A STUDY OF THE RELATIVE IMPORTANCE OF VARIOUS FACTORS CONTROLLING PROFITS IN STRAWBERRY PRODUCTION

By

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A STUDY OF THE RELATIVE IMPORTANCE OF VARIOUS FACTORS CONTROLLING PROFITS IN STRAWBERRY PRODUCTION

Introduction

The strawberry is the most popular of all small fruits. The beauty of the fruit, its delicious flavor, and the fact that it ripens before there are other fresh fruits available insure an active demand for them in all markets. In addition to its use as a dessert fruit the strawberry is widely used for canning, for preserves, and as a flavoring for ices. The recent development of a method for preserving the fruit by freezing has brought promise that the quality of fresh strawberries may be enjoyed throughout the year.

From the standpoint of the grower the strawberry has several advantages. It offers a source of cash in the early summer. The period of time between the setting of the plants and the first harvest is less than with other small fruits and much less than with tree fruits. The strawberry is adapted to culture in the garden under very intensive conditions or in the field where it can be given less detailed attention. It can be produced successfully on a wide variety of soils, under widely different climatic conditions, and it is attacked by comparatively few serious pests.

The strawberry is principally a crop for the small farmer. No expensive equipment is required for its culture. A large amount of work, especially that of harvesting, must be done with hand labor, and, therefore, the farmer with his family can care for a small planting of from

one to three or four acres with very little outlay of money and comparatively little hired help. This is the common practice in Tennessee. Large acreages are rare and most of the production comes from such small family patches.

Since the early introduction of strawberry growing into the middle west and south, Tennessee has been prominent among strawberry producing states. During the period from 1918 to 1924, inclusive, this state led all others in carlot shipments, and since that time it has been among the leading states.(14) According to the statistics prepared by the United States Department of Agriculture, Tennessee has ranked third in acreage, third in total production, and seventh in the value of the crop during the period 1931-1936, inclusive.(18) Nevertheless, there are hundreds of growers who, during that period, did not secure returns sufficient to cover the cash expenses and leave anything for the labor of growing the crop. Observations during the past five years have indicated widely different cultural practices among the growers within each major producing region and even greater differences in the methods which are followed in different parts of the state.

There is an obvious need for more definite information concerning the relative value of different cultural practices and the determination of those factors which are most influential in determining the success of any program. The plan of this work has been to make a careful survey of the literature dealing with strawberry growing, to determine the methods which were followed by the more successful and less successful growers in order to determine, if possible, the significant

differences in their programs, and, finally, to check the importance of these differences by field experiments.

PART I

REVIEW OF LITERATURE

PART I - REVIEW OF LITERATURE

HISTORICAL

The European Strawberry

The strawberry (Fragaria) is a native of the temperate latitudes of both hemispheres. Native species are common in Europe, Asia, and in both North and South America. Even though both Virgil and Ovid refer to it the early Greeks and Romans seem not to have grown it in gardens. Early interest in the plant seems to have been centered about its ornamental value as is indicated by a statement made as late as 1629 by Parkinson, the apothecary-gardener of London. His statement, concerning the value of the strawberry, was quoted by Roe(74) as follows:

> "It may be eaten or chewed in the mouth without any manner of offence; it is no great bearer, but those it doth beare are set at the toppes of the stalks close together, pleasant to behold, and fit for a gentlewoman to wear on her arme, as a varietie instead of a flower."

According to the account given by Bailey in his Standard Cyclopedia of Horticulture, the earliest record of garden culture is the growing of the native wood strawberry, Fragaria vesca, in France early in the fourteenth century. In the fifteenth century wild plants were commonly transplanted into the English gardens where they were grown for their fruits. This practice is indicated by the following quotation, from the writings of Tusser, which is given by Beckett(7) in the "Book of the Strawberry":

"Wife, into thy garden, and set me a plot
With strawberry roots of the best to be got:
Such growing abroade, among thorns in the wood,
Wel chosen and picked, prove excellent good;"

Interest in the strawberry developed gradually and during the sixteenth century it is mentioned frequently in several herbals. Further evidence of its popularity during the latter part of that century is found in the third act of Richard III where Shakespeare(84) places these words in the mouth of Richard, Duke of Gloster:

"My lord of Ely, when I was last at Holborn I saw
good strawberries in your garden there, I do beseech
you send for some of them."

By the latter part of the seventeenth century rather definite cultural practices were established and the strawberry was recognized as a desirable addition to the garden. The historical sketch which is given by Fuller(36) 1887, includes the following statements:

"Gerarde, in 1597 enumerates but three varieties,
the white, red and green fruited."

"Quintinye, in his "French Gardener," translated
by Evelin in 1672, mentions four varieties, and
gives similar directions for cultivation as practiced at the present time (1887), viz, planting
in August, removing all the runners as they appear,
and renewing the beds every four years."

The North American Strawberry

In north America the native strawberry, F. virginiana, was recognized to be of value by the very early settlers and rapidly became popular. In the introduction to "The Strawberry" Fraser(35) cites the following quotations:

> "Coming to more recent times, in 1629 William Wood, in writing of the attractions of the new land, says, 'There is likewise Strawberries in abundance, verie large ones, some being two inches about,' and in 1643 Roger Williams states, 'This berrie is the wonder of all the fruits growing naturally in all these parts'."

The native American strawberry was carried into European gardens comparatively early.(56)

> "Its culture dates back to an early period in the annals of American Horticulture. It was found growing wild when the country was discovered and I find mention of Fragaria virginiana, our North American species, being introduced into European gardens as early as 1624."

Introduction of the South American Species and the Development of Crosses

The South American species, F. chiloensis, came into the picture only a little later. It was first introduced into French gardens early in the eighteenth century. In 1712 Frezier, a French officer, returned to France from Chili taking with him a few plants of this species which attracted his attention because of their large fruits. This proved to be a pistillate type and produced very few fruits so that it was considered a failure in France.

In the "French Gardener," as translated about 1691 by Evelin,(31) there is this statement:

> "Strawberries are of four kinds; the White, the Large Red, the Capprens, and the Small Red wild strawberry."

All of these types were probably selections of the native species because it was nearly three quarters of a century later, in 1760,

that another Frenchman, Duchesne, published a book describing different sex in strawberry flowers and he is supposed to have been the first to originate new sorts by crossing. The importance of this discovery was not appreciated for many years. In fact, as late as 1828 the idea was expressed in Loudon's Gardener's Magazine that the kind of strawberry makes little difference because the care and cultivation are responsible for quality and size of fruit.

It is obvious, therefore, that the modern strawberry as we know it is of comparatively recent development. It is thought that the strawberry from which our modern varieties have been developed originated as a hybrid of the two species, F. virginiana and F. chiloensis. The following statement appears in Bailey's Standard Cyclopedia of Horticulture(34):

> "The first of the modern race of large-fruited varieties was the Keens' Seedling, originated by Michael Keens, of England, in 1819; it was a Pine (either a form of F. chiloensis or a hybrid of that species with F. virginiana) and from it have sprung most of the European varieties of today. The Hovey, from which modern North American varieties have descended in large measure, was undoubtedly a Pine in part, but there is considerable evidence that one of its parents was a variety of F. virginiana."

Soon after the development of the Keens' Seedling variety another Englishman, Knight, produced successful crosses which gave varieties of great commercial value. By 1836 as many as one hundred varieties were included in English catalogs and more than two hundred varieties were listed by French nurserymen. Many of these English varieties were introduced into the United States but the results

were usually disappointing because the plants proved unsuited to this country. In 1834 an American nurseryman, Hovey, produced a seedling which he named the "Hovey." It was a cross between the large-fruited Pine strawberry from Europe and the hardy, vigorous, native species, F. virginiana. In discussing the importance of this development, Fraser says(35):

> "It was the sensation of the age with its large handsome fruits and by 1850 it had established the strawberry as one of the leading fruits in America, a position it has never lost."

The Hovey proved to be a pistillate variety and because the sex characters of strawberry flowers were not understood it was never really successful as a market variety. The real commercial development of the strawberry industry did not begin until the middle of last century. The opening sentence in Fletcher's "Strawberry Growing"(33) is as follows:

> "Commercial strawberry-growing in North America may be said to have begun with the introduction of the Wilson, in 1854."

The Rise of Commercial Strawberry Growing in the United States

Following the introduction of the Wilson there was a feverish interest in strawberry growing and especially in the development of new varieties. The most heated discussion during this period centered about the flower characters of the plant. About 1834 Longworth, a prominent horticulturist of Cincinnati, discovered the imperfect

flowers of some varieties and for a period of more than ten years a heated discussion concerning the true character of strawberry flowers was carried on, in the current periodical magazines, between Longworth and Hovey. In Volume 12 of Hovey's "Gardener's Magazine," 1846, the editor summarized the discussion by stating his belief that there were no separate male and female plants, that staminate plants could not be made pistillate or the reverse by cultural practices, and that perfect flowering plants were necessary to insure good crops.(44) Two years later in the same periodical a committee of the Cincinnati Horticultural Society (largely under the influence of Longworth) reported that strawberry flowers were either pistillate or staminate and that they knew of no such thing as a perfect flowered strawberry plant.(45) In the first volume of "The Horticulturist," 1846, the editor, Downing,(29) announced his agreement with Longworth that staminate plants should be set with pistillate plants to insure largest yields. He disagreed, however, with Longworth's view that the flower character of a strawberry variety never changes and contended that there was a tendency to change from perfect to imperfect flowers. This controversy was continued and until the very last of the nineteenth century there were frequent statements that the question of the importance and proper use of pollinators had not been settled. Gradually, however, the necessity of considering flower characters in the selection of strawberry varieties was recognized.

During this discussion a great interest was aroused so that authors, nurserymen, and growers took sides. Careful study was given

to such questions as the effect of pollen on the fruit of the fertilized blossom, the number and distribution of pollinators which should be used in a planting, and especially the development of suitable hermaphrodite varieties. The result of this interest was reflected in the rapid expansion of strawberry growing. From less than 1500 acres at the time the Wilson was introduced the plantings increased to more than 150,000 acres before the close of the century. Fletcher(34) makes the following statement concerning this expansion:

> "The 'strawberry-fever' that swept over the country between 1858 and 1870 has not been equaled in intensity by the boom days of any other fruit."

Following this unusual expansion there was the inevitable reaction which resulted in a considerable reduction in acreage, but from 1850 to the present the general trend has been upward. The acreage devoted to strawberries in the United States at the close of the century in 1899 was reported as 151,373.(99) This was followed by a considerable decrease so that the average acreage for 1917, 1918, and 1919 was 85,670,(1) but since that time the industry has expanded so that the average acreage since 1930 has been approximately 180,000.(18) In 1934 the commercial strawberry crop in the United States ranked fifth in value among the fruit crops of the country.(2) In Tennessee the trend has been quite similar. The acreage in this state was 11,548 in 1899.(99) It was 10,350 in 1919(14) and averaged 16,300 from 1930 to 1936, inclusive.(18)

Before the industry became so widely spread Cincinnati was considered the center of the commercial culture while garden culture

was general near the cities in the eastern states. Since 1870 commercial strawberry growing has gradually increased and garden culture has gradually declined. The rapid spread of strawberry growing through the United States was reported frequently in the pages of current periodical literature. In 1855 reference was made in the Rural New Yorker to the recent introduction of strawberries in California. Three years later the same publication reported 1000 acres in Southern Illinois. In 1881 the crop is referred to as important in Arkansas and the next year an article in the same magazine recommends strawberry growing in Texas. The commercial industry began in Missouri in 1889 when the first shipping association was formed in that state, and according to the American Fruit Grower, the first small shipment moved from Plant City, Florida to Philadelphia in 1889. The Louisiana strawberry industry began about 1890 and, according to the best records which are available, commercial growing in Tennessee dates back to 1880 when shipments were made from Hamilton County in East Tennessee and 10,000 crates were shipped from Humboldt and Gadsden in the western part of the state.

A Sound Basis for Development

Two factors have contributed largely to the spread of this industry. The plant has been found to be adapted to a wide variety of conditions. In 1898 Corbett[19] makes the following statement:

> "We are coming to realize as a nation, that this berry, counted a delicacy on the millionaire's table, can be had by any owner of a patch of ground, who will spend the little time and labor necessary."

Later in the same publication he says:

> "There is no other fruit that can be had with so little expenditure of time and money."

In 1930 Strawbridge[89] made a similar statement. He says:

> "The strawberry is adapted to practically all tilled sections of the United States. It is an early cash crop for each locality in which it is grown."

The second and perhaps the more important factor which has influenced the widespread distribution of the industry is the development of improved transportation, especially the development of refrigeration. In 1866 Earle began shipping strawberries from Cobden, Illinois in chests with ice, and by 1869 he had begun to ship in carloads with ice.[3] In 1891 over 600 refrigerator cars were used for fruits and vegetables and in 1929, 40,741 were used for fruits and vegetables including 13,000 which were used for strawberries alone.

EUROPEAN CULTURE OF THE STRAWBERRY

Garden Culture and Forcing

Strawberry culture in France and England has been on an intensive rather than an extensive scale since its beginning. In both of these countries the forcing of strawberries in greenhouses or specially constructed beds has remained very important until quite recent times. "The French Gardener," translated by Evelin[31] in 1691, gives a good idea of the intensive methods employed. The following quotations are taken from that translation:

> "The soyl (soil) which they most affect, is rather a sandy than a stiff, and therefore you shall make choice of that part in your garden for them, which most approaches this mixture."
>
> "The 'Small-red wild strawberry' need not be cultivated but may be gathered from the woods or planted in beds about the home and given no special care. Other types (Large-red, White, and Capprens) are planted in borders or low beds with a path between."
>
> "To order them well, you must dress, weed and loose the mould about them very diligently, and to have fair and clear fruit, you shall stick a smaller prop to every plant, to which you shall bind their stalks with a straw."
>
> "When your strawberries shoot their strings, you must castrate them, and leave them none but such as you reserve to furnish you with plants."

Much the same recommendations appear prominently in periodical literature during the early part of the nineteenth century. In the early volumes of Loudon's Gardener's Magazine from 1826 to 1840 Knight and other writers favored the intensive culture but questioned the desirability of cutting all runners and stirring the beds in the fall. Great emphasis was placed on deep soil preparation and the liberal use of manure. There were frequent favorable references to the use of nitrate. The practice of allowing runners to set in matted beds, which were mowed and manured after picking and retained several years, was referred to by most writers as a careless, undesirable method which produced continuously smaller and poorer fruits.

Development of Field Culture

Discussions of field culture first appeared in the Gardener's

Chronicle about 1850. The hill system was used, and vegetable crops such as onions, spinach, and endive were suggested as intercrops. All writers agreed that a fertile soil was necessary but some recommended a sandy soil while others preferred a heavier type. The intensive methods of garden culture and forcing were reflected in the recommendations for field culture. In the first volume, 1872, of "The Garden" which was edited by Robinson,(95) the following statement is found:

> "Three main points to be observed in strawberry growing are digging deeply, planting early and manuring heavily."

A discussion of soil preparation about twelve years later by the same editor showed a somewhat different opinion. After stating that trenching was generally considered necessary and admitting that it probably was essential in very light soils he said(72):

> "..... I can safely assert that trenching is (under other conditions) quite unnecessary and in some cases it has proved actually disadvantageous."

For both field and garden culture late summer or fall setting was recommended. Either the plants which had been forced were used or the first runners were rooted in pots in the field. By these methods August setting was quite successful and good crops of fruit were harvested the following spring.

For many years during the last half of the nineteenth century there were comparatively few important changes in cultural recommendations. There was the usual discussion as to the proper time to apply mulch, the best season for setting, and the value of spring cultivation,

but, nevertheless, there was general agreement. In 1890 a paper on "Strawberries for Market," was read by Bunyard(11) before a meeting of the British Fruit Growers Association in which the following statements occurred:

> "Deep cultivation, heavy manuring, clean culture, and care in sorting the fruit, appear to be essentials."

Earlier in the paper the writer said:

> "I am of the opinion that, as far as culture is concerned, we have reached the best possible; and the only thing I object to in our Kent field system, is the late hoeing which is often given. If the land is thoroughly cleaned and pulverized, by the time the flower trusses show, and before they open, it would be preferable to finish hoeing at this stage, and not delay the work until the flower is out ...."

