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TOMATOES.

By

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NOTICE.

Bulletin No. 107 was prepared especially for the Paris Exposition, to exhibit the extent and character of the experiments conducted by the Alabama Station on the cotton plant. It is termed: "Results of Experiments on Cotton in Alabama," and is a resume of all experiments made by the Station since its foundation, covering a period of more than a decade. The contents relate to

The culture of cotton.
The varieties of cotton.
The fertilization of cotton.
The diseases of cotton.
A list of fungi growing on cotton.
The improvement of cotton by hybridization and selection.
The climatology of the cotton plant.
The chemistry of the cotton plant.

This bulletin was issued in a limited edition and will be sent to those parties who are specially interested in the cultivation of cotton, and it is therefore not for general distribution. However, it will be mailed to any one who may apply for it until the edition is exhausted.

P. H. MELL,
Director.

TOMATOES.

Tomatoes are everywhere recognized as among the most important of garden crops. They are widely grown for home use and for local markets. They constitute one of the principal truck crops that are grown at the South for northern shipment, and in some regions farther north they are grown in immense quantities for canning. In this State they are found in almost every garden, but as a commercial crop they have so far been strangely neglected. A few have been grown for shipment at certain points, but so far as known to the writer not in sufficient quantity to load cars. Our conditions are all fully as favorable as in neighboring states, where tomato growing is a large and profitable industry, except for the fact that our people lack the technical knowledge required for successfully handling this crop on a large scale.

In the following pages it is proposed to give a brief outline of the methods employed by the best commercial growers in this latitude, and at the same time to record the more important results of the experiments with tomatoes made at this Station during the past four years. The topics discussed will include Soils and Fertilizers, Plant Growing, Cultivation and Training, Pruning, Diseases and Insects, Varieties and Marketing.

SOILS AND FERTILIZERS.

Any good cotton or corn land is suitable for tomatoes. Probably the best soil condition is where a red clay subsoil is overlaid by a mellow, sandy loam, but good results can be obtained on quite stiff land if deeply plowed and finely pulverized. It requires more skill to

grow really fine tomatoes on very thin sandy lands than on clays, for in such locations the tendency is for the fruits to run small and to lack firmness and quality. Often the very best results are obtained in moist, but well drained branch bottoms, for while, like cotton, the tomato plant will endure drouth better than most cultivated plants, it needs a uniform supply of moisture to yield maximum crops.

There are few soils in this State rich enough to grow satisfactory crops of tomatoes without fertilization, but a less quantity of fertilizers is required than for such crops as cabbage and Irish potatoes. It should be remembered that with this crop the fruit is the valuable portion, not the modified stem or leaves, and that the fertilization should be such as will promote fruitfulness, rather than a too luxuriant growth of foliage. In other words, the fertilizer for the tomato should be rich in the mineral elements, phosphoric acid and potash, but it should also contain nitrogen enough to promote a free, but not an unduly luxuriant growth. The exact proportions of these ingredients that give the best result on any given soil can only be determined by experiment. On most of our soils the formula given in Bull. 79, page 95, for a general vegetable fertilizer, will give good results. This was three parts cotton seed meal, three parts acid phosphate and one part kainit. From 600 to 1,000 pounds per acre is as much as it will usually be profitable to use. In some localities it would doubtless be better to considerably increase the proportion of kainit.

The land should be plowed quite deeply early in the spring, and should be harrowed thoroughly after every rain, so as to get it in the best possible condition of tilth before planting. Furrows should be opened and the fer-

tilizers scattered and bedded on just as for cotton, but the beds should be run over with the harrow until they are nearly leveled down.

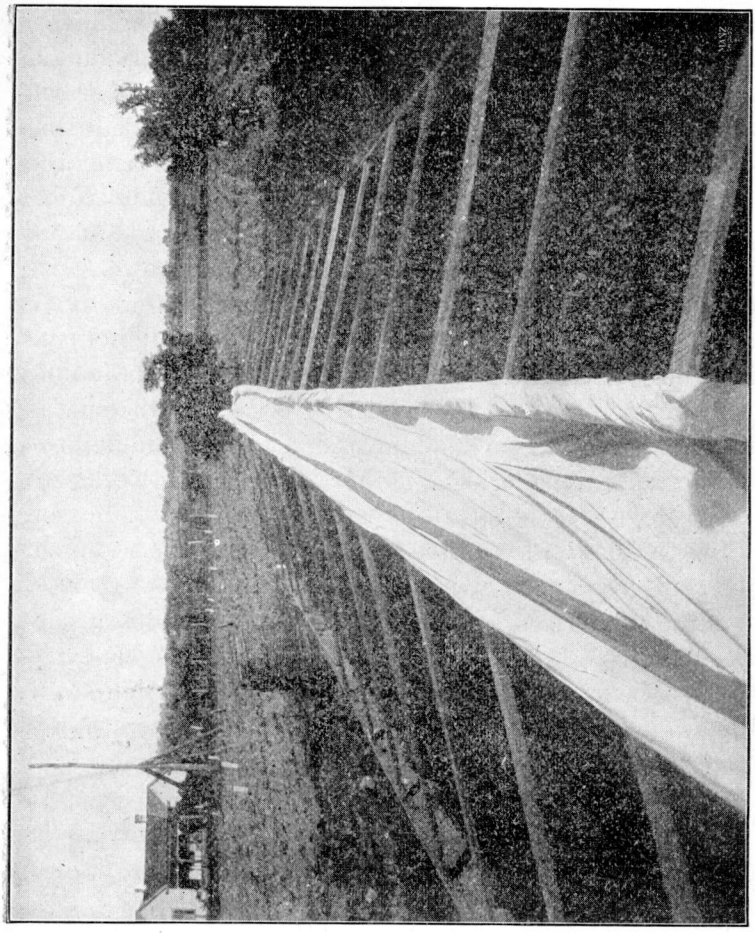
PLANT GROWING.

