941 was probably due to the heavy rainfall while garlic was on the ground in the field.

Curing on Wire Racks in Open Shed

In 1938, garlic in both topped and untopped conditions was placed on the wire racks of the open shed dried (Fig. 4) and left for 32 days. This garlic became well cured and kept well, showing a low percentage of decay when held in storage for a period of about 3½ months. The data in Table 5 show that garlic bulbs cured in the open shed for an average of approximately 13 days lost on the average about 19 per cent moisture. This was 3 per cent more than the amount lost by bulbs dried in the drier with hot air for an average of 21.9 hours (Tables 4 and 5). This indicates that the bulbs in the open shed dried more thoroughly than those that were cured in the hot air drier. It may be seen in Table 5 that there was approximately 1 per cent less loss in the cleaning of garlic bulbs cured in the open shed than for those dried by hot air. There was very little difference in the loss from cleaning of bulbs that were cured in the open shed and those cured on wire racks in the barn loft. No. 1 grade garlic cured in the open shed lost by shrinkage an average of 19 per cent

Table 6. Percentage loss in weight of garlic during 3½ months of storage as influenced by different methods of curing.

Year	On ground in field		On floor of barn loft		On wire racks in shed		On wire racks in barn		In hot-air drier	
	No. 1*	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2
Loss due to shrinkage										
1937	—	—	—	—	—	—	—	—	24	19
1938	—	—	—	—	11	18	—	—	16	20
1939	30	30	—	—	31	29	—	—	30	27
1940	17	13	—	—	11	8	—	—	16	13
1941	33	35	29	28	24	21	25	21	26	22
1942	15	12	—	—	14	12	14	12	14	12
1943	—	—	—	—	25	22	25	19	41	44
Av.	24	22	29	28	19	18.5	21.3	17.6	24	22
Additional loss due to decay										
1938	—	—	—	—	5	7	—	—	19	32
1939	8	7	—	—	8	6	—	—	8	6
1940	4	2	—	—	0	1	—	—	1	1
1941	21	15	3	0	2	1	1	0	11	4
1942	1	0	—	—	0	1	0	1	0	0
1943	—	—	—	—	1	0	0	0	16	28
Av.	9	6	3	0	3	3	0.4	0.4	9	12

*Grade of garlic.

in 3½ months' storage. This was a slightly lower amount than occurred with any of the other methods of curing (Table 6). The shrinkage for the No. 2 grade was also lower except for that cured on wire racks in the barn loft. This again indicates that the bulbs were more thoroughly dried in the open shed. In storage, the average loss from decay following this treatment was about the same (3 per cent) for both the No. 1 and No. 2 grades of garlic (Table 6). Lots of comparable bulbs dried by hot air lost 9 and 12 per cent of their weight respectively for the No. 1 and 2 grades.

Curing in Barn Loft

On wire racks: Experiments on the drying of garlic on wire racks in a barn were undertaken in order to compare results obtained by drying in an enclosed building with those obtained in the open shed. The use of a barn might also make unnecessary the construction of a drying shed which might be used for only two or three weeks each year. Several hundred pounds of garlic was cured on wire racks inside the barn (Fig. 5) each year during the period 1941-1943. A study of the data in Table 5 shows that garlic bulbs kept on wire racks in a barn for 13 days lost on the average 20 per cent of its original weight through loss of moisture. This was only slightly less (1 per cent) than the amount lost by comparable bulbs in the open shed, indicating that the rate of drying may be slightly slower in the barn. This difference, however, was not consistent, as in 1942 there was slightly greater loss in the barn than in the shed.

There was very little difference in the loss by cleaning of bulbs cured in the open shed and those cured in the barn (Table 5). Examination of the data in Table 6, considering only the 3-year period 1941-1943, shows that there is also but little difference in the shrinkage of garlic bulbs when cured in an open shed and in a barn. This was true for both the No. 1 and No. 2 grades. Garlic cured by these two methods showed less shrinkage while in storage for 3½ months than the garlic cured either in the drier, in the barn, or left in the field.

Decay in storage (Table 6), for the 3-year period 1941-1943, was slightly less when the garlic was cured by drying on racks in a barn than in the open shed, or by any other method.