About the beginning of the present century frequent references to overproduction began to appear in periodical literature. Beckett, in "The Book of the Strawberry," which was published in 1902, explained that foreign competition, that is shipments of fruit from France, was not important because the fruit deteriorated so much in transit that it was of poor quality on arrival. Only five years later, however, it was reported in the "Gardener's Chronicle" that the transportation of strawberries from Western England and from France was greatly hurting the greenhouse culture.

Even though the production in France was concentrated near the cities and came from small plantings the crop was reported to be of considerable economic importance. In 1895 de Vilmorin(100) made the following statement:

> "From a commercial point of view the culture of the strawberry (in France) is nearly as important as that of Asparagus."

There was continued increase in production in spite of declining prices until by 1911 the prices had dropped sufficiently to discourage French shipments.

During this same period a great deal of discussion occurred concerning the deterioration or "running out" of varieties. Leaf spot and eelworms were considered the principal causes and growers were urged to introduce healthy, vigorous plants from other sections at least 100 miles distant. This introduction of fresh stock and greater care in cultural practices failed to stop the deterioration and about 1928 careful research was begun on the problem. About that time Wardlow,(103) of Glasgow University, was assigned to study of a common strawberry root disease. He said:

> "The disease which is seen at its worst in May and June, is definitely diagnosed as a root disease due to the destruction of the root system by soil fungi under soil conditions unfavorable to the plant."

His later recommendations suggested no direct control but suggested more attention to the selection of favorable soils, liberal feeding, careful tillage, the use of good plants, and crop rotation.

STRAWBERRY CULTURE IN THE UNITED STATES

Influence of European Methods

During the early period of strawberry growing in the United

States the cultural practices were patterned after English methods. Frequent references may be found in the magazines of that time to practices which closely resemble the forcing methods followed in England and France. The setting of pots in the field in order to root the runners during the summer and thus provide potted plants for late summer or fall setting is an example of such practices. The statements of William Prince(68) 1828, are descriptive of these early methods. He recommended the fall setting of strong vigorous plants and said:

> "These may be placed in beds from three to four feet wide and from ten to twelve inches apart each way, according to the extent to which the variety usually expands its growth."

Later in the same discussion he said:

> "Most varieties do best when allowed to run together, so as to form a complete mat--as in this case one forms a shelter for the other from excessive heat--but when fruit is desired of the largest possible size, the plants must be kept distinct, and at a distance of one foot asunder, and the runners should be cut off as fast as they appear."

In the early volumes of Hovey's Gardener's Magazine many systems of strawberry culture were discussed. Forcing, bed culture, row culture, hill culture, and, less frequently, the practice of allowing the plants to set runners forming more or less matted rows were given considerable attention. The editor expressed a preference for the bed culture in Volume 1; in Volume 4 Downing suggested the hill system, and Bayne, just a few years later, recommended that plants be set three feet apart and runners be allowed to fill alternate middles. Thus,

the discussion has continued until very recent times. Some writers have favored one plan and others have favored another. All of the time many growers have been quite successful with widely different methods as was so strikingly expressed by Hovey,(46) 1861:

> "The strawberry is cultivated in a great variety of modes, viz in rows, in hills, and in beds, some allowing the plants to bear only one crop, others two, and some three. Some mow the leaves after the crop is gathered; others turn in the old plants to make place for the new runners, and thus keep the beds on the same ground for several years. In either way, with good judgment and proper treatment, good crops may be produced; and under ordinary garden cultivation it is hardly possible, with a good soil and liberal manuring, to prevent a successful result, whatever may be the mode adopted."

The Extensive Spread of the Industry Resulted in New Methods

With the development of more extensive commercial strawberry growing there was a very definite tendency away from the more intensive methods of culture. Forcing and the culture of this fruit in beds have practically disappeared. Strong statements may be found concerning the relative value of the hill system and matted row culture and often a modification of these, known as the hedge-row or the controlled row, has been recommended. A careful study of recent literature leads to the conclusion that the matted row plan has been generally adopted by commercial growers in most sections of the United States. The lower south and parts of the northwest, however, have turned to the hill system. The commercial crop in Tennessee is produced entirely according to the matted row plan.

The Selection of a Suitable Soil

Soil Type

The selection of a suitable location for a strawberry planting has been recognized as a matter of great importance since the beginning of the industry. Among the factors which should be considered in the selection of a desirable site, the soil has been given the most attention.

> "Whether or not it is for a market or home patch, the results secured will, in a general way, be measured by the adaptation of the soil." (90)

One of the early statements which described the characters of a good strawberry soil was made by William Prince.(68) He said:

> "A light rich loam is considered the most favorable, being soft, and pliable so that runners may easily penetrate it with their roots."

One hundred years later a similar soil was described by Loree(54):

> "Good crops of strawberries may be grown upon almost any type of soil, provided it is retentive of moisture, fairly fertile, and well drained."

During this century and up to the present similar statements have been very common, though some variations may be found.

The following statements may be taken as representative of the general opinion:

> "The type of soil, whether it be sand, silt, or clay, is not so important as that it should be well supplied with humus." (25)

> "The best soil for the strawberry is a deep rich loam. Deep it must be, if large berries and plentiful crops are desired." (30)

> "Any well drained soil of moderate fertility that has high water holding capacities is suitable. The ideal soil would be a sandy or gravely loam underlain with clay." (13)
>
> "Deep sandy loam is most desirable."
> "Good moisture penetrating and holding ability (is) necessary." (17)
>
> "..... the happy medium between the light sandy loams on one hand and heavy waxy lime lands on the other is best." (58)

Some writers favor a rather heavy type of soil while others recommend a light texture but in almost all cases they agree that humus is essential, that good drainage is necessary and that at least moderate fertility is very desirable.

The following summary statement by Fletcher,(33) gives a fair explanation of these minor differences:

> "A survey of soil preferences in different parts of the continent discloses the fact that more strawberries are grown on a sandy loam underlaid with a clay than on any other soil type. The demand for early berries has had much to do with this choice. The most popular strawberry soil in the northern and central states is a gravelly loam with a clay subsoil. Heavy loams, silts and light clays are preferred for late varieties in the East and are used very generally on the Pacific coast for all varieties."

"New ground" has been recommended frequently as most desirable for strawberries. This is probably due to the fact that such land usually has abundant humus, is in good physical condition, and is comparatively free from serious weeds. In some sections growers have depended upon "new ground" for most of the strawberry acreage but usually such land has become scarce and it has been necessary to prepare old land for this crop.

Crop Rotation

No recommendations are found in recent literature for continuing strawberries on the same land for any great length of time. The accumulation of insects and diseases, the withdrawal of certain elements from the soil and the reduction of the humus supply, leading to soil erosion on even moderate slopes, are the usual reasons which are given for crop rotation. An almost endless variety of rotations are suggested by different writers but certain recommendations are similar in nearly all references to this subject. Perhaps the most important of these is the use of some green manure crop, preferably a legume, in the rotation in order to maintain the humus supply. The following statement by Talbert(91) expresses the opinion of most writers:

> "Crop rotation systems using legumes and non-legumes, with and without manure, are valuable in preparing old land for strawberry production."

The other important point upon which practically all writers agree is that strawberries should follow a clean cultivated crop in order to reduce the problem of weed control and the danger from insects, such as cut worms and white grubs which often accumulate in sod land. Irish potatoes, sweet potatoes, tomatoes, or other vegetables are considered suitable crops to precede the planting of strawberries.

Soil Acidity

During recent years attention has been given to soil acidity

as a factor in determining the suitability of a soil for strawberry growing. It has been recognized for many years that wild strawberries are found on soils which vary widely in this regard but that a slightly acid condition is most common. Morris,(61) working with strawberry plants growing in nutrient solutions, found that the possible limits were quite wide but that best growth was produced in slightly acid solutions. He says:

> "Best results were obtained in the pH 6 solution; however, there was not a striking difference between the plants grown in the four solutions from pH 4 to pH 7 inclusive."

The belief that successful strawberry production under ordinary conditions is not limited by the soil acidity is indicated by the following statement of Morris and Crist(21):

> "The reactions commonly found in so-called "Agricultural" soils are probably per se not important limiting factors in strawberry production."

The statement of Waltman(102) favors the use of sufficient lime to promote the growth of clovers.

> "A reaction that was most favorable for growth also induced greatest fruitfulness."
> "It seems probable that enough lime can be added to the soil to promote the growth of clover without making the reaction too alkaline for the growth of strawberries subsequently."

Other Factors

Aside from the selection of a suitable soil there seems to be practically complete agreement in regard to other characteristics of a good strawberry site. Both air and water drainage are considered necessary. Where early ripening is of great importance a

southern exposure is usually suggested. Steep slopes which are subject to severe erosion are to be avoided.

The Selection of Varieties

A very large place in the literature of strawberry growing is occupied with discussions of varieties and the characteristics of desirable plants. The selection of suitable varieties is generally considered as fundamental to success with this fruit. Oskamp(64) made the following statement:

> "It is conservative to say that without any increase in acreage the growers of the State could double their output of this important small fruit by the judicious selection of varieties and the use of proper cultural practices."

In 1861 Hovey stated in the columns of his "Gardener's Magazine" that the culture of the strawberry had not advanced during the preceding ten or fifteen years and gave the introduction of excessive numbers of inferior varieties as the principal reason. At the beginning of his chapter on varieties in "Strawberry Growing" which was published in 1917 Fletcher(33) indicated that the influence of these poor varieties was still apparent. He says:

> "The Strawberry is burdened more heavily with indefinite and mediocre varieties than any other fruit."

During the time intervening between these statements, however, the aims of the strawberry breeders and the standards by which new varieties were judged changed very greatly. At the time Hovey wrote,

during the strawberry boom, and for some time later, the chief interest was in the development of large fruited varieties and in the study of flower characters. According to Darrow, one of the leading workers in this field, the interest of modern strawberry breeders is centered on quality, disease resistance, and the adaptability of the new variety to definite uses. From the standpoint of the grower the basis of selecting varieties is stated by Thayer(94) in the following words:

> "In selecting a variety, sex is of minor consideration. Vigor, productiveness, resistance to disease and insects, and good fruit characters are the things to be considered."

Two types of flowers are recognized, the pistillate and the hermaphrodite, but the hermaphrodite varieties which are grown today are very much more fertile than those grown seventy-five years ago, and are so desirable in other characters that they have largely replaced the pistillate kinds.

Since the introduction of the first "everbearing" variety early in this century there has been some interest in their cultivation. They have not become of great commercial importance, due probably to the fact that they require a more fertile soil, and more careful attention. The everbearing varieties lack in runner production and therefore are less adapted to the matted row system of culture.

The Selection of Plants for Setting

The discussion concerning the type of plant which should be

set has centered almost entirely about the size and age of runners. The use of plants which have been rooted in pots has been common where strawberries are forced in greenhouses or in beds, but it has seldom been followed for field culture. Field grown plants are used and there is general agreement that old mother plants and those which have exhausted themselves by fruit production are not desirable. The following statement by Fletcher(33) summarizes the discussion on the selection of runner plants:

> "For many years it was the prevailing opinion that the first, second, and third runners are valuable for setting in the order named; that runners formed later than these, and especially alley plants, never should be used, even though of good size..... Later evidence has shown that tip plants of fair size start off better in the spring, and have fewer fruit buds than older plants, which is an advantage."

Later in the same paragraph he says:

> "It is likely that the vigor of the plant, particularly the strength of the root system, is more important than the time of year when it was produced."

Later writers on the subject generally agree with this statement. In Kansas Circular 162, the author(6) says:

> "Available evidence does not sustain the popular idea that late set runner plants, those at the tip of the runner, are less valuable than the earlier-rooted ones."

During recent years some attention has been given to so-called "pedigree plants," those which have been grown from selected mother plants, but most writers agree that such plants are very little better than others. In 1926 Talbert(91) made the following statement:

> "Pedigreed strawberry plants are rarely better than the original variety."

A more complete statement occurred,[70] 1909, from the Central Experimental Farm, Ottawa, Canada:

> "While the results obtained do not warrant the purchase of "pedigree" plants rather than others where there is no special claim as to selection, we believe that the principle of selection is good and if thoroughly carried out, is bound to result in an improved strain, which, however, can only be maintained by continued selection."

Cultural Methods

With the spread of commercial strawberry growing and the development of extensive plantings many of the extreme practices associated with forcing and garden culture were found to be impractical and there was a tendency to question all of the old methods. The following statements of growers and correspondents, which appeared in the Rural New Yorker between 1850 and 1855, indicate this critical or questioning attitude:

> "We are persuaded that a great mistake is made in manuring too much." (77)

> "I have never trenched my ground and some of the best crops I ever raised were grown on land simply plowed the usual depth." (78)

> "Nor is mulching a perfect substitute for the hoe in summer." (79)

The result of such attitudes was the development of all sorts of variations from what might be called a standard system. Some writers were inclined to defend the old intensive methods but many turned to the other extreme and a great confusion resulted. Gradually, however,

some practices have become standardized and generally accepted.

Methods of Setting

From the very early days of commercial strawberry growing to the present there has been practically complete agreement that great care should be exercised in the setting of the plants and the recommendations have changed very little. In "The Horticulturist," 1861, Fuller recommended that the roots be trimmed for spring planting but not for fall setting, and he suggested that setting be done on cloudy days to prevent drying of the plants during the planting. He emphasized especially that the roots be spread evenly, that the plants be set deeply but not deep enough to cover the crown, and that the soil be firmed carefully about the roots. The recommendations of recent writers on this subject are fairly represented by the following quotation from Auchter and Knapp(4):

> "Set the plants firmly, at the proper depth and when the soil is moist. Any planting method that takes account of these factors will give good results..... Set the crown at ground level..... If the roots are long and straggling, clip slightly to aid in planting."

Cultivation

Leading writers uniformly emphasize the importance of thorough soil preparation, that is, deep plowing or sub-soiling followed by careful working. Though contradictory statements are found frequently concerning the comparative advantages of deep and shallow cultivation, there is almost complete agreement that strawberries respond to frequent,

thorough tillage which controls weeds and grass during the growing season. Statements similar to the following may be found in most discussions of this subject.

> "Thorough cultivation during the first season can not be too strongly urged. It conserves moisture, promotes the growth of plants, keeps the weeds down and is in every way beneficial." (20)

> "Frequent and shallow tillage the first season is one of the secrets of successful berry growing." (64)

> "The old saying 'tillage is manure' holds true for strawberries." (92)

Life of a Commercial Plantation

In some phases of strawberry culture there is not such uniformity of opinion. For example, in regard to the profitable life of a strawberry plantation, there is a wide difference of opinion. Some authors recommend that only one crop be harvested. The following statement appeared in the "Rural New Yorker"(12):

> "Any strawberry bed which needs a plow to assist in cleaning it up, should never be run the second year."

Taylor(63) expressed the same opinion, 1911:

> "Usually it is better to set new beds each year than to continue the old ones."

The more common recommendation, however, is that two or possibly three crops may be taken from a planting. The plans which are suggested for the renovation of a strawberry field after the first crop vary greatly. A review of periodical literature indicates that many growers practice no cultivation between the first and second crop,

but simply mow the weeds once or twice during the summer. Other growers and most of the leading writers recommend rather thorough working during the second summer. Such a thorough program may be outlined as follows: after the first harvest the tops are burned or mowed, the rows are narrowed with a plow or other cultivator, the plants are thinned in the row and grass or weeds are removed by hand. Following this renovation the cultivation is continued throughout the summer as it was the first season. The exact method of renovation, in fact the decision as to whether a planting should be worked at all after harvest, will depend upon the conditions of that particular field.

Fertilization--Recommendations of Last Century

It is in regard to strawberry fertilization that the literature becomes hopelessly confusing. On this subject the writings of the past two decades are fully as contradictory as are those of last century. Before the spread of extensive commercial strawberry growing it was the custom to incorporate large quantities of manure into the soil as it was being prepared. The practice was generally adopted for field culture but differences of opinion were common. Pardee(65) was among the first prominent writers to question the heavy fertilizing of this crop. In 1853 he said:

> "Almost everyone who cultivates strawberries, I notice, has fallen into two very great errors. First, of allowing different varieties to intermingle..... The other error, I observe, about as universally prevalent, is over feeding, and as a consequence, an over growth of vines and a deficiency of fruit..... Such highly enriched soils can be in a measure counterbalanced by liberal applications of potash, lime, and salt."