Seeds planted in the open field do not come on early enough in this latitude to yield profitable crops for shipment. It is therefore necessary to start the plants in hot beds and cold frames* and to move them to the field after danger of frost is over. At Auburn this is usually from the fifth to the tenth of April. Growing plants in cold frames requires some technical skill, and it is here perhaps that inexperienced persons would find most difficulty in producing a tomato crop. Seeds should be planted in a hot bed about the first of February. An ounce of good seed should give plants enough for one acre. The seed may be sown quite thickly, as the plants will be moved as soon as they begin to show a few rough leaves. It is best to plant the seed in drills four or five inches apart. When planted, cover the bed closely and do not open it till the plants are up. Then it will be necessary to ventilate carefully during the middle of every bright day or the young plants may be injured by too much heat. This is done by slipping the sash alternately up and down, so as to leave a three or four-inch crack first at the top and then at the bottom of the bed. Do not uncover entirely so as to expose the plants to cold winds. Glass sash are almost essential for the hot bed, but it will only take a few of them to cover plants enough for many acres. At this time of year very little water will be required. The beginner is likely to make the mistake of over-watering. This should be carefully guarded against, as it is likely to induce damping off. When it

*The methods of building and managing hot beds and cold frames were discussed in Bull. 79, pp. 99-103.

becomes necessary to use water it should be warmed to avoid chilling the young plants. If the disease known as damping off appears, stir the ground between the rows thoroughly and give more ventilation so as to dry out the top of the soil. Keep the bed covered closely at night and during cold cloudy days. Whenever the thermometer threatens to drop below freezing the glass must be covered with mats, sacks, corn stalks or pine straw, as any serious chilling is very injurious. In about a month, that is, by the first week in March, the plants should be big enough to transplant into cold frames. This is best done when they show two or three rough leaves. The little plants are dug up and the roots placed in a shallow dish of water to prevent drying and to cause the dirt to stick to them closely, when they are replanted. In the cold frame the plants are set five to six inches apart each way, taking care to keep them in straight rows. This is done by using a marker made from a stick as long as the frame is wide, with little pegs nailed on it at the right distance for the plants. By pressing these pegs into the soil an entire row is marked and by placing the end of the marker against the same side of the frame each time, the plants will row accurately in each direction. This is important in taking them up to move to the field. The little plants should be watered lightly when set and should be shaded for two or three days by keeping the cloth curtains down. After they have had time to strike root in their new location the curtains should be rolled up during every bright day to give the plants as much sun as possible, but they should be covered again before sun down. Water should be given very sparingly during cool, cloudy weather, but as the plants begin to grow rapidly and the weather gets warmer they will need much more frequent waterings. No specific directions can be given

for the care of the plants. Watering and ventilation are the two important factors and these must be left to the judgment and watchfulness of the grower. It should be remembered that the tomato is a native of a warm climate, and that it should be protected from all chilling influences. In cool weather always water during the middle of the day so that the chill will be felt as little as possible. In freezing weather, of course, the beds must be kept tightly closed. Most commercial growers use cotton cloth for covering cold frames, as it is much cheaper than glass, and is much easier to handle in opening and closing the beds. Ordinary unbleached, double-width or ten-fourths wide sheeting is used. One side is nailed fast to the back side of the bed or in double beds to the ridge pole, and the other is nailed between two one by two-inch strips, thus making a square roller on which the curtain is rolled up when it is wished to open the bed. By starting with one short and one long piece, so as to break joints, such a roller can be made any desired length. It will be necessary to provide some extra cover for each cold frame to use on very cold nights, for the single thickness of cloth will not turn more than a slight frost. The beds should always be well banked at the ends and sides with earth.



Photograph of a double cold frame 12 ft. wide, showing the curtains partly rolled up.

The hot bed is usually located near the house or barn, where it will be easiest to give it proper attention, but the cold frames should be scattered about in the fields, in order to save labor in carrying out the plants when planting. A double bed, twelve by sixty feet wide, will hold plants enough for an acre of ground and if located in the center of an acre cut, none of the plants will

have to be carried any great distance. Such a frame is shown in the accompanying photograph.

The soil for the cold frame should be covered one to two inches deep with well rotted stable manure, and should have a liberal dressing of acid phosphate and kainit, all to be well worked in and thoroughly mixed at least ten days in advance of planting. If the stable manure is not at hand fairly good results can be secured with commercial fertilizers alone in the cold frames. Use about two buckets of the complete mixed fertilizer to each double sixty-foot bed. It will be a saving of labor to plow the ground and thoroughly harrow in the fertilizer before building the frame.

If the plants have been successfully grown, by the first week in April they will be ten or twelve inches high and will be beginning to bloom. It is now necessary to rush them to the field as fast as possible. A few hours before each bed is needed, water it heavily, so as to thoroughly soak the ground. Take off the cloth covers and store for use another season; knock down the frames and haul off the lumber. With a long bladed butcher knife cut down between the rows of plants in each direction, thus checking the bed into six-inch squares with a plant in the center of each. Provide several light hand barrows made of two light strips seven feet long for handles with a platform of half-inch boards nailed across them. These boards should be cut thirty inches long and should cover the middle of the handles for about four feet. With a sharp spade the squares of wet earth with the plants are carefully lifted and are placed snugly together on this hand barrow. Two men now pick it up and carry it to the rows that are being planted. The ground having been previously fertilized and bedded, the beds are now opened deeply with a solid sweep or wide shovel, a few at a time, so that the plants

may go in the fresh furrows. The bearers lift the plants with a flat shingle or a mason's trowel and place them about three feet apart in the furrows. Other hands follow with hoes and draw the earth carefully about the plants. When all is properly handled very few of the squares of earth will crumble enough to expose the roots and plants can be removed even in quite dry weather without wilting or scarcely checking their growth. It is not necessary to use water when planting, except in watering the beds, as already described.

CULTIVATION AND TRAINING.

Cultivation should begin as soon as the plants are set. Nothing seems to help them to strike root and begin to grow so much as an immediate stirring of the soil. A five-tooth cultivator is usually the best tool to use in the tomato field, though the cotton scrape is also useful. One of these tools should be run through the rows at least once a week from the time of planting till the crop is ripe. This, with an occasional hoeing to kill weeds and break any crust that forms in the row will be all the cultivation required.

In the garden various devices are resorted to for supporting the vines and keeping the fruit off the ground. In the field nothing has been found practical except a light stake driven in the ground near each plant at time of planting, to which the plant is tied.

Some growers keep the plants tied to these stakes from the start, tying them three or four times or more, as necessary. Others let them lie on the ground till the fruit is nearly grown, and then lift and tie them, claiming that besides saving labor the lifting and disturbing of the vines tends to make the fruits ripen faster. On clay soils this staking and tying is quite necessary as in

rainy seasons much of the fruit will rot before ripening where it touches the ground. On sandy land there is much less trouble from this rot from contact with the soil, and it is quite permissible to save the expense of staking and tying and let the plants sprawl on the ground. Where the system of pruning to a single stem is followed that is described in the next paragraph, two plants are sometimes tied to a single stake, the two plants being set about eighteen inches apart, with wider spaces between each group of two. In all cases the stakes should be driven as soon after planting as possible. If this is delayed till the roots get started, some damage may be done to them.