On floor: Garlic growers in Lavaca and Fayette counties often place their garlic on the floor of a barn loft, after cleaning, to allow it to dry before marketing. It was observed that garlic treated in this manner was often brownish in color, instead of clear-white as desired by buyers. Therefore, in 1941, several hundred pounds of garlic was spread three to four bulbs thick on the loft floor of a barn. The walls of the barn were not tight as there was no batten over the cracks between the vertical 12-inch boards. Doors on a level with the floor on the south and north sides were left open for ventilation. When the garlic was removed 12 days later it was so damp from condensed moisture (sweating) that it was carried to the drier and dried for about two hours before it could be readily cleaned. The bulbs were brownish in color and gave a poor appearance after cleaning. The sweating of the bulbs was apparently due to several factors; lack of circulation of air under and through the bulbs; high moisture from bulbs underneath. Sweating can be prevented by construction of a false-floor of either slats or wire some 2 or 3 inches above the regular floor so that air can circulate under and through the bulbs, permitting the escape of evaporated moisture. In these studies, hardware-cloth trays that kept the bulbs about 1 inch off the floor prevented sweating and allowed the garlic to cure well in 1942 and 1943.

Drying Experiments with Artificial Heat

Preliminary tests with an incubator. In 1935 several hundred pounds of garlic furnished by the merchants of Moulton, Texas, were placed in a Buck-Eye #34 incubator as an emergency measure. The incubator was heated by a hot water coil about which the air was circulated by three twelve-inch fans. These fans merely circulated the air within the incubator and did not exhaust the air sufficiently to carry away the moisture from the surface of the garlic. The temperature within the incubator averaged about 10 degrees F. above room temperature. The highest temperature obtained in any part of the incubator for any length of time was 102 degrees F. The temperature in the room ranged from 85° F. during the night to 97° during the afternoon. As the incubator was poorly ventilated the garlic was merely heated without sufficient air velocity to carry the moisture out of the incubator. As a result, the garlic subjected to this treatment from 10 to 24 hours showed only a slight loss of moisture (3 per cent for bulbs with tops removed, and less than 5 per cent from the garlic with the tops remaining on the bulbs). This test showed than an incubator as such, was not suitable for drying of such material as garlic.

Drying with experimental drier in 1936: The experimental drier constructed at Moulton in the spring of 1936 was used in a number of experiments with garlic to determine the range of temperatures that could be safely used without injury to the market quality.

As no garlic was grown by the Station that season, several hundred pounds were purchased on the open market for experimental purposes. The garlic purchased, some of which had not been topped, evidently was harvested before it reached maturity, as the tops were still green. In drying this rather green garlic with temperatures ranging from 130° to 170° F. the more immature bulbs, after drying for 2 or 3 hours, took on a greenish-blue tinge, but after 8 or 9 hours when they became fairly dry most of the discoloration had disappeared. At the higher temperatures a yellowish sticky substance exuded from the stems of the bulbs. This, however, did not occur with the more mature bulbs. With the greener bulbs, after the outer surface and the cut end of the stem appeared to be dry, a watery liquid could still be squeezed out of the neck, indicating that moisture was removed very slowly from inside the bulb and stem during the drying process. At the higher temperatures, particularly after 4 or 5 hours' drying, the smaller bulbs began to look as if they were partially cooked. When the garlic, dried at temperatures above 140° F., was stored for a few days, it disintegrated, soon developed an offensive odor, making it necessary to discard the entire lot. Table 7 shows that garlic dried at 110° to 120° F. for 16 to 24 hours kept fairly well. These data indicate that temperatures could not be used much higher than 125° F. It also appeared that it might be better to commence drying at 100° to 110° F. and gradually raise the temperature to around 120° F. at which it should be main-

Table 7. Effects of temperature and period of drying on curing of garlic in hot-air drier, 1936.

Number of hours dried	Degrees F.	Weight—lb. Before drying	Weight—lb. After drying	Loss in drying Lb.	Loss in drying %	Sound garlic Aug. 21 %	Remarks
2	180	25.0	24.5	.5	2	00	Outside of bulb dry.
3½	95-150[1]	41.9	41.5	.5	1	76	Thin skin appeared well dried.
4	140	100.3	97.4	3.0	3	47	Did not appear to be damaged.
5½	120-140[3]	93.6	90.5	3.1	3	78	Thin skin appeared well dried.
6	95-150[2]	125.5	124.1	1.4	1	00	Bulbs appeared cooked.
6	108-130	141.2	114.1	27.0	19	59	Good originally, dried appearance good.
10	110-130	123.0	119.6	3.4	3	89	Occasional bad bulb.
10	120	103.2	100.2	3.0	3	69	Apparently good.
15½	95-130	123.3	118.0	5.3	4	86	Thin skin appeared well dried .
16	100	222.8	217.8	5.1	2	86	Skin and stem dry—badly discolored.
20	130	247.6	233.2	14.4	6	71	Badly discolored.
21½	120-130	250.0	229.1	20.9	8	77	Poor lot.
43	110-130	249.7	234.0	15.7	6	80	Fair appearance.
72	110-130	250.0	227.0	23.0	9	80	Bad lot originally.