The next year, 1854, in Hovey's "Gardener's Magazine" the editor gave a review of the book "Complete Manual for Culture of the Strawberry" which had recently been published by Pardee. In this review he took strong issue with the statement, "Few good soils need enriching at all for the Strawberry." In answer to this statement he said:

> "This may be true, but so far as our experience goes - the experience of 25 years - we are sure that fine fruit of the largest size cannot be abundantly raised without a good soil well manured..... whoever attempts to raise fine strawberries without manure (or its equivalent, guano) will signally fail." (47)

The idea that very fertile soils were not desirable for strawberries was widespread for several years but the following statement from a special committee report(87) presented before the Illinois Horticultural Society in 1877 indicates that by that time there had been a renewed interest in fertilization:

> "The theory formerly prevalent, that the soil should not be made rich for strawberries, has been generally practically abandoned by cultivators of this fruit."

A very careful study of the literature dealing with strawberry fertilization, since the beginning of the century, shows two almost opposite schools of thought, those who do not believe that the application of fertilizing materials is profitable and those who recommend the rather liberal application of one or more elements. The most striking difference of opinion concerns the application of nitrogen. A few quotations are given in the following paragraphs representing the first of these groups.

Fertilization--Negative Evidence

Davis,[27] of the Central Experimental Farm, Ottawa, Canada, makes the following statement:

> "One thing which stood out, however, was that the plants when set out were incapable of utilizing a readily available supply of nitrogen and in many instances nitrogen applied at that time resulted in injury to the newly set plants, even though the fertilizer did not actually come in contact with the foliage."

The effect of fertilizer on the carrying quality of strawberries in Alabama is reported by Kimbrough.[50] He says:

> "Judged by their condition on arrival after being shipped by express or transported by automobile a distance of over two hundred miles, the carrying quality of berries from these plants (those made excessively vigorous by 400 pounds of nitrate of soda in the spring) was not as good as that of berries from less vigorous plants."

He continues to say:

> "Heavy applications of muriate of potash did not improve the carrying quality of strawberries.
>
> "It seems evident that fertilizer treatments may affect the carrying quality of berries, but the extent of this effect is probably not as great as has been thought."

The report of a strawberry fertilizer experiment which is given in the Annual Report of the Kentucky Experiment Station,[88] includes this statement:

> "The results continued to show that a foundation treatment of the soil with lime and phosphate and the use of sweet clover as a rotation crop has made a very favorable condition for strawberry production. The addition of fertilizers containing nitrogen, phosphorus or potassium, either separately or in combination, has not increased the yield. The addition of nitrogenous fertilizers sharply reduced the yield in all cases this year."

In a recent bulletin Talbert,[92] of Missouri, makes the following statement:

> "When strawberry soils are handled as suggested, it will rarely be necessary or profitable, to apply fertilizers after planting."

Cochran and Webster,[15] of Oklahoma, report the effect of nitrogen as follows:

> "In all cases under field conditions where the application of nitrogen was high, fewer plants came through the dry season, with a smaller yield per plot."

Greve[39] has reported experiments concerning the effect of nitrogen on the growth and blooming of the Howard 17 Strawberry in Maryland. In the report of this work he says:

> "In general, there is little indication that summer and autumn nitrogen applications were in any way either significantly beneficial or injurious under the not unusual conditions surrounding the experiments."

Such evidence as has been presented above seems sufficient to prove that the application of fertilizing materials to strawberries is of very doubtful value, that it may prove injurious and that it cannot be considered a profitable practice. The literature of this same period, however, is filled with information from equally reliable sources which is almost directly contradictory.

Fertilization--Positive Evidence

Among those who recommend liberal fertilization of the strawberry there is wide variation as to the best materials but the most

writers agree that manure is beneficial. Many of those writers who recommend other materials emphasize the value of humus and very few of them offer any objection to manure. The following quotations indicate the widespread preference for manure during the first two decades of the present century.

> "Poor land will not grow strawberries profitably..."
> "Nothing is better than stable manure....." (70)

> "The best fertilizer for strawberries is well-rot barnyard manure, which should be used in large quantities." (57)

The statement by Shaw(85) from the North Carolina Department of Agriculture indicates a very definite preference for manure over the chemical fertilizers. After expressing this preference, however, he says:

> "As a rule, an abundance of nitrogen will produce heavy yields and large berries, but sufficient phosphoric acid and potash, in available forms are needed to develop the flavor, color, and firmness of the fruit."
>
> "The use of these fertilizers (chemical fertilizers) alone, without the addition of sufficient vegetable matter, will soon leave the land in an impoverished, unproductive condition."

Very significant statements were made in 1918 by Halligan,(40) of Michigan, concerning the subject of strawberry fertilization:

> "In considering the food supply of a strawberry plant, there are two important requisites, - namely, good soil texture and a liberal amount of plant food..... While strawberries do not remove excessive amounts of plant food from the soil, there is no crop that responds more readily to heavy fertilizing. An unbalanced ration, however, should be avoided..... Farm manures are the best general purpose fertilizers for strawberries."

During the last fifteen or twenty years attention has shifted largely from manure to the commercial chemical fertilizers. This has been due probably to the increasing scarcity of manure and the great improvement of the other materials. The comparative importance of different materials has been the subject of much discussion. In 1919 Mooers(59) presented a discussion of this subject before the Tennessee Horticultural Society. He reported that the evidence on the value of liming for strawberries indicated that applications directly for strawberries were not apt to be profitable and might be detrimental. He said that there was clear evidence that strawberries were sensitive to deficiencies in phosphoric acid and recommended four hundred pounds per acre as a reasonable application. Potash, on the other hand, was considered much less important and more than very light applications were discouraged. Concerning the use of these materials he says:

> "Acid phosphate may be the best single fertilizer material for the strawberry grower to rely upon, but acid phosphate, together with some such material as nitrate of soda, is generally needed to give best results."

Several years later, in 1930, Hoddy(42) reported to the same society that the strawberry growers in Blount County, Tennessee, had realized great profit from the application of potash to their fields in the spring.

The annual report(32) of the Arkansas Experiment Station, 1930, is in general agreement with the statement of Mooers:

> "The results from fertilizer treatments on old strawberry fields for 1930 were not only inconsistent but contradictory. There were, however, indications of benefit from phosphorus and of injury from the use of too much nitrogen."

> "Accumulated evidence from previous seasons shows that on both heavy and light soils phosphorus from the standpoint of production is the most important fertilizer. Nitrogen is next in importance but there is danger of using too much at a single application. Potash is the least important, but it is necessary for maximum production on light soils."

Nitrogen is given much greater importance in comparison with the other materials by many writers. Linberry and Mann(52) make the following statement concerning the effect of nitrogenous fertilizers on strawberry production:

> "Spring applications of quickly available nitrogen, sodium nitrate or ammonium sulphate, increased the yield of strawberries but the ripening was delayed and the carrying qualities lowered."

Based upon pot experiments with strawberries at the Michigan Experiment Station, Loree(55) concluded that spring applications of nitrogen stimulated vigorous runner production while summer applications had little effect on runner production but favored crown development. In regard to the importance of nitrogen he says:

> "Nitrogen has been the chief limiting element. It is an important factor in promoting vegetative growth and is particularly important at the time of fruit bud differentation."

He found no indication that fertilizer treatments had any effect on the moisture content, texture or quality of the fruit.

In the south, fall and early winter applications correspond, so far as their effect on plant growth is concerned, to spring applications in the northern sections. In 1932, Taylor,(93) of Alabama, made the following statement concerning the effect of such applications:

> "In general, applications of nitrogenous fertilizer to strawberries in Alabama in the fall and early winter increased the numbers of flower clusters, flowers, and fruits."

Darrow and Waldo(26) found that the vegetative stimulation which resulted from applications of nitrogen to strawberries, or from any other cause, tended to increase the amount of decay which occurred in the field. Nevertheless, in regard to the important fertilizer applications they say:

> "Superphosphate was apparently somewhat more effective than potash in increasing the yield of fruit."
>
> "The use of nitrogen fertilizers is essential to the production of large yields of early berries in this section."

Occasional references may be found to the profitable application of fertilizers to strawberries in the spring of the crop year. Such results are reported by Baker in transactions of the Indiana Horticultural Society, 1932,(5) but there seems to be general agreement that fertilizers intended to increase yields should be made during the summer or fall of the preceding year. In this connection Loree(55) makes the following statement based upon his pot experiment:

> "Applications of fertilizers in the spring of the fruiting year have no effect on the number of clusters, or the number of flowers per cluster."

Shoemaker and Greve[86] found that spring applications of nitrogen, in Ohio, did not increase yields while applications in August of the preceding year made marked increases. Very similar results are reported by Tucker[98] in a Virginia Bulletin:

> "Repeated tests have demonstrated that a fall application (in late August or early September) is more suitable than a spring application."

A study of the "Seasonal Changes in Nitrogen and Carbohydrate Content of the Strawberry Plant," as reported by Long,[53] of Missouri, gave emphasis to the importance of summer and fall care. He says:

> "The fruit production of a strawberry plant is determined by the food reserves that accumulate during the growing season and are made available in the spring."

The effect of varying nutritive conditions both in the soil and in the plant at different seasons of the year were given careful study by Gardner[37] in Missouri. In the discussion of these tests the following statements are made:

> "It is clear, however, that the nutrition question, as it relates to strawberries, is a late summer and fall question to a much greater extent than has been generally suspected, and that investigators and growers can well afford to give it consideration from this point of view."

Fertilization--Conclusions Must be Indefinite

In spite of the inconsistent and contradictory results which have been reported from experimental tests, the application of

fertilizers is a general practice among commercial growers in the leading strawberry states. So many other factors influence the yields and quality of berries that it is often difficult to determine the real effects of fertilizer treatments. The possibility of such confusion is indicated by the following statement by Kimbrough,[51] of the Alabama Experiment Station:

> "Comparisons of the quality of strawberries based on determinations of moisture content, sugar content, and firmness showed a much greater difference in the berries due to rainfall and to variations in soil moisture than to fertilizer treatment."

A study of the effects of fertilizers on the yields and quality of strawberries in North Carolina is reported in the Annual Report,[83] 1930, of the North Carolina Experiment Station.

> "It must be concluded, therefore, that the care exercised in picking is probably more important in influencing rot, disease and carrying quality than possible differences due to type and kind of fertilizer used."

Such a review of the literature concerning the fertilization of strawberries leads to rather indefinite conclusions. The statement of Cochran[16] in the Biennial Report, 1922-24, of the Oklahoma Experiment Station, represents the opinion of many leading writers. He says:

> "It seems quite probable that the strawberry should be grown on land containing a good deal of humus and that the fertilizer had best be applied to the crop preceding the strawberries, depending upon the decaying of organic matter for the fertilizer for the berries."

The statement which was made by the editor[28] of "The Horticulturist" more than half a century ago is probably as true today as it was then.

> "Understanding the general principle, or that the strawberry roots deep, good common sense must then guide as to the condition of the soil, and its want of manure or otherwise."

Insects and Diseases

Among the important fruit crops the strawberry is one which suffers less from insects and diseases than most. In this review no attempt has been made to follow in detail the literature concerning the various pests. A regular program of spraying has never been adopted by most of the growers in any commercial section because such cultural practices as careful plant selection, crop rotation, clean cultivation, and thorough sanitation have prevented or greatly reduced the losses from the common pests. In the Introductory paragraph to Chapter XIV in "Strawberry Growing" Fletcher[33] says:

> "Fifty years ago, when the same plantation was fruited ten to fifteen years, damage from pests was much more pronounced than now, when most plantings are fruited but one year and practically none more than four years."

Later in the same paragraph he says:

> "Probably over ninety-five percent of the commercial strawberry crop is grown without any spraying whatever."

Probably the most generally distributed strawberry diseases are those which affect the leaves such as the leaf spots, scorch, leaf blight, mildew, yellows, and strawberry dwarf or "crimps." Except for the last two of these, commercial control has usually been secured

by the selection of resistant varieties, and the careful burning of the old leaves after harvest. In unusual cases the use of Bordeaux mixture as a dip for the plants before setting or a spray as growth is starting in the field has been used. Strawberry yellows has been most serious on a comparatively new variety, Blakemore, and no control has been developed except the planting of disease free plants well isolated from infected plantations. Strawberry dwarf or "crimps" is caused by a nematode, different from the one which causes root knot, and is controlled best by rather long rotations and careful rogueing.

The most serious strawberry root disease is one known as "Black Root." This disease usually first appears with hot weather and may cause the death of a considerable percent of the plants during the summer. The fungus which has been most frequently reported as associated with the trouble is Rhizoctonia but many writers believe that the condition described as "Black Root" is often caused by winter injury. Roberts,(73) in Wisconsin, found that mulching previous to temperatures of 20° F. prevented the blackening of the roots as is commonly found in the field.

Fruit rots of the strawberry, such as gray mold, leather rot, hard rot and leak (Rhizopus), often cause heavy losses in the field, in transit or in the market. The leather rot, hard rot and even gray mold are usually more serious in the field and the losses correspond closely to the weather conditions. Warm rainy weather favors the spread of these diseases. Discussing the "Relation of Strawberry Fruit

Rots to Weather Conditions" Rose[75] makes this summary statement:

> "Therefore the inference seems justified that, in the regions studied, rot of strawberries in the field (Leather rot and all other rots) is dependent upon two factors, rainfall and temperature."

The Rhizopus fruit rot, frequently called "Black Mold" or "Leak," is responsible for more loss in transit than all other kinds of rots combined, according to the work reported by Rose[76] in 1926. These losses are, also, closely related to the weather conditions. Considering the conditions in Arkansas, Tennessee, and Louisiana, the author makes the following statement:

> ".....in the two wet years for all three states the total average rot was nearly five times as great as in the two succeeding dry years."

Among the insects attacking the strawberry the crown borer, white grub, and weevil are the most serious. The leaf-roller and root louse are widely distributed but usually are not of great economic importance. Under ordinary conditions crop rotation, careful sanitation, and the selection of plants makes it possible to avoid serious losses.

Economic Problems of Importance

Yields

Since the early spread of extensive strawberry growing the crop has maintained a place of importance as a cash crop. There have been periods of expansion and periods of decline but the general trend has been toward a wider distribution both of producing areas and of market

outlets. The general trend in yield per acre, however, seems to be downward. The popular strawberry literature between 1850 and 1875, while the industry was expanding so rapidly and spreading into new territories, contains comparatively few references to yields of less than 50 bushels per acre and most reports give yields ranging from 100 to 150 bushels per acre. The popular literature of more recent times indicates that the yields range from 50 to 100 twenty-four quart crates per acre. In his report on "The Cost of Producing Strawberries," 1930, Waller says that among 103 records there were 26 growers reporting yields less than 2000 quarts (about 83 crates) and 24 growers reporting more than 4000 quarts (about 165 crates) per acre.(101) The average yield in the second early group of states, which includes Tennessee was, 1930, approximately 2000 quarts per acre.(89)

Labor Requirements

The labor required for the production of strawberries was given by Hutson(48) in Kentucky Bulletin 225, 1924. The average for 63 growers was given as 111.8 man hours for the first crop, 51.2 hours for the second crop, and 34.7 hours for the third. The number of horse hours decreased in a similar way. The average requirement of horse labor was 65.7 hours for the first crop, 29.6 for the second, and 20.8 for the third. Concerning the importance of abundant labor the author made the following statement:

> "A careful analysis of the data available suggests that most growers could increase their profits from strawberries by giving the growing crop more careful attention."

> "Figure 7 also shows that some farmers got about two crates of strawberries for each hour spent in cultivation, while others devoted almost two hours for each crate. This difference is due, to a great extent, to efficient and inefficient practises."