PRUNING.

By pruning commercial growers mean the pinching out of all lateral branches as soon as they appear, thus confining the growth strictly to one stem. When about three clusters of fruit are set the vines are topped, thus stopping all farther growth of vine, and turning the energies of the plant entirely to the growth and maturing of the fruits that are already set. The advocates of this system claim that it greatly increases the size of the individual fruits and that the bulk of the crop ripens several days earlier than on unpruned plants. Of course each plant produces fewer fruits than when allowed to grow unchecked, but this is partly compensated for by increased size and by the closer planting that is possible on this system, thus allowing a greater number of plants to the acre. In several of the more important tomato growing regions this system is very widely followed. During 1897 and in 1899, pruning experiments were tried at this Station. In both years the crop was so much injured by the boll worm and by the black rot as

to largely vitiate the results. In both seasons, too, the plants were injured by unfavorable weather. It is therefore not deemed expedient to publish the results in detail, but in both cases the pruned rows gave decidedly heavier early pickings, and the average weight of the fruits was from five to fifteen per cent greater. The few other stations * that have experimented with this method of pruning all report earlier maturity as the result, and the opinion of commercial growers who have practiced it is so unanimously in its favor that we must admit the fact as established that pruning is profitable and advisable wherever earliness and size are of more advantage than total weight of crop. It is perhaps still an open question whether or not under southern conditions pruning does not really increase rather than decrease the total yield aside from its other admitted advantages. In the first place it allows much closer planting, the increased number of plants per acre offsetting the supposed lighter yield per plant. Again, on lands that are infested with either the Bacterial Wilt or the Sclerotium Wilt the earlier maturity caused by the pruning may secure a partial crop before the death of the attacked vines, while without it the crop on such vines would be a total loss, and there are probably few tomato growing regions in the South where one or the other of these troubles is not present. It was hoped that the experiments mentioned above would throw some light on this question of the total yield of pruned and unpruned plants, but as in each case fully half of the crop was destroyed by the combined ravages of the black rot and the boll worm it seems unsafe to draw any conclusions from the results obtained. In fact, it is useless to attempt plot experiments with tomatoes until we learn

*See Tenn. Station Bull. for Nov. 1892 and Oct. 1893, and Also Louisiana Station Bull. 22.

how to better control these two seriously disturbing factors. If it were possible to make plots large enough to fairly equal commercial conditions then the losses from these sources could be safely ignored, but not otherwise, and this is beyond the means of most experiment station workers. Further experiments are greatly needed to determine the best distance to give pruned plants, in order to secure maximum yields per acre, and also to determining the results from topping at two, three or four clusters as compared with pruning, but not topping.

To secure the best results from pruning it is necessary to go over the plants as often as once in five or six days in order to remove the laterals before they get more than an inch or two long, and when they can be pinched out by the thumb and finger. If they are allowed to remain until they develop leaves and woody tissues, it is of course done at the expense of the other parts of the plant, and we have in part defeated the very purpose for which we prune. Furthermore, the removal of a considerable quantity of leaves by a belated pruning may derange the balance between root and leaf surface, thus causing injury. The effect of pruning can be very quickly noticed in the increased size and deeper color of the leaves and in the rapidity with which the fruits set and grow. There is often great complaint among tomato growers that the early clusters of flowers do not set fruit. This is very apt to be the case where plants are making a rapid growth and the weather is at all unfavorable. On pruned plants this loss is very largely avoided. The first clusters almost always set perfectly and this probably explains in part at least the heavier early pickings as the result of pruning.

The practice of pinching to a single stem seems to be a rather common one with experimenters on tomatoes

under glass, but in field culture it has attracted less attention from experiment station workers than its importance deserves. Most of the references to tomato "pruning" in horticultural literature are found to refer to topping the vines to promote branching, or to some other practice than that now under consideration.

DISEASES AND INSECTS.

[Under this heading only the more important tomato insects and diseases that are known to occur in this State will be discussed.

Boll-worm (*Heliothis armigera Hubu*): This is the same insect so often found in ears of corn and that later in the season bores into and destroys the cotton bolls. It is the larva of a dull colored, inconspicuous, night flying moth. The eggs are laid on the leaves and young fruits. In a few days they hatch and the young worms for a few hours at least crawl and feed on the surface of the plant. During this time it is possible to kill some of them by spraying with Paris green or other arsenical poisons. To be effective such spraying must be done just as the eggs are hatching. No sufficiently careful experiments have been recorded to show what proportion of the worms can be killed in this way. Certainly not all of them, for they so soon bore into the young fruits, where they are safe from poisons. One or two properly timed sprayings will probably pay in combating this insect, but spraying alone can not be depended upon. In this latitude the worms begin hatching early in May. In 1899 the first were noticed on May 13th.

The piercing of the cuticle of the tomato by the worm in making his entrance to the fruit usually serves to introduce germs that sooner or later cause a wet rot. This is not pleasant to the worm, as he perfers sound to rotted fruits. He soon backs out and bores into another

fruit, carrying, of course, the rot germs with him. This process is repeated again and again, so that one worm often destroys a dozen or more fruits. This indicates the necessity for picking and removing from the field all wormy fruits as soon as detected, thus preventing further injury on the part of the worms thus captured. This hand-picking, if faithfully done three or four times a week, will do more than anything else to minimize the loss from this pest, which frequently amounts to a half or more of the early crop. Planting corn as a trap crop is the remedy usually recommended for this worm in the cotton fields, as it is said the female will lay her eggs in fresh corn silks in preference to any other food crop. This is also sometimes recommended for tomatoes, but it is difficult to have corn far enough advanced to give much protection from this first brood, that is the one usually causing most loss to the tomato grower.

Tobacco Worm (*Phlegethontius Carolina*): These large green, repulsive larvæ are frequently seen on tomato plants. They are such gross feeders that if only a few are present they soon do very serious harm. They are so conspicuous that they are easily destroyed by hand picking, and this is usually the only remedy employed against them. When pruning the vines it is an easy matter to search out and kill these worms when evidence of their presence is observed. If Paris green is used for the boll worm it will be effective against these also.