[1]1 hour at 150° F.
[2]3½ hours at 150° F.
[3]Started at 120° F. and gradually raised to 140° F.

tained. The lots of garlic that did not decay soon after drying were taken to College Station and stored in an open shed until October. At this time, the loss in weight during storage was determined and the garlic was sorted to ascertain the amount of sound garlic and the amount of garlic that was totally or partially decayed (Table 7).

Drying with experimental drier 1937-1943: The preliminary studies made with the experimental drier (Figs. 6 to 8) in 1936 showed that freshly harvested garlic bulbs would be injured if subjected to temperatures over 125 degrees F. for more than a few minutes. Therefore, in all subsequent tests, care was taken to keep the average temperature of the in-going air about 120 degrees F. There was an average difference or drop in temperature between the in-going and the out-going air of 14 degrees for the seven-year period 1937-1943. This drop was caused by the cooling effect of the garlic and the walls of the chute. The amount of garlic in the chute affected the flow and velocity of the air and this in turn affected the difference in temperature between the out-going and incoming air. Readings taken with an anemometer showed that the velocity of the out-going air ranged from 150 to 300 feet per minute, depending upon how thickly the garlic bulbs were placed on the trays.

Table 5 shows that an average of 16 per cent moisture, on a fresh weight basis, was removed from garlic bulbs when dried at the average temperatures shown in Table 8. The low amount, 7 per cent, removed in 1939 was apparently due to the fact that the bulbs were already partially

Table 8. Temperature of air before and after passing garlic in drier.

Place of reading	1937	1938	1939	1940	1941	1942	1943	Av.
Entrance	125	125	117	116	122	116	126	120.8
Exit	108	109	106	106	114	103	102	106.8
Difference	17	16	11	10	8	13	24	14.0

cured before drying. During this season, the plants were run under with a U-shaped blade (Fig. 9) which cut the roots, loosened the soil under and around the plants and stopped all growth. The plants remained in this position for about a week before they were lifted, topped and the bulbs placed in the drier.

The removal of moisture from garlic bulbs at low temperatures is rather slow as the cloves are enclosed by several layers of thin leaf bases, which fold around and extend over the tops of the cloves to form the stem of the plant. If the stem is fairly green and contains a high percentage of moisture it will require from 20 to 30 hours to become thoroughly dry (Table 4). Large stems about one-half inch in diameter will not always dry thoroughly in this time. The closely-folded condition of the leaves in the stem also prevents moisture from drying out of the thin tissue between the cloves. Unless both the stem and tissues between the cloves are thoroughly dry there is danger of decay. More time is required to dry bulbs which are harvested while the tops are still green than is necessary with bulbs the tops of which have matured and dried enough to cause them to fall over. The green immature bulbs are also more easily injured by the heat than the dry mature bulbs. Immature bulbs often turn a greenish or bluish color after heating, but discoloration will generally disappear if the bulb is thoroughly dried; bulbs harvested before they are well matured are also very susceptible to decay.

The average loss in cleaning was slightly more (1 per cent) for the garlic dried in the drier with hot air than by that dried on wire racks in an open shed or on wire racks in a barn loft (Table 5). This slight difference may have been due to more thorough drying of the outer layers of the bulb and also to the loss of dry soil from the bulbs. Bulbs dried by hot air were easy to clean as the husks and roots were dry and crisp.

The data in Table 6 show that No. 1 garlic bulbs dried by hot air lost an average of 24 per cent from shrinkage when stored for approximately 3½ months. The shrinkage of No. 2 garlic was slightly less than that for

No. 1. Both grades lost more by shrinkage than did garlic dried on the wire racks. The high shrinkage loss which occurred in 1943 was probably due to the garlic being harvested slightly green, to poor drying of the garlic in the drier, and to the high percentage of decay. In loading the trays with garlic in 1943 a large amount of loose shucks and leaves remained mixed with the bulbs and this prevented the free movement of air through the bulbs. As a consequence, the garlic was not thoroughly dried and more shrinkage took place while in storage.