According to Arkansas Experiment Station Bulletin 218, 1927, the cost of producing, harvesting, and delivery for shipment in 24 quart crates was about eight cents per quart. The labor and farm power previous to harvest was said by the authors to range from 5 to 10 per cent. of the total, while harvesting, packing, and delivery for shipment amounted to 50 per cent. and the cost of the crates alone amounted to 15 per cent. of the total cost.(10)

The labor requirement for strawberry production under Maryland conditions in 1929 was given by Whitehouse, Hart and Walker.(104) In the Marion area where strawberries were a very important cash crop about 12 cultivations and four hoeings were given during the first year and three cultivations with one mowing and raking but no hoeing were given the second season. For such a program the labor requirement was 186.6 man hours and 66.9 horse hours for the first year and 18.0 man hours and 15.0 horse hours for the second year. The authors gave the approximate distribution of costs in this region as follows:

14.5% preharvest labor and power
47.5% harvest labor and power
27.2% materials
6.8% miscellaneous expenses
4.0% interest

Cost of Production

The attempt to analyze the cost of producing strawberries, especially the distribution of the cost among the separate items, and an attempt to determine the profits which have been received by the producers of this crop is very unsatisfactory. General statements concerning the cost of production may be found scattered through the popular literature but very little actual data are available. In Volume 4 of "The Horticulturist,"(60) a grower of Watervliet, Michigan, reported a cost of $60.00 per acre. Pardee,(66) 1858, gave the cost of cultivation as $15.00 to $25.00 per acre. A grower near Wallingford, Connecticut, gave, in more detail, the costs of producing 9¼ acres of strawberries. A summary of this record(80) is as follows:

Team work and labor.....	$ 836.75	Picking and marketing..	$846.04
Manures.....	415.63	Freight, traveling, tel.	565.60
Bog hay and straw mulch...	378.00	Commission.....	279.42
Interest on capital, taxes	109.13	Team work.....	60.00
		Wear of crates.....	125.00
Total production costs....	$1739.50		
		Total marketing costs..	$1875.96

A much more detailed statement of production costs was given in the American Fruit Grower for February 1919. In this report(9) the expenses are given separately for the first and second years:

First Year		Second Year	
Rent.....	$ 7.00	.....	$ 7.00
Taxes.....	1.80	.....	1.80
Plowing.....	2.00	Mowing.....	1.00
Harrowing.....	1.00	Rejuvenating.....	2.50
Marking.....	.15		
Setting, four days.....	6.00		
Plants and digging.....	1.50		
Cultivating, seven times..	3.00	..... six times...	3.00

(Continued)

(Continued)

First Year		Second Year	
Hoeing, cutting runners and blossoms	$ 8.00	Mulch	$ 4.00
500 lbs. fertilizer	6.00	Mulch application	3.00
Sowing 1 bushel oats	1.20	Mulch removing	1.50
200 crates, 16 quart	24.00	100 crates	12.00
Picking	40.00	.....	25.00
Packing and hauling	10.00	.....	7.00
Total	$111.65	Total	$67.80

An examination of this information shows that approximately 65 per cent. of the total cost was that of picking and handling the crop and between 50 per cent. and 60 per cent. of the production costs were required for labor.

Profits Reported

General statements concerning the profits derived from strawberry growing should not be expected to agree because so many factors of a local nature influence the results. In "The Horticulturist," 1859, Hooper,(43) the secretary of the Cincinnati Horticultural Society said that profits under the best circumstances should be $100.00 to $120.00 per acre clear of all picking costs. In the Rural New Yorker, 1869, a grower, Purdey,(69) from western New York, said, in answer to the question, "Do strawberries pay?":

> "I can say that they have paid us and will do so, so long as we can get even 6¢ a quart here."

In the proceedings of the 16th Session, 1877, of the American Pomological Society, Berckmans(8) of Georgia reported an average price of 12½¢ per quart and said:

> "This admits of very satisfactory profits when this fruit is properly grown."

At the Annual Convention, 1921, of the Tennessee Horticultural Society, Garrison[38] reported profits of $335.00 per acre based on the records of 23 farms. Since that time prices have declined to a point where many growers report returns which are barely sufficient to cover the cost of production.

It is not surprising that reported profits vary greatly because many factors influence both the cost of production and the returns. Most recent writers agree that the most important of these factors are associated with yields per acre and quality. Gardner[37] makes the following statement in Missouri Research Bulletin 57, 1923:

> "Success in the commercial production of strawberries, as of most other fruits, usually depends on yield to a greater extent than on any other single factor."

A very similar statement is made by Loree[54]:

> "The profits from strawberry growing are proportional to total yield and the quality of the fruit produced, and these, in turn, are determined largely by the intensity of culture."

The improvement of the quality of the strawberries which are placed on the market is not a new problem and its importance has been emphasized by writers since the very early days of commercial strawberry growing.

Factors Affecting Price

In addition to the yield per acre the market price is an important factor in determining profits. Five factors which affect

strawberry prices are quality, quantity, condition which causes a variation in demand, the bargaining ability of growers organizations and the efficiency of the whole marketing system.(96) A very recent publication by Thomsen(97) contains this statement:

> "Yearly fluctuations in the price of strawberries in the United States are largely the result of changes in the quantity marketed and in the purchasing power of the consumers."

Since the early days of the extensive field culture of strawberries there have been repeated discussions of the danger of overproduction. As early as 1868 such discussions were common in the pages of the Rural New Yorker and other periodicals and again twenty years later considerable emphasis was being placed on the danger. As the industry has spread through widely separated sections and the transportation facilities have been greatly improved so that such a perishable crop can be put in distant markets successfully the matter of over-production is an interstate problem. For example, the Tennessee strawberry season extends from late April to early June. This season corresponds almost exactly with the Arkansas season and competes with the peak of the crop from North Carolina, Kentucky, Virginia, Missouri, and overlaps with the crop from states both north and south of these.(89) The marketing problem has received much attention in strawberry literature during the past few years. The following quotations indicate the relation which is recognized between problems of production and marketing:

> "From the viewpoint of marketing it is important that the best cultural and handling methods be used by the growers because quality aids in the sale of the berries." (49)

> "The best of marketing facilities, however, cannot overcome the handicap of indifferent handling methods....." (41)

> "A rigid system of inspection at the loading station is a prerequisite to the permanent success of shipping associations." (41)

Recent Research of Importance

The strawberry literature of the past fifteen or twenty years shows a decided trend toward more scientific investigations. In these studies much attention has been given to questions concerning runner production, fruit bud formation, and plant nutrition. Among the early works of this type, "Studies in the Nutrition of the Strawberry," by Gardner,(37) may be listed as one of the most important. In the introductory statements the author emphasized the importance of yield and he continued to say:

> "Yield depends directly on the number and size of berries per plant or per unit of area. The number of berries depends in turn, on the number of flower clusters per plant, the number of flowers per cluster and the percentage of these flowers that set and mature fruit."

The importance of favorable nutritive conditions during the summer and fall is clearly indicated by this work and the relation which exists between the number of pistils in the flower and the size of the berry is established.

Practically all of the writers during this period agree that early set runners are very desirable. In 1922 Darrow(22) made the following statement:

> "Varieties differ greatly in the number of runners produced and in the time of producing runners."

Later in the same publication he said:

> "Runner plants formed during July and August produce more fruit than plants formed later."

Richey and Schilletter[71] reported in 1929 that with the Dunlap variety in Iowa the first runner plants are formed about sixty days after setting and that the different runners in a series are formed from ten to eighteen days apart. These authors reported the results of flower counts with that variety. Mother plants constituted 4.5 per cent. of all the plants counted but produced 10.34 per cent. of all the flowers, mother plants with the first five runners constituted 69.8 per cent. of all the plants but they produced 87 per cent. of the flowers while the runners from sixth to tenth in the series constituted 29.19 per cent. of all the plants counted and produced only 13.33 per cent. of the flowers.[82]

More recently a report[62] of a conference on strawberry investigations, between various bureaus of the United States Department of Agriculture and the North Carolina Experiment Station, contains this statement:

> "The earlier the runner plant roots in the summer the greater the average number of flowers and berries per plant and the yield per acre."

The investigations dealing with the differentiation of fruit buds throw more light on this subject. Most writers agree that the principal period of flower bud formation is in the summer and fall

preceding harvest, that varieties differ greatly in the time as well as the rate of flower bud development, and that external factors such as low temperature, lack of moisture or unfavorable nutritive conditions influence this development. Darrow and Waldo[23] make the following statement:

> "In Florida the varieties there evidently initiate fruit buds continuously throughout late fall, winter and spring, as flower cluster production is a continuous process from November until June. From Georgia to North Carolina winter temperatures are cold enough to enforce short dormant periods, but the fruit-bud formation of fall is again resumed as soon in the spring as the temperatures become high enough for growth. From Virginia northward there seems to be no period of spring fruit-bud formation, and consequently no second crop."

That fruit bud formation was closely correlated to the leaf area of the plant was reported by Pickett[67] in Illinois as long ago as 1917.

> ".....so far as strawberries are concerned, abundance of foliage and high production go hand in hand. Therefore, not only variety selection but all that good culture implies should be effective in increasing yield."

In the 1935 proceedings of the same organization, Darrow[24] makes a very similar statement and strongly emphasizes the importance of avoiding crowding in the matted row because of reduced leaf area per plant. He says that plants in crowded matted rows with two leaves produced only one fifth as much as the plants in spaced rows with ten leaves.

PART II

FACTORS CONTROLLING PROFITS IN MODERN STRAWBERRY PRODUCTION

PART II - FACTORS CONTROLLING PROFITS IN MODERN STRAWBERRY PRODUCTION

METHODS OF THE PRESENT STUDY

Statement of Conditions in Tennessee During the Study

Tennessee has been, for many years, one of the leading strawberry producing states. For a period from 1919 to 1923 it was first in acreage and in production, and, according to the best statistics that are available, it holds third place at the present time.

The strawberry is a rather intensive crop. It is planted, usually, by individual growers in rather small acreages and is produced at a comparatively high cost per acre. The more than 60 commercial growers who cooperated in this study reported an average of only two acres in each planting and they fairly represent the growers throughout Tennessee. Large acreages are occasionally found in single plantings but in most instances the strawberry is a family crop and the acreage is limited to that which can be cared for by the family labor with additional help during harvest. It is a common practice for extensive growers to divide their total acreage into small units so that each family in their employ can have a comparatively small area.

The strawberry crop, like all agricultural crops, follows rather regular cycles. There are periods of increased interest during which the acreage is rapidly expanded, followed by definite periods

of decline. With this as with other crops, however, the normal trend has been disturbed by the abnormal economic conditions of the past ten years. As a result there has been a period of several years, longer than would occur in a normal cycle, during which a large percentage of the commercial growers have found it impossible to make even a small profit. Under such conditions there is more than the usual interest in all of the factors which influence the possible profits from this crop. The investigations which are reported in this publication were planned to throw light on this problem by determining the relative importance of the various factors. The study was begun in 1929 when conditions were comparatively favorable and has continued through the most difficult years of the depression.

Production Records from Representative Growers

The problem has been approached from two angles. First and major attention has been given to a study of the commercial practices and methods of production which have been well established and are widely accepted in the state. Through the cooperation of county agricultural agents, vocational agricultural teachers, and others, contact was made with strawberry growers in each of the important producing sections and production records were secured. These records show the methods employed, the labor distribution, and all important production costs. These records represent the widely different conditions under which strawberries are produced in Tennessee. Both

progressive and unprogressive growers were included and the work was continued during a six year period from 1929 to 1934, inclusive. In all 69 records were secured and their average should present a fair picture of existing conditions.

Direct Comparisons in Field Plot Tests

Supplementary to this study experiments were planned and conducted to provide direct comparisons between different methods of cultivation, fertilization, and other important cultural practices. Several of these tests dealing with methods of cultivation and fertilization were conducted at different places in Tennessee. In Middle Tennessee tests were conducted at the Mericourt Experiment Station, Clarksville, and on the farm of a commercial strawberry grower, Mr. H. H. Gregory, in Sumner County. In the eastern part of the state tests were conducted on the farm of Mr. Lee Widener and on the University Farm at Knoxville. In this way the tests were placed on different soil types and under different conditions of soil fertility. All comparisons were run in triplicate, unless otherwise noted, and were repeated during two or more growing seasons. The experimental plot work has been conducted continuously at Knoxville since 1931. Many phases of the problem have been included in this experimental program.

The usual statistics from the Bureau of Agricultural Economics, the Agricultural Census and similar reliable sources have been used

in a brief discussion of the marketing problem. Recent work done by the Tennessee Valley Authority in cooperation with the University of Tennessee is the authority for brief statements concerning the possible development of the frozen fruit industry as an outlet for our surplus volume.

COSTS WHICH DIRECTLY INFLUENCE PROFITS

There can be no argument that strawberry profits like those from any agricultural crop depend upon three factors, namely, the cost, the yields, and the selling price.

General Distribution of Costs

The total cost involved in the production and harvesting of the first strawberry crop from a new planting, according to the average of 63 records, was $120.27. The average cost of the second crop, for which the cost of establishing the plantation was not necessary and for which the period of cultivation was shorter, was $77.90 per acre. Less intensive culture was given by most growers during the second year of the plantation's life. All of these costs fall naturally into one or the other of two large groups, first, the production costs which were involved in the growing of the crop to maturity and, second, those expenses which were necessary for the harvesting and handling of the fruit after it had been produced. Based upon the production records of commercial growers Table 1 shows the relative importance of these two groups.

Table 1. Cost Per Acre of an Average Strawberry Crop

	Number of Records	Cost of Production		Harvesting & Handling		Total Cost
		Actual	% of Total	Actual	% of Total	
First Year	63	$55.73	46.3	$64.54	53.7	$120.27
Second Year	40	19.11	24.5	58.79	75.5	77.90

Table 2. Cost of Production

	Number Records	Yield Per Acre (Crates)	Labor Cost			Cash Expenses			Overhead			Total Cost	
			Per Acre	Per Crate	% of Total	Per Acre	Per Crate	% of Total	Per Acre	Per Crate	% of Total	Per Acre	Per Crate
First Year	63	67	$28.53	42.6¢	51.2	$19.93	29.7¢	35.8	$7.27	10.8¢	13.0	$55.73	83.1¢
Second Year	40	61.2	7.77	12.6¢	40.6	3.77	6.2¢	19.8	7.57	12.4¢	39.6	19.11	31.2¢

For the first crop nearly half of the total expense was incurred before the fruit was mature, while for the second crop three-fourths of the expenses occurred during the harvesting and handling of the fruit. A careful analysis of the items which compose both the cost of production and the cost of handling the fruit, therefore, is a logical step in the consideration of this problem.

Analysis of Production Costs

It is convenient to separate the production costs into three parts, as is done in Table 2.

This table shows that labor was an important part of the production cost, representing 51.2 per cent. of the total during the first year and 40.6 per cent. of the total during the second year. The cash outlay which was involved in the production of strawberries was not excessive but does represent a significant proportion of the total cost. During the first year in which the plantation was established the average cash outlay was $19.93 per acre which was 35.8 per cent. of the total production cost. An important reason for keeping a strawberry plantation for the second crop may be found in the greatly reduced cash expenditure. According to the average of 40 records only $3.77 in cash was required to produce the second crop of fruit. It may be seen from this table, also, that the overhead or fixed cost did not vary greatly in amount but represented a much

larger proportion of the total cost during the second year than during the first.

Overhead or Fixed Costs

Land Use

The charge for land-use has been listed as rent and 10 per cent. of the land value is charged. Each grower was asked to place a value on the land which was occupied by the strawberry planting according to the value of his entire farm in relation to conditions in the community. This value was discussed and checked with the local agricultural agent or vocational teacher in order to avoid large inconsistencies. As would be expected there was a wide variation ranging from $25.00 per acre in some of the more isolated sections where a comparatively poor ridge land was cleared and used for strawberries, to as much as $200.00 per acre in a few cases where strawberries were produced near large cities. The more common range was from $40.00 or $50.00 up to $100.00 and the average for all records was approximately $70.00 per acre. These amounts fairly represent the value of land which is used for strawberry growing in this state.

Land rental, therefore, was an item of considerable significance since, according to Table 3, it represented 11.9 per cent. of the total production cost for the first crop and 38.6 per cent. of the production costs for the second crop.

Equipment Depreciation

As an additional fixed cost some charge was necessary for the use of equipment. With the exception of a disc, which is used during the first preparation of the soil, the entire cultivation of a strawberry planting, according to the methods which are followed in Tennessee, is done by very durable and inexpensive tools. All of the cultivation is done with one-horse plows and after careful consideration it was decided to charge one cent per horse hour for equipment depreciation. As can be seen in Table 3 this represented a very small part of the total production cost and less than 10 per cent. of the overhead.

Cash Expenses

The cash expenses which are involved in the production of strawberries are very important to the commercial grower. Since a large part of the labor is performed by the family and, therefore, does not require an outlay of money and since the fixed charges are usually even less tangible there is a tendency for the grower to consider the cash expenses somewhat more important than they really are.