Flea Beetle (*Phyllotreta vitata Fabr.*): This is a minute dark colored, actively jumping beetle that sometimes does considerable injury by feeding on the underside of the leaves. It eats minute pin holes in the leaves, sometimes fairly riddling them like lace. When the weather is favorable and the plants are growing rapidly they usually do but little damage, but in cold, cloudy weather

early in the season they sometimes give the plants a very serious check. The most damage is usually done either in the cold frame or soon after the plants are set in the field. It is thought that their injuries to the leaves often serve to enable *Alternaria solani,* the fungus causing target board spots on the leaves, to gain a foothold. It has been observed that these beetles do not attack leaves that have been coated by a spray of Bordeaux mixture, so that this spray has come to be the recognized remedy for them. It does not kill the insect, but simply acts as a repellent.

Cut-worms (various species): Where the land is infested with cut worms they often do great damage by cutting down the plants when first set in the field. Occasionally they are also troublesome in the cold frames, but here it is an easy matter to dig them out and kill them. If it has not been discovered that the land is infested until the plants are set in the field this hunting out and killing the worms by hand will be the only recourse. The worms feed at night and seek shelter by burrowing into the ground by day. A worm seldom travels far from the place where he had his last meal, so when a freshly cut plant is found it is usually easy to locate the worm by a little digging. It is often necessary to go over the field of newly set plants every morning to search out and kill the cut worms.

Fall plowing is said to do much toward ridding the land of these pests, but in the South this is not always permissible on account of the increased washing and leaching of the soil during our heavy winter rains. Probably the best means for killing cut worms is by the use of poisoned baits scattered over the field a few days in advance of planting. Some cabbage leaves or other similar "greens" may be plentifully sprinkled with

Paris green and dropped over the field, or if nothing of this kind is at hand, a bran mash, poisoned with Paris green and sweetened with molasses may be used instead, dropping a spoonful at frequent intervals. To be effective this must be done in advance of planting, otherwise the worms will prefer the tomato plants to the baits.

Nematode Root Knot (*Heterodera radicicola*): This dreaded pest of southern fields attacks cotton, many kinds of garden vegetables and some fruit trees. It causes little knots or swellings on the roots, finally causing them to rot and thus killing or seriously injuring the plant. It is often found on tomato roots and frequently causes their premature dying. The tomato is, however, a plant of so much natural vigor that it usually succeeds in ripening at least a part of its crop before it succumbs to the nematode attacks. Pruned plants, on account of their earlier maturity, usually suffer less than unpruned ones.

Where the microscopic worm causing this trouble is established in a field no means is known for destroying it except by starving it out by not allowing any of its food plants to grow on the land for at least two years. For a further discussion of this subject see Bull. 107, under the head of cotton diseases.

Black Rot or Blossom-end Rot (*Bacillus* sp.): In this state this well known disease probably causes the loss of more fruits even than the boll worm and should be given first place among the enemies of the tomato grower. Spraying with Bordeaux mixture has been widely recommended as a remedy for this disease. In 1896 an elaborate experiment was undertaken in which certain plots of tomatoes were thoroughly sprayed as many as ten times with Bordeaux mixture, beginning when the first rough leaves were formed, and continuing

till the ripening of the fruit. The treatment did not have the slightest effect in controlling the disease. As large a proportion of the fruits rotted on these excessively sprayed plants as on the checks that were not sprayed at all. This, and somewhat similar previous experiences led to the belief that the usually accepted theory, that the disease was caused by certain fungi frequently found in connection with it, was incorrect. A search was accordingly begun for other possible causes and as the result of studies extending over the past three years, it has been quite certainly proven that the disease is bacterial, not fungal, being caused by the growth of an undetermined species of *Bacillus*. The results of these studies were embodied in a paper read before the Botanical Club at the recent Columbus meeting of the American Association for the Advancement of Science. As this paper has not been printed, it is here reproduced in full, as giving my present views regarding this disease.

The "Black Rot" or "Blossom-end Rot" has been familiar to the writer since boyhood as a destructive disease of the tomato. The first careful account of it that we have seems to be by Galloway in his Annual Report, as Chief of the Division of Vegetable Pathology for 1888, pp. 339-343. He says that "specimens of this [disease] have been received from all parts of the United States where the tomato is grown." He gives a good description of the later stages of the disease with a colored plate; and states that *Macrosporium Tomato* Cooke. and *Fusarium Solani* Mart. are so constantly associated with the disease that they must be considered as the probable cause. His cultural experiments, however, showed that the latter species could not attack the healthy tissue of a green tomato, but that it developed abundantly on ripe fruit or on injured tissue of the green fruit. The *Macrosporium* was unable to penetrate the uninjured epidermis, but he found that it grew abundantly when the spores were inserted beneath the cuticle of either green or ripe fruits. In his

report for 1889, p. 418, the same author gives some encouraging results in preventing this disease by spraying with Bordeaux mixture from some experiments at Greenville, S. C.

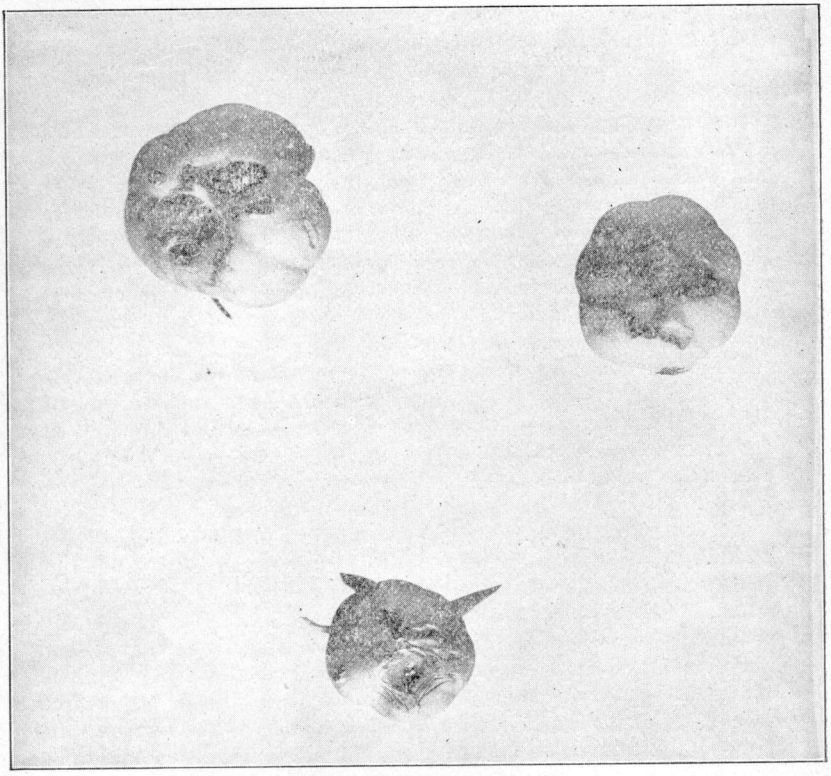
Since this time, brief mention of this disease has been made in the publication of many of the Experiment Stations. *Macrosporium Tomato* has been given as the cause except where through error *Macrosporium Solani* has been named instead; and spraying with Bordeaux mixture has been recommended as a remedy. In a rather hasty review of the literature, I find very few instances where the results of actual experiments with this disease are recorded. In fact no new light seems to have been thrown on the subject till the investigations of Jones and Grout, published in the Annual Reports of the Vermont Experiment Station for 1895 and 1896 and more in detail in Bull. Torr. Bot. Club 24: 254-258 (May, 1897). These authors show conclusively that the so-called *Mascrosporium Tomato* Cke. is only a form of a widely occurring saprophyte found on many kinds of decaying vegetable matter, and known under many names, *Alternaria fasciculata*, (C. & E.), Jones & Grout, being the one finally adopted for it by them. They state positively that this fungus is not the cause of the tomato rot, since when pure cultures of it are introduced under the skin of healthy green tomatoes it invariably fails to grow. Unpublished experiments of my own, made during 1897 and 1898 fully confirm this opinion. In no case have I succeeded in getting a growth of this fungus by inoculating sound green tomatoes with a pure culture.