Decay losses in storage obtained by sorting the decayed bulbs from the good bulbs after approximately 3½ months storage show (Table 6) that there was a greater percentage of decay in hot-air-dried garlic than with any other methods of curing. This could have been due, to some extent, to the green bulbs that were not thoroughly dried in the drier.

CHEMICAL TREATMENT OF BULBS PREVIOUS TO STORAGE

In an effort to prevent and control the decay organisms of garlic, some experiments were conducted to determine the effects of various chemicals on the keeping quality of garlic bulbs. A number of samples weighing approximately 3½ pounds were dusted with the following chemicals: Sulphur (Mist Brand), Tennessee tri-basic copper sulphate, powdered alum, paraformaldehyde, Bordow, U. S. Rubber Co. Fungicide No. 20, Cuprocide 54-Y, naphthalene flakes, and fuller's earth. After about three months' storage, a high percentage of the bulbs were found to be in good condition in all of the treatments. U. S. Rubber Co. Fungicide No. 20 caused a black color to penetrate deeply into the interior of the bulb. Cuprocide 54-Y, however, could be removed with the outer scales. Bulbs treated with Bordow were of a bluish color, but in good condition, but a faint odor of the chemical was noticeable. In general, bulbs treated with these chemicals and held in storage did not keep any better than the control selected bulbs.

SELECTION OF SOUND SEED REDUCES DECAY

The statement was made above, that, at the time these studies were begun, farmers were selling their best garlic and keeping for seed the poor unmarketable garlic. This practice, no doubt, resulted in the spread of seed borne decay organisms, and in lower yields. Farmers were urged to select good sound disease-free seed for planting purposes. When the farmers were shown the unsoundness of planting poor seed they discontinued the practice.

Sound, nearly disease-free seed were selected and used each year for planting the experimental block. It required two or three years to build up a stock of sound seed. Table 6 shows that when garlic was cured on wire racks in a shed the average decay after 3½ months storage, for grades No. 1 and 2 was 6 and 7 per cent in 1938 and 1939 respectively. For the period 1940 to 1943 the average decay that occurred during storage was less than 1 per cent. The garlic dried on wire racks in the barn loft for the period 1941 to 1943 averaged 0.4 per cent, a very low loss.

Where garlic was cured by leaving it on the ground in the field and by artificial heat the average decay ranged from 7.5 to 10.5 per cent for the five-year period 1938-1943. The decay that occurred with these methods of curing cannot be attributed to kind of seed planted but to the treatment of the bulbs in the curing process.

FURTHER STUDIES ON GARLIC MOSAIC

An apparently undescribed trouble of garlic believed to be caused by a virus was mentioned earlier (Tex. Agri. Exp. Sta. Cir. 98) as occurring in Texas fields. More recent experiments tend to confirm the fact that this disease is transmitted through the cloves. Consequently, by planting cloves from infected bulbs, the disease is increased from year to year. Table 9 indicates the increase of mosaic in the 1943 crop when cloves were taken from plants showing symptoms of the disease when harvested in 1942, as compared to plants from cloves produced by apparently disease-free bulbs. No satisfactory evidence of the nature of this trouble has been obtained by artificial inoculation nor of the part insects might play in the transmission of the disease.

In two tests on consecutive years, the average weight of bulbs from apparently healthy stock was shown to be better than that for bulbs from mosaic-infested stock. Averaging the data for 1941 and 1942, bulbs from

Table 9. Transmission of mosaic by planting of cloves from mosaic plants.

Condition of cloves	1942		1943	
	Number of plants	Percent mosaic	Number of plants	Percent mosaic
Healthy*	259	5.7	719	18.8
Mosaic	253	51.7	555	66.3
Field run	500	3.0	—	—

*Healthy bulbs selected on the basis of absence of external symptoms of mosaic in the leaves late in the previous growing season.

mosaic plants were 43 per cent lighter than those from apparently healthy plants. It is evident from these figures that considerable loss in yield would occur when a sufficiently large percentage of the plants were infected.

Experiments conducted during the 1942 season dealing with various methods of mechanical transmission of the mosaic symptoms failed to give satisfactory results. Inoculations were made by applying expressed plant juices hypodermically into the leaves and bulbs and by needle prick through externally applied plant juice, by needle prick through diseased leaves, by swabs of plant juice with fine emery dust, and by joining healthy and diseased plants in the field so that exposed inner leaf bases in the necks of the plants were in contact for several months. The examination of cloves from plants thus inoculated in the 1941-1942 season, planted in the fall of 1942, and observed up to harvest time in 1943, failed to establish satisfactory evidence of transmission. This entire experiment, however, was based on the ability of the experimenter to determine healthy from diseased plants by external symptoms alone, hence the masking of symptoms may have caused diseased plants to be included in the apparently-healthy lots used for controls.