Plants

The largest single item according to this study was the cost of plants which represented 55.1 per cent. of the cash expenditure during the first year. There was considerable variation among the

Table 3. Detailed Analysis of Production Costs Per Acre

Item	First Year	Second Year
Number of records	63	40
Total overhead charge	$ 7.27	$ 7.57
Rent	$ 6.61	$ 7.39
% of overhead cost	90.9%	97.6%
% of production costs	11.9%	38.6%
Equipment charge	$ .66	$ .18
% of overhead cost	9.1%	2.4%
% of production costs	1.2%	1.0%
Total cash expense	$19.93	$ 3.77
Plants	$10.98	
% of cash expense	55.1%	
% of production costs	19.7%	
Fertilizer cost	$ 5.83	$ 2.29
% of cash expense	29.3%	60.8%
% of production costs	10.4%	12.0%
Mulch	$ 3.12	$ 1.48
% of cash expense	16.6%	39.2%
% of production costs	5.6%	7.7%
Total labor cost	$28.53	$ 7.77
Establishing plantation or renovation	$10.90	$ 2.04
% of labor cost	38.2%	26.2%
% of production costs	19.6%	10.6%
Summer cultivation	$16.06	$ 5.10
% of labor cost	56.3%	65.8%
% of production costs	28.8%	26.7%
Spring care	$ 1.57	$ .63
% of labor cost	5.5%	8.2%
% of production costs	2.8%	3.3%
Total production costs	$55.72	$19.11

growers in this charge because many of them purchased their plants locally at a cost frequently running as low as $1.25 per thousand or used their own plants and recorded a similar charge. Other growers cooperating in this study purchased plants from distant plantsmen at prices ranging as high as $3.50 or $4.00 per thousand. Additional variation was caused by the fact that some growers set eight to ten thousand plants per acre while others spaced the plants much more widely and set only four to five thousand plants. In most cases the growers who purchased expensive plants spaced them more widely and placed them on a better quality of soil than the average. The average cost given in Table 3 is $10.98 per acre for plants and approximately one third of the individual records show a charge within $2.00 of that amount.

Fertilizer

The second largest expense was for fertilizer even though 23 per cent. of the growers made no application during the first year and 5.5 per cent. of the records for the second year show no fertilizer cost. The average expenditure by those growers who made an application during the first year was $7.49 per acre, and the average for those making an application during the second year was $5.08 an acre. Considering the average for all records, however, as is given in Table 3, the first year fertilizer cost represented approximately 30 per cent. of the total cash expense and 10 per cent. of the total production cost. The second year fertilizer cost represented 60 per cent. of the

total cash outlay and 12 per cent. of the total cost of production for that year.

Mulch

A similar condition exists in regard to the use of mulch. Only 40 per cent. of the growers cooperating in this study applied mulch for the first crop and only 25 per cent. made an application for the second crop. The average cost for those growers who made an application was approximately $7.00 per acre and was, therefore, a very significant part of the total cost of production.

Labor Requirements and Costs

The cost of farm labor varied considerably during the period of this study. The rate according to the average of all records was 14.1 cents per hour. During the first two years, 1929 and 1930, the usual charge was 20 cents per hour but during the most difficult years of the depression farm labor was available as low as six or eight cents per hour. It seems that these two extremes balance each other and the average fairly represents the usual cost of farm labor in Tennessee. A similar variation occurred in the cost of horse labor which showed a range from six to ten cents an hour with an average of slightly more than eight cents. A considerable part of the hand labor which is performed in a strawberry plantation is done by boys and this has tended to reduce the average cost per hour.

In an analysis of the labor required for the production of

strawberries it is convenient to separate the total amount into three parts. First of all there is the labor required for establishing a plantation or renovating the planting after the first crop. Second, we should consider the labor required for cultivation and other care during the growing season, and, third, the labor required during the spring before harvest.

Establishing the Plantation

The different types of land which are used for strawberry growing cause rather wide variations in the expense necessary for soil preparation and the establishment of a plantation. In East Tennessee a considerable proportion of the strawberry acreage is on new land or land that has been cleared only a very short time. Five of the production records included the cost of clearing land with an average of 87 man hours and 60 horse hours per acre. Since the other records did not include such an item and since the cost of clearing cannot properly be charged against the strawberry crop this item is omitted in Table 4 where the distribution of labor is presented.

According to the data presented in this table it is clear that the labor required for the preparation of the soil, setting, and other work connected with the establishment of a strawberry plantation represented nearly one third of the total labor required for the first year. The hand labor of setting plants was the largest single item and represented 17.5 per cent. of all labor before the first crop was harvested. The amount of time required for setting varied greatly

Table 4. Analysis of Labor Distribution
(On an Acre Basis)

First Year, 63 records

Establishing the plantation
- Man labor
  - Setting --- 28.5 hrs.; % of total 17.5
  - Other labor 20.7 hrs.; % of total 12.7
  - Total -- 49.2 hrs.; % of total 30.2
- Horse labor -- 33.0 hrs.; % of total 51.6
- After prorating labor
  - Man labor - 24.6 hrs.; % of total 17.8
  - Horse labor 16.5 hrs.; % of total 34.8

First summer labor
- Number times hoed 4.2
- Number times plowed 6.1
- Man labor - 105 hrs.; % of total 64.5
- Horse labor 25.1 hrs.; % of total 39.2

Spring before first crop
- Man labor - 8.4 hrs.; % of total 5.2
- Horse labor 5.8 hrs.; % of total 9.1

Total labor
- Man hours: Actual 162.6, prorated 138
- Horse hrs.: Actual 63.9, prorated 47.4

Second Year, 40 records

Renovation
- Average based on all records
  - Man labor --- 7.7 hrs.; % of total 17.9
  - Horse labor - 6.7 hrs.; % of total 37.2
- Average based on records reporting (24)
  - Man hours --- 12.8 ; Horse hrs. 10.5

Summer care after first crop
- Average based on all records
  - Number times hoed 1.4 ; times plowed 2.2
  - Man labor --- 32.5 hrs.; % of total 75.5
  - Horse labor - 10.3 hrs.; % of total 57.2
- Average based on records reporting (33)
  - Number times hoed 2.1 ; times plowed 2.8
  - Man labor 39.3 hrs.; Horse labor 12.2

Spring care before second crop
- Average based on all records
  - Man labor --- 2.8 hrs.; % of total 6.7
  - Horse labor - 1.0 hr. ; % of total 5.5
- Average based on records reporting
  - Man labor --- 7.5 hrs. (15 records)
  - Horse labor - 4.1 hrs. (8 records)

Total labor
- Average based on all records
  - Man labor: Actual 43, prorated 67.6 hrs.
  - Horse hrs: Actual 18, prorated 34.5 hrs.
- Average based on records reporting (35)
  - Man hours --- 49.1 ; Horse hrs. 20.7

according to the spacing of the plants and the care which was used in the work. Seventeen of the 63 records showed less than 20 and 18 of the records showed more than 35 hours per acre required for setting, leaving approximately one-half of the records between these amounts. The preparation of the soil was the principal work requiring horse labor and represented approximately one-half of the total amount required for the first year. Under normal conditions in Tennessee it is the practice to harvest two crops from a strawberry planting and under such conditions one-half of the labor used in the establishment of the plantation should properly be recorded against the second crop.

Field Culture from Setting to Harvest

The proper care of a strawberry planting is not well standardized in Tennessee. Many growers consider that it should be given very intensive care during both the first and second summer. Other growers favor intensive care during the first summer and comparatively little work after the first harvest, while still other growers do not practice intensive culture during either year. According to the production records which are available for the first year 13 of the 63 growers hoed their planting more than five times, 23 hoed three times or less during the first season and 27 hoed four or five times. There was a similar difference in the horse cultivation which was practiced. Those who followed the more intensive methods plowed their planting from eight to ten times during the season, while almost an equal number plowed only three or four times. Some justification for

these differences may be found in the kind of land which is set. If the strawberries are following a very intensively cultivated crop like tobacco the soil will be fairly free from weeds, will be in good condition, and will require less cultivation than if land is used which has been carelessly tilled or has been laying out. According to the data which are available it requires on an average of 19 hours hand labor each time the strawberry planting is hoed. Less time is required during the early season before runners start than is necessary during late summer when the matted row has become established. Practically all of the horse cultivation is done with one horse plows, with two to five shovels, and on the average it requires approximately four hours per acre for each working.

Comparatively little labor is required in a strawberry planting during the spring before the first harvest if proper cultural practices were followed during the previous summer. Only 34 of the 63 records showed any hand work during the spring and only 28 reported horse labor. The distribution of fertilizer and the spreading of mulch are the principal items which were reported by the 34 growers. When the average time required for spring work is based on all the records it amounts to but 5.2 per cent. of the total man labor requirement and 9.1 per cent. of the total horse labor. Those growers who reported spring work, however, used on an average of 15.7 man hours and 12.9 horse hours per acre which is a more significant factor in the total labor requirement. Some growers practice the pulling of

large weeds during the spring before harvest but no great amount of labor is used for such work.

The actual labor used in the care of a strawberry planting before the first harvest varied from a minimum of 67 hours per acre reported by a single grower to a maximum of 285 hours reported by a single grower. These extremes represent exceptional cases since only eight of the 63 records reported less than 100 hours and only 13 reported more than 200 hours per acre. The average which is given in Table 4 fairly represents the labor requirement for satisfactory strawberry culture under Tennessee conditions.

The care of a plantation after the first crop depends greatly upon the conditions which exist. Many growers who have given their planting only mediocre care during the first season do not find it profitable to continue the planting for a second crop. A large number, also, allow the planting to remain without any care and harvest a second crop if prices are favorable and there is a sufficient quantity of fruit to justify picking. The production records which are available show these differences quite clearly. For example, only 24 out of 40 second year records reported any definite plan of renovation. Only 33 of the 40 did any cultivation after the first crop, and five of the 40 growers who reported on a second crop did no work of any kind after the first harvest. The averages which are presented for the second year in Table 4 may be misleading for these reasons. When averages are based upon all records they show only 7.7 man hours

and 6.7 horse hours per acre to be required for renovation while the 24 growers who did special renovation in their plantings reported an average of 12.8 man hours and 10.5 horse hours per acre. Even those growers who practice cultivation during the second summer follow less intensive methods than are customary during the first season. Seventeen of the 33 growers who reported cultivation hoed their planting one time or did not hoe at all but used horse cultivation entirely. Only four of the records showed more than three hoeings during the second summer. Approximately one-half of the records show that plowing was done three or four times, and only two report that plowing was done more than four times.

The practice of applying mulch during the spring before the second crop is less common than it is during the first spring and, therefore, less labor is usually put on the plantation at that time.

The totals which are given in Table 4 show that on the average only 26.8 per cent. as much man labor and 28.1 per cent. as much horse labor was actually used during the second year as during the first. After the labor of establishing the plantation has been divided, approximately half as much labor is charged against the second as against the first crop. It is clear, therefore, that when other conditions are reasonably favorable the opportunities to secure a profit from the second crop are greater than from the first crop. This fact in large measure justifies the thorough intensive care of a strawberry plantation during the first year.

Harvesting and Handling Costs

The strawberry is an extremely perishable crop and requires close attention during harvest. It is necessary that the fruit be picked regularly, carefully, and that it be handled promptly. Carelessness in picking, especially the picking of unripe or overripe fruits, is responsible for great losses to Tennessee strawberry growers. In order for the fruit to reach the consumer in desirable condition it must be picked as soon as it is entirely colored, it must be handled as little as possible and moved into the market in the least possible time. Since more than half of the total expenses are involved in the harvesting and handling of the crop it is quite important to study each item in this cost. The cost per acre varies directly with the yield and is much less significant than the cost per crate. A separate tabulation of the harvesting and handling cost for the first and second crops showed no significant difference in the percentage of the total cost which was reported for the different items. For that reason all records are combined in Table 5 which gives the separate items in the harvesting and handling of this crop.

Packages

All of the strawberries in Tennessee are marketed in standard 24 quart crates. The cost of these packages is a very heavy expense to strawberry growers, representing 30 per cent. of the total expenses for harvesting and handling the crop. The cost of crates has not

Table 5. Harvesting and Handling Costs

	Package Cost	Labor Cost				Hauling Cost	Total Cost
		Picking	Grading and Packing	Super-vision	Total Labor		
Per Acre	$19.04	$30.03	$5.60	$2.66	$38.29	$4.98	$62.31
Per Crate	29.4¢	46.4¢	8.6¢	4.1¢	59.1¢	7.7¢	96.2¢
% of Total	30.6%	48.2%	9.0%	4.2%	61.4%	8.0%	

Number of records: 103. (63 for the first crop and 40 for the second crop.)

Yield per acre: 64.8. (67 for the first crop and 61.2 for the second crop.)

varied as much as would be expected during the period of this study. The lowest price that was reported by any considerable number of growers was 26 cents and the highest price reported was 35 cents per crate. These packages are never returned for use the second time and in seasons when the price is low the difference between profit and loss may hinge upon the cost of packages.

Picking

The labor required for the handling of a strawberry crop is the largest item of expense. According to the data presented in Table 5 the cost of labor was approximately 59 cents per crate which represented 51.4 per cent. of the total harvesting and handling cost. Picking strawberries is slow and expensive. Women and children are used a great deal in Tennessee and are usually found to be more satisfactory than men for this work. They are usually paid by the quart and the rate is practically uniform in each community. During the early years of the present study 2 or $2\frac{1}{2}$ cents per quart was the customary rate, but during the worst years of the depression this was reduced to 1 cent per quart and in recent years it has generally been increased to only $1\frac{1}{2}$ cents. Some of the large growers who employ large numbers of pickers make it a practice to hold back a fraction of the pay until the close of the season, giving it as a bonus to those pickers who remain with them throughout the entire season. Most growers with small acreages are able to do most of the picking with their own family and the help of their neighbors. It is desirable to

have a large proportion of the cost of harvesting and handling a strawberry crop remain in the family or in the immediate community. According to the data which are presented in Table 5 the cost of picking amounted to approximately half the total cost of harvesting and handling the crop and represented more than 75 per cent. of the labor.

Growers with rather large acreages find it necessary to supervise the picking and packing carefully. Those who have a small acreage and are able to care for the work with their own family and the help of their neighbors do not employ additional help for this purpose. Only 65 of the 103 records gave a separate charge for supervision and the average cost according to these 65 records was $4.23 per acre. Seven growers reported a cost of $10.00 per acre or more for supervision and in every instance they were large growers who had employed field bosses to supervise the picking.

Grading and Packing

The methods used in grading and packing strawberries differ greatly in different communities and also from year to year. During seasons when the supply is limited and the market demand is active growers find it unnecessary to practice as careful grading as is done during seasons when there is a distinct surplus of fruit. A comparatively small minority of strawberry growers in Tennessee practice uniform methods of grading in order to supply a constant quality to their trade. These growers usually follow a definite plan as follows: as soon as the pickers deliver the fruit to the packing shed

the packers take each cup and turn it into an empty cup so that all defective berries can be removed. The fruits in the top layer are then arranged in a uniform way to hide the calyx and to present a smooth uniform surface. The expense of such handling amounts to from 8 to 12 or possibly 15 cents per crate according to the condition of the crop. Most strawberry growers in Tennessee, however, simply rearrange the top berries and do not turn the cups at the packing shed. According to the average of more than one hundred records included in this study the cost of grading and packing was 8.6 cents per crate. This amounted to only nine per cent. of the total harvesting and handling cost, but represented 14.6 per cent. of the labor.

Hauling

The cost of hauling fruit to the shipping point was not easily determined. In every community growers are scattered over a rather wide area amounting to as much as 15 or 20 miles where road conditions were favorable and shipping points were widely separated. Under such conditions the cost of hauling represented a significant proportion of the total cost. On the other hand, many growers who were located within a few miles of the shipping point delivered berries in passenger cars at very little expense. It was very common for such growers to report that they were going to town anyway and it did not cost anything to take the few crates of berries which they had. Hauling charges were usually based on a per crate charge when the work was done by a special truck hired for that purpose. In cases when the owner delivered his

own berries to the shipping point a per mile charge was used varying according to the quantity of fruit which was delivered. The average charge of 7.7 cents per crate given in Table 5 is liberal considering the conditions in most strawberry shipping communities in Tennessee. This charge represents eight per cent. of the total harvesting and handling cost according to these data.

FACTORS WHICH CONTROL STRAWBERRY YIELDS

The survey of literature which has been reported in Part I indicates quite clearly the wide difference of opinion among growers and writers as to the cultural methods which produce the highest yields of strawberries with the greatest profits. It is quite evident that there are many factors which contribute to the profitable production of this crop and the securing of high yields per acre. A summary has been prepared from a group of records on Klondyke strawberry fields which were set in 1929. These records, in Table 6, are arranged according to the total yields and by a study of this tabulation some idea can be secured of the relative importance of various factors which influence production. One of the most obvious relationships is that between the yield and the land value. The average land value for the high producing group is $94.16 and for the low producing group it is only $58.33.