When tomatoes are attacked by this disease in the field, the first stage to be noted is the appearance of a small, irregular watery area, usually, though by no means always, surrounding the remains of the pistil. This watery spot resembles somewhat the condition known as "Water Core" in apples. On making a cross section this watery condition is found to be confined to the portion immediately under the skin. It usually does not involve the tissues to any great depth even after it has extended so as to cover a considerable surface area. Growth of the fruit over the infected area stops so that after a few days the spot seems somewhat sunken. If the tomato is nearly ripe, maturity will be hastened and the watery spot may dry down so as to look as if the fruit had been slightly seared with a hot iron. The greater number of infections take place when the fruit is about an inch in diameter. Such fruits are utterly ruined. The disease may invade the entire surface, causing them to fall, or the premature ripening of the lower portion may arrest it, when the partially dried diseased portion often becomes blackened by a velvety growth of the *Alternaria*.

The peculiar watery appearance of the first stages of this disease long ago suggested to me the idea that it was possibly caused by bacteria, but no steps were taken to verify this hypothesis till June of last year (1898). One morning while walking through the tomato field while the plants were still moist with dew some half grown rotted fruits were observed that seemed to be smeared with a sticky exudation. On further examination, all the fruit showing the disease in about this stage of advancement, were found to show more or less abundantly drops of this sticky exudation. The appearance at once suggested the well known sticky exudate on blighting pear trees, and revived in my mind the theory of the bacterial nature of the disease. As the dew dried off the drops of exudate dried down to a hardly noticeable glaze. On taking specimens to the laboratory this exudate was found to be swarming with bacteria. As the writer was prepared for a somewhat extended absence, the rotted fruits were taken to the Veterinary Laboratory, where my colleague, Dr. C. A. Cary, kindly undertook to make some cultures for me. The exudate yielded an almost pure culture of a bacillus. The same germ was found abundantly within the diseased tissues. Sound green tomatoes under a bell jar were inoculated with a pure culture prepared from the exudate. In all cases they showed signs of rot in twenty-four hours. When Agar containing the germs was smeared on the surface of sound tomatoes, no rotting took place even after a number of days. Puncturing the skin through the Agar would promptly induce rot.

After my return the matter was not taken up till the middle of September, when an Agar tube of the pure culture from the exudate was secured from Dr. Cary and further inoculations were made under bell jars and in the field till no doubt remained that the bacillus in question was abundantly and promptly able to cause a destructive rot of tomatoes. At this time the disease was entirely absent in the fields as it was noted to be in the Fall of 1897.

The rot induced by inoculation did not in all cases exactly resemble that occurring naturally, the act of inoculating seeming to introduce the disease more deeply in the tissues. A very shallow scratching of the surface was resorted to and a few very characteristic cases were secured, though such shallow inoculations more often dried down and failed to take.



Three tomatoes inoculated with black rot germ from laboratory cultures kept over winter. Inoculated May 12, photographed May 15, 1899.

Fresh Agar tubes were prepared on November 8, 1898, and allowed to stand till May 8, 1899. Although completely dried down, the vitality of the germ was uninjured and fresh tubes were soon growing, inoculated from these old ones, that were used for further field and laboratory tests. Without going into details the following facts seem pretty well established.

The disease can not be contracted through the flowers as is the case in pear blight. The stigmas of many open flowers were smeared with cultures of the germ without inducing a single case. In no case were inoculations successful where the fruit was less than 1 centimeter in diameter. In 1898 the disease was very abundant and destructive and great numbers of some species of Thrips were observed running about over the diseased and healthy fruits, frequently smearing themselves with the sticky exudate. In 1899 compara-

tively few of the Thrips were to be seen and there was less rot than I have known for many years.

In my experience, extending over a number of years, Bordeaux mixture has always failed to give any marked result in controlling this disease.

It is a well known fact that when a larva of the boll worm eats its way into a tomato, the injury is often followed by a watery rot. The worm does not like this and backing out, he bores into another tomato, which rots in turn, and the process is repeated till the same worm may have destroyed a dozen fruits. This rot is caused by the same Bacillus that causes the blossom-end rot, and the injury is more like that produced by a deep inoculation in the laboratory. Where the rotting material from a wormy tomato drops on one below that is weather cracked, that will rot also.

These are the main facts observed in regard to the effect of this germ on the tomato. Owing to lack of time and the pressure of many duties its botanical characters have not been carefully worked out and no attempt has been made to decide whether or not it is a described species.