RECOMMENDATIONS FOR CULTURE AND CURING OF GARLIC

The methods of culture practiced by the farmer are important in producing high yields of marketable-size garlic bulbs. Various cultural practices to consider include: selection of suitable soil, application of fertilizers, preparation of the seed bed, methods of planting, cultivation, and harvesting.

Soils and fertilizers: Most any land suitable for onion culture is also suitable for garlic. Garlic can be profitably grown on either the light sandy soils or the heavier clay soils. The greater portion of the Texas crop is produced on the heavier soil types common to the Blackland region of Central Texas. Garlic grown on the lighter soils usually requires the application of fertilizer to produce good yields. Fertilizers applied to the heavy black soils in the vicinity of Moulton did not increase yields, however. In areas where commercial fertilizers are necessary, about 300 pounds per acre of a high phosphate fertilizer (such as 4-12-4 or 4-10-7) is usually recommended.

Preparation of seed bed: Land that is to be planted to garlic should be flat broken and harrowed to produce a good seed bed free of large clods and crop residue. Low ridges are thrown up with a middle-breaker if the rows are spaced 20 inches apart (the closer spacing of rows makes for larger per acre yields). Garlic has been found to grow better on ridges than on level land, since the ridges afford better drainage during the

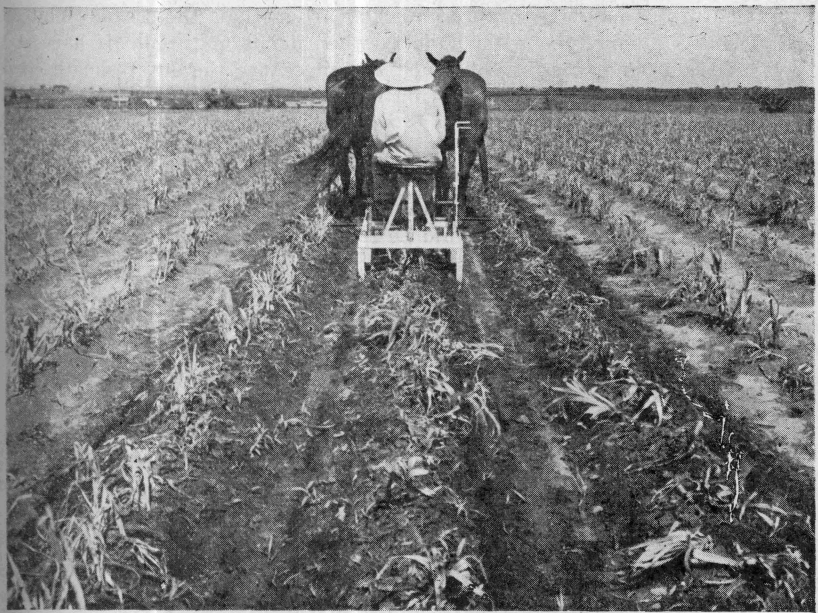

Figure 10. **Garlic digger in operation. This digger had a U-shaped blade that cut the roots and loosened the soil around the bulbs so they could be lifted. The leaves and bulbs lost some moisture and became partially cured when left in dry soil for a few days, following the use of the digger.**

winter. Also when grown on ridges, bulbs are formed near the surface permitting more uniform bulb development and maturity. Bulbs grown deep in the soil often become malformed because of inability to expand in the tight soil.

Planting: In South Central Texas the best yields of garlic are obtained when the crop is planted in October and early November. Generally, the experimental plantings made around the middle of October have resulted in larger yields than the later plantings. This has been especially true of the early Louisiana Italian variety. The bulbs are not separated into their parts (cloves) until just prior to planting, as the cloves tend to dry out and deteriorate rather rapidly if stored for any length of time after separation. Only the sound and disease-free cloves should be selected for planting. From 175 to 250 pounds of seed (cloves) are needed per acre depending on the spacing of plants and the width of row. The amount of seed necessary can be estimated by determining the number of cloves per pound and calculating the length of row this amount will plant at the desired spacing.

In planting, a shallow furrow is opened into which the cloves are dropped by hand, similar to the planting of Irish potatoes. Cloves are dropped from 4 to 6 inches apart in the row, depending upon the variety or size of clove, and covered with about 1 inch of soil.