Table 6. Relation Between Cultural Factors and Yields

No. Grower	Crates Per Acre	Land Value	Soil Preparation Per Acre		Fert. Cost	Cultivation Per Acre		Date Last Cult.	No. Cultivations	
			Man hrs.	Horse hrs.		Man hrs.	Horse hrs.		Hoe	Plow
10	108	$100	10	15	$6.00	82	15	8/14	4	6
29	90	100	15	30	--	81	24	8/20	3	6
7	80	100	12	24	--	109	21	8/21	4	5
27	82	100	29	42	13.00	84	20	?	2	5
28	87	100	33	24	--	91	40	7/28	3	7
1	103	65	19	19	--	150	48	10/1	4	9
AVERAGE	91.6	$94.16	19.6	25.6	$3.16	99.5	28	8/23	3.3	6.3
2	28	$100	5	12	--	80	20	?	4	4
4	47	100	16	24	9.00	81	12	7/10	3	4
5	44	50	8	16	9.50	131	17	8/17	4	4
6	36	40	30	30	5.60	62	14	7/14	3	6
8	60	35	30	30	4.00	46	14	6/14	2	4
9	52	25	10	20	4.42	41	17	7/29	3	5
AVERAGE	44.5	$58.33	16.5	22	$5.42	73.5	15.6	7/17	3.2	4.5

Records of Klondyke Fields set 1929, grouped according to total yield.

Adaptability of the Soil

Among the many factors affecting the profitable production of the strawberry crop the soil requires first attention and is tremendously important. Growers speak with considerable assurance that certain areas have a strawberry soil and other locations do not. Experience and observations make this fact quite certain even though definite proof is difficult to secure and strawberries are recognized as a crop which can be grown on a wide variety of soils. The characteristics which make a soil satisfactory for strawberry culture are many and varied. Each factor exerts its influence but no one or two factors completely determine the suitability of a given soil.

Characteristics of So-called "Strawberry Land"

A very desirable strawberry soil may be described as a sandy or gravelly loam which is in good physical condition, contains abundant humus, is at least moderately fertile, and is well drained. The lighter types of soils are more easily worked, more responsive to care, and are generally preferred by successful growers in Tennessee. Because strawberries are frequently grown in newly cleared land which is naturally poor some have formed the opinion that it is a poor land crop. Observations throughout this study and the expressed opinion of successful growers throughout the state, however, indicate that satisfactory yields are very difficult to secure on poor land. Most growers in this state who use thin unproductive soil consider "new ground" to

be necessary and usually attempt to grow only one planting of strawberries on a single location. To be satisfactory, a strawberry soil must be well drained yet retentive of moisture because plants are easily injured by either a water soaked condition or a definite lack of moisture in the soil. This is especially important in the spring as harvest approaches. It is desirable to have a subsoil slightly heavier than the top soil because such a condition tends to retain fertilizers and moisture but it is very important that the subsoil be sufficiently open to allow the penetration of strawberry roots and to permit normal drainage.

The many factors which go to make up a desirable soil for strawberry growing are interdependent. If any one is seriously deficient it may become the limiting factor and practically prevent successful culture. When the factors are well balanced the most satisfactory yields are secured with reasonable effort. Nevertheless, observations have lead to the conclusion that the physical condition of the soil and the previous care which it has had are of greatest importance. In Tennessee, strawberries are produced entirely by the matted row system of culture, and thorough cultivation is difficult after many runners have become established. If the soil has been poorly managed in previous years so that it is infested with weeds of various kinds the successful growing of this crop is difficult indeed. It is for this reason that successful growers prefer to plant strawberries following a clean cultivated crop like tobacco or a truck crop. Observations during this study have indicated repeatedly that low yields and

unsatisfactory results usually follow the planting of strawberries on foul land.

Inspection Before Planting as a Guide

In order to secure evidence on the importance of the soil in determining strawberry yields the soil was rated or scored by the writer in the fields which were included in Table 6. The rating of the soil was given at the time the planting was made and was based upon the factors which have been discussed above. In Table 7 those fields having more desirable soil are separated from the ones which had less desirable soil and sufficient data are included to indicate the care which the fields had before the first harvest. In most cases, though not in all, the land which was given a high valuation by the owner was rated as satisfactory for strawberry growing by the writer even though the land valuation was not considered in the scoring. The fields in both groups were given practically the same care in preparation, but the group on the more desirable soil was given somewhat more careful cultivation during the season and cultivation was continued later in the summer. No doubt this additional care had some influence on the yields which were secured but it is not sufficient to account for all the difference. It is interesting to note that five of the six growers having less desirable soil applied fertilizers while only two of those in the group having more desirable soil made such applications. Except in one instance the soils judged to be more satisfactory produced high yields in comparison with those considered

Table 7. Effect of Desirable Soil on Yields

More Desirable Soil (Judged by Inspection at Setting)

Record No.	Land Value	Soil Preparation Per Acre		Fert. Cost	Cultivation Labor Per Acre		No. Cultivations		Date Last Cult.	Crates Per Acre
		Man hrs.	Horse hrs.		Man hrs.	Horse hrs.	Hoe	Plow		
10	$100	10	15	$6.00	82	15	4	6	8/14	108
1	65	19	19	--	150	48	4	9	10/1	103
28	100	33	24	--	91	40	3	7	7/28	87
7	100	12	24	--	109	21	4	5	8/21	80
4	100	16	24	9.00	81	12	3	4	7/10	47
29	100	15	30	--	81	24	3	6	8/20	90
AVERAGE	$94.10	17.5	22.7	$2.50(1)	99	26.7	3.5	6.1	8/14	85.8
		Less Desirable Soil (Judged by Inspection at Setting)								
27	$100	29	42	$13.00	84	20	2	5	?	82
8	35	30	30	4.00	46	14	2	4	6/14	60
9	25	10	20	4.42	41	17	3	5	7/29	52
5	50	8	16	9.50	131	17	4	4	8/17	44
6	40	30	30	5.60	62	14	3	6	7/14	36
2	100	5	12	—	80	20	4	4	?	28
AVERAGE	$58.33	18.7	25	$6.09(2)	74	17	3	4.66	7/17	50.3

(Records of Klondyke Fields set 1929)

(1) Average $7.50 for those including fertilizer.
(2) Average $7.30 for those including fertilizer.

less desirable. The low yield for Record 4 may be explained by notes which were taken during the growing season showing that the land was worked a little wet during soil preparation and only about 60 per cent. of a stand was secured at setting. Notes that were made in the fall indicate that later cultivation was very desirable but that some vacant places did not fill properly with plants.

Among all the production records which were made in this study 29 fields produced a yield above the average which was 67 crates per acre. Only seven of these 29 fields had a land valuation less than $50.00. Ten were valued from $50.00 to $100.00, and 12 were valued at $100.00 or more. The average value of all fields included in this survey was approximately $70.00, and 18 of the 29 fields which produced a yield above the average were given a land valuation above the average also. There seems to be no doubt, therefore, but that in most cases successful strawberry growers use good land and not cheap land which is worth very little for other purposes.

The importance of a good soil was clearly indicated during the field experimental work which was conducted in this investigation. In 1932 cultural plots were established in three locations near Knoxville. All three of these plantings were on soil of similar type, being of dolomitic origin, but one of the soils had been worn out with long cropping so that it was less fertile, contained less humus, and was inclined to run together more seriously than the others. One of the three soils had been very carefully managed during previous

years and an alfalfa sod was turned during the early fall in preparation for a spring planting of strawberries. This soil was in excellent physical condition, was distinctly more fertile, and would be considered more desirable in every way than the first. The third planting was made on a soil intermediate in condition. It was less impoverished than the first but was distinctly less fertile than the second. Similar field tests were conducted on all three locations and the average yield which was secured reflected the original condition of the soil. The poor soil averaged 73 crates, the most fertile soil averaged 163 crates, and the intermediate one produced 92 crates per acre. Many similar observations have been made throughout the state during the course of this investigation.

Importance of Available Phosphoric Acid

An attempt was made to secure more specific evidence by collecting and testing samples of the soil from the fields where records were being kept. The available supply of phosphoric acid and nitrogen was determined by the method described in Michigan Technical Bulletin 132. The acidity was determined by the LaMotte test and the humus content was determined by burning a sample of soil to constant weight.

All of the soils included in the survey were distinctly acid in reaction. The approximate pH value ranged from 4.9 to 6.2 but no significant relation could be found between acidity and yields. The test for potash which is described in Michigan Technical Bulletin 132 was not sufficiently sensitive to show variations and, therefore, no evidence was secured for that material. In regard to available nitrogen

the data were equally inconsistent. A group of 22 records in Monroe County included ten which reported a yield above the average for the group but only four of these ten high yields came from fields showing more than an average amount of available nitrogen. Of the 12 fields which produced a yield less than average, six were soils testing below and six above the average in available nitrogen. The only consistent data secured in this study was on the importance of phosphoric acid. Soil samples were secured for testing from 52 fields from which production records were available. Seventeen of these soils showed 75 pounds or more of available phosphoric acid per acre. Eight, or 47 per cent. of these soils, came from fields which produced more than the average yield, 67 crates per acre. Twenty of the soils tested 50 pounds available phosphoric acid and nine, or 45 per cent., of these samples came from fields producing yields above the average. Of the 15 soils which tested 25 pounds of available phosphoric acid or less only three, or 20 per cent. came from fields where high yields were secured. Among the fields producing yields above the average there were 20 which were tested for available phosphoric acid and of these 15 per cent. showed 25 pounds or less, 45 per cent. showed 50 pounds, and 40 per cent. showed 75 pounds or more of available phosphoric acid.

A group of 22 records from fields which were set in 1932 in Monroe County were included in this study. Ten of these fields produced a yield above the average (62 crates) for the group and only one of these showed 25 pounds or less of available phosphoric acid, four showed 50 pounds and five showed 75 pounds. Of the 12 fields which

produced yields less than the average only two showed 75 pounds of available phosphoric acid or more and six showed 25 pounds or less.

To secure additional evidence soil samples were collected again in 1934 from fields where labor records were not available but from which yield records could be secured. Forty-six of these tests were made and the average yield per acre for these fields was 81.6 crates. The data concerning acidity and the available nitrogen supply were equally as inconsistent as in the previous study. Nineteen of these fields produced yields above the average and 79 per cent. of these high yielding fields showed 75 pounds or more of available phosphoric acid while only 51.6 per cent. of the 27 fields producing yields below the average showed this high amount of available phosphoric acid. Twenty-five records with the Aroma variety are included in this study and ten of these fields produced yields above the average (79.9 crates per acre). Only two of these ten fields had less than 50 pounds of available phosphoric acid per acre.

Though not conclusive these results do indicate the importance of phosphoric acid in strawberry soils.

Throughout the studies inconsistent results could frequently be explained by notes which were made during the growing season. Many times the low yield in a field which showed favorable amounts of phosphoric acid was explained by poor cultivation, a poor stand of plants, or failure to harvest the entire crop. On the other hand, high yields from fields where the soil did not show a favorable amount of available phosphoric acid could frequently be explained by the unusually good care which was given during cultivation and harvesting.

Influence of Previous Care

In this study some indication was found that humus is an important factor in strawberry soils but no significant data were secured. One group of treatments were intended to reduce the humus. For this purpose a series of three plots was kept free of all growth during the entire season and in another series of plots corn was grown with careful cultivation. Another group of treatments were planned to add organic matter to the soil without nitrogen and for this purpose weeds were allowed to grow without control in one series of plots, and sudan grass was seeded in another series. A third group of treatments were planned to add both nitrogen and humus to the soil. For this purpose an application of ten tons of manure was made in the spring and another application of ten tons was made in the fall to a series of three plots and in another series a spring crop of peas was turned under followed by a summer crop of soy beans which was turned under in the fall. To the final series German peat was applied at the rate of 10 tons per acre. In the spring of 1932 strawberries were set in these plots and the plants were confined to the hill system. The production of runners recorded frequently during the growing season serves as an index of comparative vigor. Table 8 shows the results of this test at the first crop which was produced in 1933. The humus content of the soil was influenced by its treatment during the previous summer. The yield both in weight and in number of berries corresponded rather closely to the humus content. Evidence is presented showing that the proportion of large berries was increased as the soil condition was improved by the addition of humus.

Table 8. Effect of Soil Treatment on Humus Content, Total Yield and Size of Fruit

Treatment	Percent Humus at Harvest	Runners Produced	Average Yield	Av. Total No. Berries	% of Berries		
					$\frac{3}{4}$ -	$\frac{3}{4}$ - $1\frac{1}{4}$"	$1\frac{1}{4}$" +
Clean Cultivation	4.92	125	8.72	170	16.8	71.7	11.5
Weeds	4.93	136	10.80	207	12.2	70.7	17.1
Manure and Weeds	5.12	188	13.72	242	11.7	67.6	20.1
Peat and Weeds	5.78	131	13.86	262	14.3	68.7	17.0
Legume, Peas, and Soybeans	5.13	153	12.16	255	11.4	74.1	14.5
Sudan Grass	5.12	91	9.88	192	14.7	70.3	15.0
Corn Cultivation	5.03	123	8.31	155	14.4	71.1	84.3

There is sufficient evidence available to justify the statement that success in strawberry growing is greatly influenced by the selection of a suitable soil and the management of that soil before strawberries are planted in such a way as to avoid serious weeds, and to maintain it in desirable physical condition and fertility.

Method of Cultivation

Amount and Thoroughness of Cultivation

A study of Table 6 shows that cultivation is a factor which greatly influences strawberry yields. In Table 9 the same group of records are rearranged to include those receiving the largest amount of cultivation in one group and those receiving less cultivation in a second group. It will be seen immediately that there is a striking similarity in the two arrangements. In fact, only one field, Record 29, dropped into the lower group in the rearrangement and was replaced by Record 28. If the separation was based upon the number of cultivations which were given rather than the labor applied there would be comparatively little change. Record 29 would be returned to the higher group and Record 6 would replace Record 27 in this group. The date of the last cultivation may be even more significant than the total number of cultivations which are given in strawberry fields. This information is available in ten of the twelve records which are included in Table 6. When the records are arranged on this basis all of those in which cultivation was continued late into the summer,

Table 9. Effect of the Number of Cultivations on Yields

No. Grower	Crates Per Acre	Cultivations		Land Value	Soil Preparation Hours Per Acre		Fert. Cost	Cultivation Hours Per Acre		Date Last Cultivated
		Hoe	Plow		Man	Horse		Man	Horse	
1	103	4	9	$ 65	19	19	--	150	48	10/1
10	108	4	6	100	10	15	$6.00	82	15	8/14
28	87	3	7	100	23	24	--	91	40	7/28
29	90	3	6	100	15	30	--	81	24	8/20
7	80	4	5	100	12	24	--	109	21	8/21
6	36	3	6	40	30	30	5.60	62	14	7/14
AVERAGE	84	3.5	6.5	$84.17	19.8	23.7	$1.93	95.8	27	8/19
2	28	4	4	$100	5	12	--	80	20	?
5	44	4	4	50	8	16	$9.50	131	17	8/17
9	52	3	5	25	10	20	4.42	41	17	7/29
27	82	2	5	100	29	42	13.00	84	20	?
4	47	3	4	100	16	24	9.00	81	12	7/10
8	60	2	4	35	30	30	4.00	46	14	6/14
AVERAGE	52.1	3	4.3	$68.33	16.3	24	$6.65	77.2	16.7	7/20

Records of Klondyke fields set 1929.

except one, Record 5, are included in the high yielding group, and only one in which cultivation was stopped in July is included in this group.