The following facts in regard to it have been noted:

It is an actively motile rod shaped Bacillus of medium size, with nothing peculiar in its appearance. It stains readily with all the usual stains. No spore formation has been detected. It grows readily on the flesh of sound green tomatoes, causing rot, but it can not penetrate the cuticle unaided. It grows on ripe tomatoes, but less readily than on green ones. It grows feebly and to a very limited extent on raw Irish potato, but it grows readily on boiled potato, soon covering the surface with a yellow slime. It fails entirely to grow on strawberries, apples, Kohl Rabi, cabbage, onions, and sweet peppers. It develops rapidly on the surface of ordinary peptone Agar, forming a white pelicle that becomes cream yellow and somewhat wrinkled with age. It seems to be strictly ærobic, developing only on the surface of the culture medium. It grows very slowly in litmus milk, after five or six days developing a slight acid reaction and finally separating the casine Its behavior on gelatine has not been determined.

These fragmentary studies seem to point to the following conclusions:

1st. That the cause of the "Black Rot" or "Blossom-end Rot" of the tomato is a Bacillus and not any of the filamentous fungi found associated with its later stages.

2nd. That the method of infection in nature has not been fully determined, but that the agency of some minute insect is probable, since infection cannot take place through the flowers, nor by the unaided action of the Bacillus on the cuticle of the tomato. A small,

rather than a large insect, is indicated since the character of the disease is such as is produced by surface abbrasion, not by deep puncturing of the fruit. The strictly ærobic nature of the germ seems to confine its injury to the surface layers, except where air is admitted to the interior by deep wounds or punctures.

3rd. That some species of Trips has been observed in suspicious connection with the disease, but that its agency in spreading it has not been proven.

4th. That when this Bacillus is carried deeply into the tomato with an open wound, as is done by the Boll Worm, the result is a wet rot, quickly involving the entire fruit.

5th. It follows from the foregoing that in seeking a remedy for these rots, we should look among the insecticides, rather than among the fungicides, first determining fully what insects are instrumental in conveying the infection.

Experiments are planned for the coming season to demonstrate the agency of the Thrips in distributing the bacilli and inducing the disease; and the attempt will be made to control the rot by destroying or driving away the Thrips.

Bacterial Wilt (*Bacillus solanacearum*, E. F. Smith*): Also called Southern Tomato Blight and Bacteriosis. This serious disease of the tomato has so far only been observed in the southern part of the State. It is very destructive in Mobile and Washington counties. It is caused by a germ that grows and multiplies in the vascular bundles of the stem, finally plugging up the ducts so as to cut off the ascending water current and thus causing the sudden wilting of the entire plant. A plant that, to the casual glance, seems perfectly healthy today may be wilted and practically dead by tomorrow. A careful examination of such a plant will show a section of the stem usually just above the ground that looks watery and on cutting it open the water ducts of the vascular bundles will be browned and discolored. When

*A Bacterial Disease of the Tomato, Egg-plant, and Irish Potato, by Erwin F. Smith, Bull. 12, U. S. Dept. of Agr. Div. of Veg., Phys. & Path., Dec 1896.

once established in the soil the contagion persist from year to year so that each succeeding crop suffers worse than the last. A careful rotation of crops seems to be the only remedy for this disease and in regions where it prevails great care should be taken not to plant tomatoes on land where either tomatoes, peppers, eggplants or Irish potatoes grew the year before since all of these plants and some solanaceous weeds are subject to the disease. There are no exact experiments to determine how long the contagion can exist in the soil if none of these food crops are present. There is reason to believe, however, that more than one year must elapse before it is safe to plant these crops again on soil that is once infected. Dr. Smith has shown (l. c. p. 22) that the disease may be conveyed from plant to plant by insects, their bites or punctures serving to inoculate healthy plants with germs from the diseased ones. After describing some experiments where the disease was carried to healthy plants by allowing Colorado potato beetles to feed on them that had previously been feeding on diseased plants, he says: "Just what insects are most instrumental in disseminating this parasite in any particular locality can be determined only after a prolonged and careful study of the disease in the field. No experiments have been made with other insects, but it is likely that flea beetles, blister beetles, chrysomelids and many other leaf eating insects may act as carriers of the disease.

"No experiments have been made to determine whether this bacillus can gain entrance to the plant through an uninjured epidermis. Most of the infections probably occur above ground and as the result of insect injuries. Very likely there are some underground infections."

As this disease does not occur at Auburn, the writer has had no recent opportunity of studying it, but as the result of rather wide experience with it in Mississippi, I am of the opinion that direct underground infections do take place as suggested by Dr. Smith in the closing sentence quoted above, and that probably they are the usual mode by which it spreads. Contagion carried by winged insects may well be the means by which the disease first becomes introduced to new fields, but this method of infection can hardly account for the spread of the disease from year to year in somewhat regular concentric circles from such new centers, especially as it usually takes almost every plant in its path. Insect infection would not either account for the facts reported by me in the 6th Ann. Rept. of the Miss. Station, pp. 53-61, where, in a large tomato field that was under observation, the disease was very largely confined to a narrow strip of wet, seepy land, running diagonally through it, while the drier land on either side was nearly exempt.

As the disease is thus so markedly a soil disease, the possibility of soil treatment as a remedy at once suggests itself. Very few experiments are recorded in this direction. In the Mississippi experiments mentioned above in one case heavy applications of kainit seemed beneficial and in another case there was apparent benefit from the use of lime. Marked benefit also seemed to follow the use of lime in an experiment at Deer Park, Ala. (See Ala. Bull. 92:109.) These experiments, however, need confirmation. Sulphuring the soil does not seem to have been tried. Spraying the plants and the surface of the ground with Bordeaux mixture gives no result. (See also Rolfs in Fla. Bull. 47:135.)

There seems to be some slight difference among varieties in power to resist this disease. I have observed that

Dwarf Champion seems to have some power of resistance, and Rolfs (l. c. p. 134) notes the same thing of Dwarf Golden Champion and Ford Hook Fancy, also in a marked degree in a tomato-egg plant hybrid. This is an interesting field for further investigation.

Sclerotium Wilt (*Sclerotium sp.*): Also called Fungus Blight and Florida Blight. This disease manifests itself like the last one by a rather sudden wilting of the plant. Although the effect is much the same, the cause of the disease in the two cases is very different. Here we have to do with a filamentous fungus, the sterile mycelium of which lives on decaying vegetable matter in the soil and under certain conditions is able to attack the underground portion of living plants. If a plant attacked by this disease is pulled up the smaller roots will be found to have rotted away and the larger ones will be covered by a more or less conspicuous white mould-like coating. In wet weather, or when the diseased roots are placed in a moist chamber, numerous small brown balls as large as a pin head are formed on this white mycelium. These are the so-called sclerotia and consist of closely compacted fungus threads. They perform the function of reproductive bodies, and are very resistant to unfavorable conditions, retaining their vitality for long periods. In one case a rotted tomato fruit was found lying on the ground that was completely covered by these sclerotia. It was transferred to a four-inch pot filled with soil and was placed under a bell jar on my laboratory table, where it remained for over a year. The pot was watered occasionally so as to keep a moist atmosphere in the hope that the fungus might be induced to develope some other fruit form. The sclerotia remained entirely unchanged for twelve months, when a small Irish potato was placed in the pot in contact with them. Stimulated by the presence of this fresh food supply they promptly germinated and quickly enveloped the

potato in a white coating of mycelial threads, which in turn, as the food supply became exhausted, developed a fresh crop of sclerotia.