Harvesting: Texas White garlic is ready to harvest in late May or early June in the Moulton area, after the bulb growth has stopped and most of the tops have turned brown. The Louisiana Italian and Mexican strains mature from two to three weeks earlier than the Texas White. Garlic should be harvested without delay when it has matured. If harvest is delayed, rains or excessive soil moisture may cause the outer sheath enclosing the cloves to rot away allowing the cloves to spread apart—a condition called "splits."

If the soil is loose the plants may be pulled by hand. Where the soil is heavy or the bulbs are deep in the soil it is necessary to plow them out with a sweep or to loosen the soil around the bulbs with a U-shaped blade as shown in Figure 10. Care should be taken to set the digging tool deep enough to prevent cutting of the bulbs.

After the plants have been plowed out or loosened, they are collected in piles along the row. As soon as possible, the tops should be removed and the bulbs placed on racks, under shelter, in a well ventilated place and allowed to cure for about 10 days. They are then ready for cleaning and marketing.

ACKNOWLEDGEMENTS

The Station, and particularly the authors, wish to express their appreciation to Joe Stary, Sr., and his family for their assistance in planting, cultivating, harvesting, and cleaning of garlic used in these experiments, J. T. Jaeggli for his helpful cooperation, advice and use of grading equipment, Edwin Jaeggli for the use of site for the drier, and the Edwards Gas Appliance Company of San Antonio for lease of butane gas system. The authors also wish to thank Dr. A. A. Dunlap and W. E. McCune for their assistance in collecting data and advice in the preparation of this manuscript, and all others who rendered assistance in connection with these experiments.

SUMMARY AND CONCLUSIONS

The data presented in this bulletin gives results of experiments, conducted during the period 1936 to 1943, to find a suitable, inexpensive method of controlling and preventing the decay of garlic bulbs.

A total of 25 strains and varieties of garlic were planted to compare their keeping qualities. A number of well known fungicides were used to treat garlic cloves (seed pieces) prior to planting to determine their effect on stand of plants and ultimate keeping qualities of the bulbs produced from the treated seed. Five methods of curing garlic bulbs were tested and compared in an effort to find a method that would give a uniform high quality of garlic for the market.

Surveys made in 1935 revealed that farmers growing garlic usually made a practice of leaving freshly harvested garlic exposed to the weather, and of selling their best quality and keeping for seed the poor, unmarketable garlic. There was also a tendency to harvest the crop before it was fully matured. These practices resulted in crop and monetary losses to both the farmer and the merchant.

The fungi most frequently obtained in culture from decaying garlic included species of *Aspergillus, Diplodia, Fusarium, Helminthosporium, Penicillium,* and *Trichoderma,* together with *Sclerotium bataticola* Taub. and *Sclerotium rolfsii* Sacc. Bacterial growth of various types were also common in the cultures; *Bacillus carotovorus* L. R. Jones being the only species readily recognized and identified.

Little response in yield was obtained on the black-land soil near Moulton with either 4-12-4, 6-12-6, or 6-18-6 fertilizers applied at 300, 600, and 900 pounds per acre.

Most of the foreign strains either gave poor yields due to small bulbs, or they matured too late to be of commercial importance.

The Mexican and Louisiana Italian strains matured 10 to 15 days earlier than the Texas White variety (commonly grown in the Moulton area) but produced small bulbs and lower yields.

Delayed germination, poorer stands, and lower yields were obtained when sulphur and Cuprocide were applied in the seed furrow before dropping the seed.

Pre-planting treatment of garlic cloves for seed with nine different well known chemical disinfectants appeared in most cases to retard and reduce stands and did not increase yields as compared with stands and yields obtained with non-treated seed pieces.

Garlic decayed less during 3½ months storage when cured 10 to 14 days on wire racks either in an open shed or in a barn loft, than when cured on floor of barn, left in field or cured by artificial heat.

Drying garlic bulbs with hot air required 20 to 30 hours when the temperature of the in-going air averages 120° F.

Temperatures above 125° will injure bulbs, thereby causing increased decay.

Garlic bulbs treated with chemical disinfectants and held in storage did not keep any better than the control bulbs.

Studies of the garlic mosaic disease indicate that the virus is transmitted through the cloves, and that the disease reduces yields. Consequently, all plants with streaked or mottled leaves should be rogued from the field.

To obtain best yields and a good quality of garlic, sound disease-free seed pieces should be planted on low ridges, in October and early November, harvested when most of the tops have turned brown, then cured under shelter on open racks for 10 to 14 days.