To secure more direct comparisons and more reliable data field tests were arranged to determine the influence of efficient cultivation on strawberry yields. In 1930 plantings for these tests were made at an experimental substation near Clarksville on the farm of a commercial grower in the strawberry section near Portland, and at the University, Knoxville, Tennessee. The Aroma, Premier, and Klondyke varieties, respectively, were used in these tests. Each test was run in triplicate with three record rows in each plot and a guard row between the plots. Clean cultivation was practiced in all plots during the early summer and was continued in one series throughout the summer and early fall. This cultivation was sufficiently frequent and intensive to control weeds and to keep the soil in reasonably good condition. In one series no cultivation was practiced after August 1 and in the third group of plots only horse cultivation was continued after that time because the matted row made hoeing difficult and expensive. The season of 1930 was relatively dry so that late summer neglect did not result in a serious growth of weeds as would occur during normal seasons. To secure some competition in the planting at Portland a very light seeding of spring oats was made in early fall in those plots where cultivation had been discontinued. The effect of this competition is clearly indicated in Table 10. In this table

Table 10. Effect of Fall Cultivation on Yield and Cost

Treatment	Test 1			Test 2			Test 3				Combined Average			
	Hours Per Acre		Average Yield	Hours Per Acre		Average Yield	Hours Per Acre		Average Yield	Crates Per	Total Labor Per Acre		Labor Cost	
	Man	Horse	Per Plot	Man	Horse	Per Plot	Man	Horse	Per Plot	Acre	M.Hours	H.Hours	Total	Per Crate
Clean Cultivation All Season	191.5	81.9	85.15	146.25	69.0	100.50	155.0	79.1	67.70	140.7	164.2	76.6	$40.50	28.8¢
Clean Until August 1 - None Later	176.5	74.4	65.33	116.25	62.5	54.60	122.5	66.1	57.80	98.7	138.4	67.7	34.45	34.9¢
Clean Until August 1 - Horse tools Only After That Date	184.0	78.1	70.59	123.75	69.0	96.13	135.5	79.1	58.70	125.2	147.7	75.4	37.08	29.3¢

Test 1 -- Aroma ----- Clarksville -- Planting 1930, harvest 1931.
Test 2 -- Premier --- Portland ----- Planting 1930, harvest 1931.
Test 3 -- Klondyke -- Knoxville ---- Planting 1930, harvest 1931.
Labor charge, man hours 20¢, horse hours 10¢.

the average labor and yield for each test is presented and in addition the three tests are averaged in order to permit a comparison of yield, total labor and labor cost. The difference in yield is sufficient to be significant and definitely favors continued careful cultivation during the summer. The reduction in yield where horse cultivation only was continued is much less severe than where all cultivation was stopped. It is clear from this table that the cost per crate and the yield per acre favor efficient cultivation.

For one picking late in the season (June 9) all of the fruit in Test 1 was graded carefully according to size. It was found that those plots which had been cultivated all summer had 62.7 per cent. of the fruit above seven-eighths inch in diameter while those plots in which cultivation was stopped August 1 had only 47.1 per cent. of the fruit above that size. Similar determinations were made during the four last pickings in the Klondyke tests at Knoxville and it was found that those plots in which careful cultivation was continued throughout the summer had 67.7 per cent. of their fruit above three-quarters inch in diameter and those in which cultivation was stopped August 1 had only 58.7 per cent. above that size.

To secure further evidence arrangements were made with two commercial growers in Monroe County to conduct a demonstration with a planting of strawberries. One of these demonstrations was on the farm of Mr. W. T. Smith, Madisonville, and was located on a Knox shale soil which was in excellent physical condition and which had

been given very good care during previous years. A good crop of clover and one of lespedeza had been turned under shortly before the soil was prepared for strawberries. In this field the top soil was about eight inches deep but there was no clear line separating it from the subsoil. The entire area was gently sloping to the west but was not subject to erosion. Previous care of the land had controlled weeds very thoroughly.

The second demonstration was on the farm of Mr. Anderson about two miles from Mr. Smith's field. The soil in this area was a red Tellico sandstone. It was old land which had been rather worn out by continual cropping and appeared to be deficient in humus. The top soil in this field was not more than four to six inches deep and the subsoil was of rather heavy nature. The entire area sloped gently to the south but was not subject to erosion. Previous management of this area had not been intensive and the common weeds proved to be rather a serious problem in the care of the strawberry plantation.

The entire area in both demonstrations was given the same care in soil preparation, fertilization, and planting. Following the establishment of the plantation, however, one-half of each field was given very thorough and careful cultivation in order to keep the soil in the best possible condition and prevent the competition of weeds at any time. The other half was given more ordinary care. Cultivation was delayed until it was needed but was given before the average grower would consider the planting very seriously injured. Mr. Smith

plowed and hoed the part which was being given most careful attention six times. He plowed the other half only four times and hoed it five times. Probably the care which was given the second half was somewhat too good for the best demonstration because the soil was so free of weeds and was in such good condition that at no time did any part of the planting really suffer. At the time of the first harvest there was very little difference in the total amount of labor which had been given the two areas. The difference amounted to only 20 man hours and five horse hours per acre. There was an increased yield, however, of 23 crates per acre in the part of the field which had been given most care.

The condition on Mr. Anderson's farm was quite different. The weed problem made cultivation much more important. He plowed the more carefully cultivated area six times and hoed it seven times. The other area he plowed five times and hoed six times which was more cultivation than is done by the average strawberry grower in Tennessee. Nevertheless, the weeds became serious and made cultivation expensive when it was neglected until they were well established. As a result the part which was given fewer cultivations required 20 hours more man labor before the first harvest and only four hours less horse labor than did the area which was cultivated more times so that the work was done more effectively. The influence of this neglect was quite evident in the yields because there was a difference of 30 crates per acre in favor of the more intensive cultivation.

During the course of this investigation field tests have been

conducted in order to secure more direct comparisons on the importance of cultivation and its influence on strawberry yields.

In 1933 a planting was made at the University to secure more accurate information corresponding to the demonstrations described above. The test was run in triplicate with four test rows in each plot and a guard row separating adjoining plots. The results of this test are presented in Table 11. This test was conducted on a red dolomite soil which was of moderate fertility, in reasonably good condition, but somewhat deficient in humus. Previous care of the area had not controlled the weeds as perfectly as is desirable for a strawberry planting. The results corresponded closely to those reported from the commercial demonstrations in Monroe County. The difference in total labor is not as great as would be indicated by the number of cultivations because of the additional work which was necessary after a period of neglect. That part of the planting which was given careless culture was not neglected more seriously than a large percentage of the commercial strawberry growers in Tennessee are in the habit of doing. It was neglected sufficiently, however, to permit definite competition with weeds and the result was a greatly reduced stand of plants and some injury to the plants when they were cleaned out. Even the neglected area produced 40 crates per acre which was above the yield of many commercial growers following the dry summer of 1933. The summary which is given in Table 11 shows a very great increase in cost per crate when neglect results in

Table 11. Relation of Thoroughness of Cultivation to Yield and Labor Cost

Treatment	No. Cultivations		Total Labor Per Acre		Labor Cost		Average			Summary		
	Hoe	Plow	Man Hours	Horse Hours	Total	Per Crate	No. Plants	Total Plot Yield	% Below $\frac{3}{4}$ Inch	Yield 100 Plants	% Below $\frac{3}{4}$ Inch	Crates Acre
Very Careful Culture	9	13	234	72	54.00	55.9¢	2505	77.3#	2.69	3.08#	3.4	96.62
Careless Culture	5	6	200	48	44.80	$1.12	1442	32.0#	1.01	2.21#	3.1	40.00

Plots are four rows (1/45 acre) each, Aroma set 1933.
Labor -- man hours 20¢, horse hours 10¢.

seriously reduced yields. The results of these tests justify a strong statement that the timeliness of cultivation is of tremendous significance in the production of reasonable yields at a reasonable cost.

Depth of Cultivation

Observations throughout this study have indicated a very wide variation in the methods of cultivation which are practiced by commercial growers. In most instances tools which stir the soil deeply are used even during comparatively dry seasons and on soils where surface cultivation is common with other farm crops. This observation raised the question as to whether strawberry yields are improved by shallow or deep cultivation and in order to secure evidence on this point additional field tests were planned. The results of six such tests are presented in Table 12.

Three of these tests were conducted in 1930, two in 1931, and one in 1932. The work was repeated in Middle Tennessee at both Clarksville and Portland, and on the University Farm at Knoxville. The three leading varieties, Aroma, Premier, and Klondyke, were included in these tests. In Table 12 the results of a test at Knoxville on Klondyke are presented in more complete form. The number of plants in each plot was counted after the close of the growing season and the yields per 100 plants are included. During the harvest of these plots in 1933 the percentage of berries which were below three-fourths of an inch in diameter was determined throughout the entire picking season and the percentage of small berries is presented in the table.

Table 12. Effect of Depth of Cultivation on Yields.

Treatment	Yield in Pounds Per Plot					Test 6, 1932					Combined Av. Yield	
	Test 1 1930	Test 2 1930	Test 3 1930	Test 4 1931	Test 5 1931	Pounds Per Plot	No. Plants	% Below $\frac{3}{4}$ Inch	Pounds Per 100 Plts.	Crates Per Acre	Pounds Per Plot	Crates Per Acre
Surface Cultivation	103.33	63.35	43.04	28.61	22.38	131.66	2242	17.6	5.58	219.4	65.39	108.98
Medium Cultivation	97.52	75.01	81.41	29.35	34.78	142.84	2230	21.0	6.40	238.1	76.82	128.00
Deep Cultivation	83.91	80.38	83.73	29.90	34.53	112.53	1894	17.7	5.94	187.6	70.83	118.05

1. Set 1930 -- Klondyke -- Knoxville -- first crop.
2. Set 1930 -- Premier -- Portland -- first crop.
3. Set 1930 -- Aroma -- Clarksville -- first crop.
4. Set 1931 -- Klondyke -- Knoxville -- second crop.
5. Set 1931 -- Aroma -- Clarksville -- second crop.
6. Set 1932 -- Klondyke -- Knoxville -- first crop -- excellent soil.

The yields presented in this table show that there is comparatively little difference between the medium and deep cultivation except in the one test which was conducted at Knoxville in 1932. The table shows, also, that, except in one test which was conducted at Knoxville in 1930, the yield was less with shallow than with medium cultivation.

The apparent inconsistencies may be explained by the peculiar soil conditions or weather conditions during the test. The first test reported in this table was conducted at Knoxville on a soil of moderate fertility and in reasonably good physical condition. In this test, Plot No. 9 (deep cultivation) was damaged late in the growing season so that the yield was reduced to some extent. Near the close of the growing season the following note was made concerning these plots:

> "All plots started vigorously. Plots with deep cultivation seemed distinctly most vigorous and those with shallow cultivation least vigorous. This disappeared during early fall and there was very little difference in appearance of the plots after that."

The second test which was conducted, during the same season, at Portland on the farm of a commercial grower was on a soil which was deficient in humus and rather low in fertility. The following note was made concerning these plots at the close of the growing season:

> "All plots started vigorously and uniformly. Gradually the shallow cultivated plots fell behind so that by fall there was a notable difference. The medium and deep cultivation appeared similar."

The third test was conducted at the substation near Clarksville, on a soil which was inclined to run together and become very hard. The following note was made at the close of the growing season:

> "Throughout the growing season there were more plants and there was greater vigor in the medium and deep cultivated plots. The soil was hard in the shallow cultivated plots and much more open and rough in the others. Weeds and grass were not a factor affecting plant growth in any plots. The entire growing season was unusually dry so that there was never an excess of water at any time."

The labor records in all of these tests show that there was no significant difference in the labor required by the different methods. As a result of these tests it must be concluded that strawberries differ from many farm crops in their cultural requirements, and that they are not injured by cultivation of medium or considerable depth. During the season of 1932 a brief study was made of the distribution of strawberry roots and it was found that they do not spread widely but are inclined to turn rather directly down and penetrate the soil to a considerable depth. Such a root distribution is not disturbed by cultivation and whenever the soil becomes hard it will be improved by deep stirring. Growers are, therefore, not unwise in their selection of tools with from two to five shovels which stir the soil to a considerable depth. Good judgment should be used in each planting and the depth of cultivation should be varied according to the conditions.

Cultivation After the First Crop

The problem of strawberry cultivation during the second

season, after the first harvest, has been the subject of much discussion. Many growers in Tennessee who practice rather careful, intensive cultivation during the first season believe that it is unprofitable to attempt any cultivation after the first crop. These growers simply allow their fields to remain without attention during the summer and in early fall or before harvest the second spring they mow the heavy weeds and remove them so that they will not interfere with the picking. Such practices are common but have been generally condemned by writers on this subject. Other growers practice very haphazard methods of cultivation following the first harvest and never approach the thorough work of the first growing season. They may work the planting thoroughly after harvest by way of renovation and then give only scant additional attention, or they may not practice intensive renovation but cultivate occasionally during the second growing season. There are many growers, however, who believe that cultivation is as important during the second as during the first season and they practice intensive methods of renovation followed by thorough cultivation until fall.

The influence of local and seasonal conditions makes it difficult to secure reliable data on which to base an opinion concerning the cultural practices which are advisable during the second year. In Table 13 a group of 15 records from strawberry fields in Monroe County are listed in the order of their yields at the second harvest and the amount of labor following the first crop is presented. The

Table 13. Effect of Cultivation After Harvest

Record No.	Yield	No. Cultivations		Total Labor Per Acre	
		Hoe	Plow	Man	Horse
65	124	2	3	43	16
66	104	3	4	28	14
67	98	2	2	20	15
55	75	3	4	79	16
45	49	1	4	36	16
58	48	1	3	44	18
51	40	3	5	112	12
68	30	4	6	72	30
59	28	--	--	--	--
43	26	--	--	--	--
69	22	3	4	56	24
46	20	3	4	75	16
57	20	--	--	--	--
47	11	1	3	32	12
44	5	--	--	--	--

Fields of Aroma in Monroe County set in 1932.
68--------- Estimated that more than 1/3 of fruit was lost in field as overripes and, therefore, more truly belongs in higher group.
46 & 47---- No systematic renovation.

effect of cultivation stands out quite clearly in this table. All of the fields where no cultivation was done following the first crop are in the low producing group and only two fields, where a considerable amount of cultivation was done, are included in this group. One of these, Record 69, was from a piece of foul land where the weed problem was very serious and cultivation was often delayed until the weeds had done serious injury. Records 46 and 47, which show some cultivation and yet are included in the group producing very low yields, are fields where no systematic renovation was practiced but where occasional cultivation was given during the season. An attempt to arrange similar tables with other groups of records proved very much less successful. There was so much variation in cultural practices and such wide differences in the yields which were produced that it was difficult to group them in any logical way. Considering the entire group of 40 records for which information is available during the second growing season there is certainly some evidence that cultivation does produce larger yields but that the expense per crate may frequently be increased to such an extent as to reduce the profits.

To secure more direct comparisons field tests have been conducted during this investigation to show the value of cultivation during the second year. The results of several such tests are presented in Table 14. Several important observations can be made from this table. First of all it is quite clear that cultivation after harvest greatly reduces the number of plants which are available for the

Table 14. Effect of Cultivation Following Harvest

Treatment	No. Plants	Plot Yield lbs.	% below ¾"	Yield Per 100 Plants	Crates Per Acre	Date of Renovation	Total Labor Per Acre		Labor Cost	
							Man hrs.	Horse hrs.	Acre	Crate
				No Cultivation After Harvest						
Test 1	--	11.15	11.8	--	18.6	--	11.0*	--	2.20	11.8¢
Test 2	--	12.74	17.4	--	20.7	--	6.7*	--	1.34	6.4¢
Test 3	792	17.30	13.6	2.18	28.8	--	41.0*	--	8.20	28.7¢
Test 4	1944	81.57	28.7	4.09	135.8	--	12.0*	--	2.40	1.8¢
Test 5	1694	27.10	--	1.60	67.7	--	--	--	--	--
Test 6	2420	36.25	8.5	1.49	90.6	--	4.0	--	.80	.9¢
Average	1712.5	31.02#	16.0%	2.34#	60.4	--	14.9	--	$2.99	9.9¢
				Renovation Soon After Harvest with Later Cultivation						
Test 1	--	21.55	8.9	--	35.9	7/3	96.4	31.0	22.38	62.3¢
Test 2	--	5.87	15.3	--	19.8	6/17	154.7	50.7	36.01	$1.82
Test 3	978	86.76	14.0	8.71	144.6	6/22	144.2	63.2	35.16	24.2¢
Test 4	1678	78.89	18.8	4.52	126.4	6/5	151.2	48.0	35.04	27.7¢
Test 5	789	28.55	--	3.62	71.4	6/14	54.4	40.6	14.94	20.9¢
Test 6	1626	10.24	4.3	3.70	150.6	6/14	170.3	84.3	42.49	28.2¢
Average	1268	46.98#	12.3%	5.14	89.8	6/17	128.5	53.0	$31.00	25.2¢**
				Renovation Delayed						
Test 4	979	46.81	17.4	4.78	77.8	8/7	171.2	55.0	39.74	51.1¢
Test 5	579	31.59	--	5.44	79.0	8/18	66.4	50.1	18.29	23.0¢
Test 6	861	47.77	5.55	4.40	119.4	8/8	123.0	53.0	29.90	25.0¢
Average	806.3	42.06	11.5	4.87	92.1	8/11	120.2	52.7	29.31	33.0¢

All tests have 3 row plots except Test 5.
**Tests 1 and 2 omitted from the average.
1 -- Set 1930, Aroma, Clarksville --
2 -- Set 1930, Klondyke, Knoxville --
3 -- Set 1931, Klondyke, Knoxville --
*Applying fertilizer, mulch, pulling big weeds, etc. Dry season caused almost complete crop failure.
4 -- Set 1932, Klondyke, Knoxville.
5 -- Set 1932, Aroma, Knoxville (poor soil) 2 row plots.
6 -- Set 1932, Aroma, Knoxville.

second crop. The amount of the reduction depends upon the soil and weather conditions during the growing season and in some cases the reduction may be so great as to reduce the total yield of fruit at the second harvest. The value of cultivation during the season is very clearly indicated on the basis of the yield per 100 plants. In every case where such a record is available there is a significant increase with cultivation. The proportion of berries which are above the minimum size for U. S. No. 1 is another important consideration in determining the value of cultivation following the first harvest. In all instances except one there was a distinct increase in the proportion of fruits above this minimum size and the average for the five tests indicates a significant value from this view point.