This disease was first studied by Prof. P. H. Rolfs while connected with the Florida Experiment Station, and he has written practically all that has been published regarding it.* In his experience with the fungus, both in the laboratory and in the field, covering a period of several years, he never succeeded in detecting spores or reproductive bodies of any kind other than these sclerotia. Such sterile sclerotia-forming fungi are placed in the form genus *Sclerotium*, but this one seems never to have received a specific name.

This disease is by no means confined to the tomato. Rolfs has published a long list of hosts for it in Florida. In this State it has been detected on tomatoes, Irish and sweet potatoes, beans, cow peas, peanuts, beets and strawberries. It is doubtless conveyed direct from the soil to the roots of the plant. How long it may persist in the soil if deprived of any of its numerous host plants has not been determined. The fact that it attacks so wide a range of plants makes it difficult to arrange a proper rotation for soils infested by it. It does not, however, attack corn, sorghum or the small grains. Vetch, growing as it does during the winter and early spring while this disease is dormant, will probably escape and so far it has not been detected on the velvet bean.

While this is a very troublesome and probably quite a widely occurring disease in this State it does not usually wipe out entire fields as is the case with the bacterial wilt, but is scattered about in somewhat restricted areas. It seems to spread more rapidly in wet weather and where the vines are so rank as to completely shade the

*See particularly Annual Report for 1896, pp. 38-47; also Bulletins No. 21 and 47.

soil. Rolfs states that spraying the ground along the row with a soluble fungicide like potassium sulphide or ammoniacal carbonate of copper is effective in controlling it while the solid particles formed in Bordeaux mixture do not penetrate the earth deeply enough to do any appreciable good.

In 1896, supposing that we had the bacterial wilt to deal with, a rather elaborate experiment was planned that yielded some interesting results although the expected disease did not appear and this one was present to only a limited extent.

Eight plots were prepared as follows: All were fertilized alike with acid phosphate and cotton seed meal at the rate of 200 pounds of each per acre. Plots 1 and 5 received in addition kainit at the rate of 1500 lbs. per acre. Plots 2 and 6 received lime at the rate of 1500 lbs. per acre. In plots 3 and 7, Bordeaux mixture was poured along the furrows that were opened for planting. Plots 4 and 8 were checks and received no treatment. One row on each plot was planted to Irish potatoes, one to peppers and eggplants, one to Dwarf Champion tomatoes and one to Acme tomatoes. These plants were grown in specially prepared seed beds the soil in which had been treated with kainit, lime and Bordeaux mixture respectively. The plants in the seed beds had been sprayed with these substances at intervals from the time that they first came up and the sprayings were continued in the field so that each lot received in all ten sprayings with kainit solution, thin whitewash and Bordeaux mixture respectively. As stated above the Bacterial wilt did not appear but there were several cases of Sclerotium wilt especially in the potatoes. Black rot was abundant and the Alternaria leaf blight (see p. 32) was present in both tomatoes and potatoes so that an opportunity was offered for studying the effect of these treatments on these three diseases. As stated on page 20, no appre-

ciable effect could be observed with the black rot, the fruits on all the plots rotting freely with the greatest impartiality. The Bordeaux mixture largely prevented the Alternaria leaf blight. On May 28, only 7½% of the plants on these plots were affected by it while on the other plots there was an average of 19% affected.

On April 29, one or two potato plants were observed to be wilting on the first kainit plot. On May 5, there were 3 wilted potato plants on the first kainit plot and 4 on the second kainit plot and 1 on one of the checks. On May 21, one wilted tomato plant on one of the checks. On May 28, out of 104 hills of potatoes on the kainit plots 30 were wilted, while of 393 hills on all the other plots only 20 were wilted, or nearly 29% on the kainit plots and only slightly more than 5% on the others. On July 23, when the potatoes were dug, only 10% of the stalks were alive on the kainit plots and an average of 38% were alive on the others. The yield of tubers was 60% less on the kainit plots. At this date 43% of the potato plants on the Bordeaux plots were still alive, thus showing them to be slightly better than the average.

The predisposition on the part of the potato plants to take the disease on the plots that had been over fertilized with kainit was an entirely unlooked for result, especially as potatoes are supposed to require a fertilizer rich in potash. Curiously enough the tomatoes were not so affected. The following notes on their condition were taken on July 23.

"At this date the tomato plants are beginning to fail rapidly. A few have died from the wilt and a few from nematode root knot. The foliage of the lime, Bordeaux and check plots is in about equally poor condition. The kainit plots are decidedly the best, some of these plants still growing quite vigorously. Eggplant and peppers are all healthy."

"The three striking results of the experiment are the

beneficial effect of the kainit on the general health and longevity of the tomatoes, the marked effect of the Bordeaux in controlling the Alternaria leaf blight on the potatoes, and the totally unexpected and unaccountable failure of the potatoes on the kainit plots."

Alternaria Leaf Blight (*Alternaria Solani* (E. & M.) Jones and Grout.) Also called Macrosporium Blight, Target-board disease and Early Blight. This well known disease of tomato and potato foliage causes circular deadened brown areas on the leaves that are usually marked by concentric circles of a darker color. This appearance has suggested the name of Target-board disease that is sometimes applied to it. In severe cases it causes the falling of the leaves and the consequent premature death of the plant. It has not been very troublesome at Auburn though traces of it have been observed almost every season. It was more conspicuous in 1896 than in any of the subsequent years. The injuries to the foliage caused by the flea beetle often seem to aid this fungus in gaining a foot hold on the leaves. Bordeaux mixture is the recognized remedy for this disease on either tomatoes or potatoes and three or four sprayings early in the season will usually protect the plants effectively.

Septoria Leaf Blight (*Septoria Lycopersici* Speg.): This is a comparatively new disease that first attracted attention about 1894. It appeared so suddenly and with such virulence as to practically destroy the crop in some of the Eastern trucking regions for two or three seasons. It has attracted less attention for the past two or three years. In this disease the leaves are thickly dotted with small irregular brown spots. These spots are not as large as in the Alternaria blight and lack the characteristic target-board markings of that disease.

During a prolonged period of cold, rainy weather in the Spring of 1897, this disease was so abundant in the cold frames at Auburn as to seriously check the growth

of the young plants. As soon as it was observed the plants were sprayed with Bordeaux mixture. The one spraying served to check it entirely and the plants recovered. Later it appeared on some of the plants in the field but again it yielded readily to the Bordeaux treatment. It has not since been sufficiently troublesome to attract attention.

Leaf Mould (*Cladosporium fulvum* Cke.): Also sometimes called Leaf Blight and Mildew.

The cause of this disease is a fungus that does not make definite spots on the leaves as in the last two cases, but forms mold like, greenish brown, velvety patches on the under surface, causing the leaf to turn yellow and fall. It is often a serious trouble where tomatoes are forced under glass during the winter, and at the South it frequently attacks the plants in the field. It is more troublesome on the coast and in Florida than in the latitude of Auburn, but at times it has been rather troublesome here. It usually yields readily to spraying with Bordeaux mixture. A single spraying in the greenhouse has served to check a bad attack of the disease and to protect the plants for a number of weeks. This disease is largely dependent on weather conditions, being much more troublesome in moist than in dry weather. Although it usually yields so readily to the Bordeaux treatment a few cases have been reported to me where repeated sprayings failed to prevent it from defoliating entire fields. It is seldom fatal to the plants but keeps them too much enfeebled to mature their fruit.

VARIETIES.

The requisites for a market tomato are medium to large size, smoothness, solidity, earliness, productiveness and the freedom from surface cracks in wet weather. The last, however, is something not yet fully attained. Color too is a matter of importance. In most

markets the light purplish red or "Acme color" is preferred to the bright scarlet red of the old fashioned varieties and any shade of red is preferable to yellow. It is not proposed to give here a detailed description of the many varieties of tomatoes now in cultivation in this country. Such information can be obtained from the better class of seed catalogues. For a discussion of the botanical relationships and the evolution of the cultivated varieties of the tomato the reader is referred to the admirable chapters on the subject in "The Survival of the Unlike," by L. H. Bailey.

The Acme was one of the first varieties to be introduced that satisfactorily fulfilled the requirements for a market tomato. It quickly became a general favorite and in regions where pruning is practiced it is still more planted than any other kind. Without pruning it often runs too small to be desirable especially toward the last of the season.

Livingston's Beauty and Ford Hook First are much like Acme and are preferred by some planters. In those parts of Florida where pruning is not practiced Stone and Belgino's Best, two of the bright red kinds, are much planted on account of their large size and productiveness. The Dwarf Champion and the more recently introduced similar kinds, all of which are sometimes spoken of as "tree tomatoes" are quite popular for the home garden on account of their stiff, erect, dwarfish growth, that largely obviates the need for staking. They have been grown to some extent for market but they are a little lacking in size and in shipping qualities and have not become general market favorites.

Lemon Blush has at this Station for the past three seasons been by far the most satisfactory variety for the mid-summer and fall crops. The plants are very vigorous and withstand heat and drouth remarkably. It

is strongly recommended for home use as it is of delicate texture and fine flavor, but it cannot be recommended for distant markets on account of its yellow color and soft flesh.

Overly large kinds like Ponderosa and Mikado are seldom fully satisfactory. Individual specimens may be very fine but there are usually many irregular ones and the yield is often poor.

In planting for market it is much better to plant at least four or five of the best kinds rather than to rely on any one alone. The different seasons affect varieties differently and the kind giving the best result this year may fall from first place next year. More important than this, however, is the fact that with several varieties the average daily pick runs more evenly. No two kinds will give their biggest picking on the same day but one will be a little earlier or a little later than another thus distributing the greatest rush over a number of days.

MARKETING.

For a general discussion on marketing fruits and vegetables and of the methods of transportation, see Bull. 79, pp. 103-110.

There are two methods in vogue for handling the distant shipment of tomatoes. At most points in Florida the fruits are picked dead green, as soon as they reach full size and at least a week before they would begin to color. They are wrapped in paper and are packed in the well known six basket crate, the same that is used for handling the Georgia peach crop. These green tomatoes are shipped by fast freight in ventilated cars. The wrapping in paper prevents them from shriveling and by the time they reach market some of the more mature ones are usually beginning to color. The greatest drawback to this system is that when picked in that condition no one can tell the exact stage of maturity and it is impossible to so assort them that all in one package will ripen

together. When opened on the market some of the fruits in a basket will be fully ripe while others are dead green. Such uneven packages are less saleable than where all are evenly ripened. Again if the weather is cool during transit ripening is delayed so that none are ripe on arrival and the consignment has to be stacked up in the store and held till ripening begins. In this way stocks often accumulate enormously, and if the weather suddenly turns warm, causing all to ripen at once the entire accumulation must be forced off at once or it will be lost entirely, thus causing a disastrous glut.

In Mississippi the usual plan is to allow the tomatoes to hang until they are slightly tinted. The fields are picked over every day so as to get as many as possible of them in this tinted condition. At the packing shed they are assorted into three grades as to color: ripes, mediums and greens. Usually firsts and seconds are made of each of these grades thus really making six grades besides a seventh cull grade that is not shipped but sold to canning factories or fed to stock. The tomatoes are packed without wrapping in flat, four basket crates, and are shipped in refrigerator cars. Where this plan is thoroughly carried out it ensures a very even quality of tomatoes in each package and as the goods are ripe when they arrive they can be sold at once thus avoiding the disastrous accumulation of stocks. The cost of refrigeration makes this method slightly more expensive than the other even though the cost of wrapping the tomatoes is saved. On the whole however, it is more satisfactory and there can be little doubt that for the latitude of Alabama it will on the the average yield larger net returns.

The growing of tomatoes on a large scale is an exacting business requiring constant personal care and attention from the time the seed is planted until the crop is harvested. It is not a crop that can be successfully handled by ignorant tenants. It has however, proven profitable at many localities in the past when intelligently handled and there is no reason to suppose that it will not continue to be profitable in the future. As has been stated on a previous page, there seems to be no reason why Alabama should not claim a respectable share in it. Her soils, climatic conditions and transportation facilities are all sufficiently favorable.