The amount of labor which was used in these plots was as much as is usually required during the first growing season. The delayed renovation which is frequently practiced by growers did not result in labor saving because of the large amount of hand work which was required to put the field in reasonable condition after the weeds had become well established. From these results it seems clear that under normal conditions cultivation will definitely increase the amount of fruit which is produced at the second harvest when such cultivation does not seriously reduce the stand of plants and that the size of the fruit will be improved by such cultivation. It is very important, however, to note the increased labor cost per crate which follows this intensive culture during the second season. In Tests 1 and 2 which

were given quite intensive cultivation following the first crop unfavorable weather conditions reduced the yield to such a point that the cost per crate was excessive and the work was definitely not profitable. The following note was made near the close of the growing season concerning the second test reported in this table:

> "The season of 1931 following renovation was excessively dry and practically no new plants were formed in plots where thorough renovation was practiced and no serious weeds or grass developed in the uncultivated plots."

Intensive renovation of a strawberry field may be accomplished in different ways. Many growers prefer the following plan: as soon as possible after harvest the plants are mowed and the tops are raked from the field together with the mulch which had been applied during the late winter or early spring. The middles between the rows which have been packed by the pickers during harvest are cultivated in order to destroy weeds and to loosen the soil on the surface. A few days later the rows are barred off with the turning plow leaving them from eight to 12 inches wide and covering all plants and weeds between the rows. The narrow row which remains is then hoed or chopped in such a way as to remove weeds and thin the strawberry plants. After this has been done the middles are cultivated carefully and dirt is thrown back to the row or slightly over the row in order to add fresh dirt about the crowns of the plants which remain. Frequently a turning plow is used so that the row is covered and then the dirt is leveled with a harrow until the strawberry plants begin to show.

A very much less intensive method of renovation is recommended by many growers, especially in seasons when the soil is not in good condition to work. By this plan the rows are not barred off but the middles are carefully cultivated with a double shovel or three foot plow. The work is continued until the soil has been thoroughly pulverized and weeds or strawberry runners have been destroyed. Then the strawberry row itself is cleaned out by hand with a hoe. By this method the row is not reduced in width and the plants are not thinned as severely as they are by the more intensive plan.

To secure some evidence as to which method is most desirable tests were conducted during 1932 and 1933. The results of these tests are reported in Table 15. These results indicate that more plants are available for the second crop following the less intensive method of renovation, but that the increased yields per plant largely balance this so that the yield per acre is not greatly affected. The large amount of hand work which is required for cleaning out the row without barring off makes the total labor cost as much or slightly more than when the more intensive practices are followed. The conclusion which follows this work is that the method of renovation is of comparatively little importance so long as the work is thoroughly done and therefore the method should be adjusted according to the soil conditions and the stand of plants.

Fertilization

Among the factors which were found to be significant in the

Table 15. Comparison of Renovation Methods

Treatment	No. Plants	Plot Yields lbs.	% Below $\frac{3}{4}$"	Yield per 100 Plants	Crates per Acre	Renovation Labor per Acre		Labor Cost	
						Man Hours	Horse Hours	Acre	Crate
			Intensive Renovation with the Rows Barred-off						
Test 1	978	86.76	14.0	8.71	144.6	41.1	20.1	10.29	7.1¢
Test 2	1524	57.98	19.9	3.80	96.6	42.0	37.2	12.12	12.5¢
Test 3	814	37.71	--	4.63	95.4	25.3	27.5	7.81	8.2¢
Test 4	1626	60.24	4.3	3.70	150.6	39.0	34.2	11.22	7.5¢
Average	1235	60.67#	12.7%	5.21	121.8	36.8	29.9	10.36	8.8¢
			Less Intensive Renovation without Barring-off						
Test 1	1031	91.99	14.6	8.92	153.3	35.5	7.5	7.85	5.1¢
Test 2	1904	63.42	24.2	3.33	105.7	39.0	27.6	10.56	10.0¢
Test 3	817	20.67	--	2.03	51.7	30.7	15.2	7.66	14.5¢
Test 4	2335	60.62	5.7	2.59	151.6	39.5	26.7	10.57	6.9¢
Average	1522	59.17#	14.8%	4.22	115.6	36.2	19.3	9.16	9.1¢

Labor charged 20¢ man hours and 10¢ horse hours.
1 -- Renovation, 1932, Klondyke, Knoxville. 3 -- Renovation 1933, Aroma, Knoxville (poor soil).
2 -- Renovation, 1933, Klondyke, Knoxville. 4 -- Renovation 1933, Aroma, Knoxville (good soil).

cost of strawberry growing the item of fertilizers was prominent. It averaged 45 per cent. of the total cash expense and 11.2 per cent. of total production cost during the two years. Among the 69 records which were included in this investigation 49 included a charge for fertilizer during the first year and 15 of the 40 records for the second crop included a charge for that item. It is evident that the application of commercial fertilizers to strawberry fields is generally practiced and is a matter of considerable importance.

Evidence from Field Records

Observations during this investigation have led to the conclusion that there is very little uniformity in this practice. It seems that some of the most successful growers consider the strawberry to be a crop which does not require liberal fertilization while others believe the application of comparatively large quantities of fertilizers is a necessary part of successful culture. This apparent inconsistency was equally evident in a study of the detailed records which are included in this investigation. Among the 12 records which are tabulated in Table 6 the highest yield was produced on a field which received rather liberal fertilization and the lowest yield came from a field which was not fertilized. The fifth highest yield, however, was produced on the field which received the largest quantity of fertilizer and all except one of the group which produced comparatively low yields received moderate to liberal applications.

When these same records are classified according to the

application of fertilizer, as is done in Table 16, it appears that this factor is of minor importance in the production of high yields. Only one unfertilized field failed to produce a high yield and only two fields which were fertilized produced a yield above the average. This distribution of records adds additional emphasis to the importance of cultivation which has been previously discussed. A study of 17 records on Aroma fields from Monroe County failed to show any greater consistency. Nine of these 17 growers spent more than the average for fertilizer but only three of the nine produced a yield above the average for the entire group. Among six growers in this group who produced yields above the average, 65 crates per acre, three spent more than the average and three less than the average for commercial fertilizer. When the 17 records are divided into two groups, placing eight in the higher and nine in the lower group, on a basis of yields and again on the basis of fertilizer cost, four which appear in the high yielding group are also in the group receiving larger amounts of fertilizer and four are in the group receiving smaller amounts of fertilizer. From all of these observations, therefore, it appears that the practices which are now followed by commercial strawberry growers are not producing consistent results and therefore a group of field tests have been conducted to secure additional information on this phase of strawberry production.

Nitrogen Applications

Observations throughout the state and a study of the production

Table 16. Effect of Fertilizer Application on Yield

No. Grower	Crates	Fert. Cost	Land Value	Soil Preparation Hours Per Acre		Cultivation Hours Per Acre		Date Last Cult.	No. Cultivation		Total Costs	Net Returns	Profits
				Man	Horse	Man	Horse		Hoe	Plow			
2	90	--	$100	15	30	81	24	8/20	3	6	$35.79	$141.30	$105.51
3	80	--	100	12	24	109	21	8/21	4	5	51.85	85.65	33.80
5	87	--	100	33	24	91	40	7/28	3	7	40.54	108.21	67.67
6	103	--	65	19	19	150	48	10/1	4	9	54.45	165.43	110.98
7	28	--	100	5	12	80	20	?	4	4	29.46	49.61	20.15
AVERAGE	77.6	--	$ 93	16.8	21.8	102.2	30.6	8/26	3.6	6.2	$42.42	$110.04	$67.62
11	60	$4.00	$ 35	30	30	46	14	6/14	2	4	$38.44	$106.20	$67.76
12	52	4.42	25	10	20	41	17	7/29	3	5	21.27	101.01	79.74
10	36	5.60	40	30	30	62	14	7/14	3	6	37.29	59.32	22.03
1	108	6.00	100	10	15	82	15	8/14	4	6	34.34	220.27	185.93
8	47	9.00	100	16	24	81	12	7/10	3	4	49.71	44.01	-5.70
9	44	9.50	50	8	16	131	17	8/17	4	4	41.22	55.30	14.08
4	82	13.00	100	29	42	84	20	?	2	5	44.95	180.80	135.85
AVERAGE	61.3	$7.36	$64.28	19	25.3	75.3	15.6	7/24	3	4.9	$38.17	$109.56	$71.38

Fields of Klondyke set 1929.

records indicated quite clearly that nitrogen was considered the most important fertilizing material by commercial strawberry growers. First attention, therefore, was given to the investigation of results which may be secured from applications of nitrate of soda. In Table 17 the effect of applications at setting and during the first growing season are presented from four different tests. All of these tests were run in triplicate and the averages of each test are presented in the table. Test 1 was conducted at a substation in Middle Tennessee on a comparatively poor soil which had been out of cultivation for two or three years. The yields from individual plots in this test were less consistent than would be expected, and the value of nitrate of soda was not clearly indicated. Test 2 was conducted on the farm of a commercial grower near Portland, Tennessee, with the Premier variety. The conditions for this test appeared to be unusually favorable, there were no apparent variations in the soil, and all plots started to grow quite uniformly. Observations during the growing season did not show any marked difference in the vigor of plants or in the color of foliage according to the fertilizer treatments. In this test, as in Number 1, there was as much variation among plots with the same application as between different treatments, and there was no consistent evidence that applications of nitrate of soda were effective. Tests 3 and 4 were conducted near Knoxville; Number 3 on a moderately good soil at the University and 4 on poor land a few miles from the city. The area for both of these

Table 17. Effect of Nitrate of Soda Applications on a New Planting During the Growing Season

Treatment	Test 1		Test 2		Test 3		Test 4			Average		
	Runners 7/15	Plot Yield	Runners 7/16	Plot Yield	Runners 7/11	Plot Yield	Runners 7/28	Plot Yield	Yield 100 Plts.	Runners by late July	Plot Yield	Crates per Acre
150# Nitrate at Setting	247	74.04	187	105.61	--	--	490	97.63	5.50	308	92.43	154.1
75# Nitrate at Setting and in June	260	78.11	203	109.80	270	69.28	565	105.43	4.95	324	98.88	164.8
50# Setting 50# June 50# Sept.	251	72.23	231	104.66	297	83.43	471	106.23	5.74	312	99.96	166.6
No Nitrate	229	76.74	182	106.26	293	80.07	361	80.34	5.64	266	93.66	156.1
75# June 75# Sept.	236	70.01	201	106.86	265	70.57	419	85.20	5.16	280	90.72	151.2
150# Nitrate September	223	64.15	210	98.56	--	--	463	85.90	4.95	299	82.87	138.12

1. Clarksville -- Aroma ---- 3 row plots -- first crop 1931.
2. Portland ----- Premier -- 3 row plots -- first crop 1931.
3. Knoxville ---- Aroma ---- 2 row plots -- first crop 1931.
4. Knoxville ---- Aroma ---- Poor soil ---- 3 row plots ---- first crop 1933.

Crates per acre are based on Tests 1, 2, and 4, inclusive.

tests appeared quite uniform and a good stand of plants was secured at setting in both tests. The following notes were made during the growing season concerning Test 3:

> "The applications of nitrate immediately after setting and in early June were followed by good rains which should have carried the material to the roots. The soil was more dry following the September application."

No difference in plant vigor or foliage, either color or size, could be observed during the growing season or in the spring before harvest. The detailed yield records for Test 4 are somewhat more consistent than for either of the others and apparently the value of nitrate is indicated. In this test the number of plants was counted before harvest so that the yield per 100 plants could be calculated. These counts indicate that the advantage resulted from the production of more plants rather than the increase in production per plant. During July the number of runners which had been produced before that time were counted in each test. These counts indicate that the number of plants may be somewhat increased by the application of nitrate of soda during the first year but that the increase is not sufficient under most conditions to result in a significant increase in yield per acre.

In Table 18 six tests are presented showing the results of applications about the time growth was starting in early March. These tests represent a wide variety of conditions such as is found among strawberry fields in the state. Two of these, 1 and 2, were conducted in Middle Tennessee at Portland. The other four were conducted near

Table 18. Effect of Spring Application of Nitrate of Soda on Yield

	No Nitrogen	March 1 150# Nitrate of Soda
Test 1		
Plot Yield	118.16	124.78
Test 2		
Row Yield	18.64	16.38
Test 3		
Row Yield	7.84	7.51
% below $\frac{3}{4}$"	25.6	26.5
Test 4		
Row Yield	14.07	16.70
Yield 100 Plants	3.28	3.68
Test 5		
Row Yield	22.34	21.41
Yield 100 Plants	7.67	6.88
% below $\frac{3}{4}$"	7.4	6.9
Test 6		
Row Yield	22.45	22.14
Yield 100 Plants	6.29	5.41
% below $\frac{3}{4}$"	2.14	2.75
Average		
Row Yield	33.91 (16.27)	34.82 (15.10)
Yield 100 Plants	6.98	6.14
% below $\frac{3}{4}$"	18.1	20.3
Crates per Acre	169.6	174.1

1 -- 1932, Portland ---- Premier, 2nd crop.
2 -- 1932, Portland ---- Aroma -- 2nd crop.
3 -- 1932, Knoxville --- Aroma -- 2nd crop.
4 -- 1934, Knoxville --- Aroma -- 2nd crop, poor soil.
5 -- 1933, Knoxville --- Aroma -- 3rd crop.
6 -- 1935, Knoxville --- Aroma -- 2nd crop.
Average row yields in () based on Tests 2, 3, and 5 only.

the University. Test 4 was on quite a poor soil a few miles from the city. All tests were conducted in triplicate and the detailed yield records show considerably more consistency than was reported for the applications during the first summer. Field observations following these applications did not indicate increased plant growth except in Test 4 where a darker green color and possibly increased vigor was observed.

In Test 2 and Test 5 an application of 300 pounds of nitrate of soda was included. In Test 2 this increased application produced an average yield of 16.84 pounds and in Test 5 21.44 pounds per row. These yields are practically the same as those produced by applications of 150 pounds per acre and in both cases are less than those produced in these tests where no spring application was made.

The effect of nitrate of soda in the spring before harvest was tested by varying the time of application and the results are presented in Table 19. In Test 3 which was conducted on very poor land near Knoxville the influence of spring applications appeared in the darker green of the leaves and a noticeable increase in plant vigor. Test 6, however, which was conducted on good land at the University did not show such a response and at the beginning of harvest it was not possible to pick out those rows to which nitrate had been applied. There is a very slight indication in these results that applications of nitrate of soda before the second crop produce more favorable results than similar applications before the first crop.

Table 19. Effect of Time of Spring Application of Nitrate of Soda on Yield

	150# Nitrate of Soda Feb. 1	75# Nitrate Feb. 1, Mar. 1	No Nitrogen	50# Nitrate Feb. 1, Mar. 1 and May 1	50# Nitrate Mar. 1, Apr. 1 and May 1
Test 1					
Plot Yield	98.50	89.63	106.26	79.76	90.31
Test 2					
Plot Yield	70.89	72.83	76.74	74.74	76.16
Test 3					
Yield 100 Plts.	4.78	5.06	5.64	5.26	5.50
Plot Yield	72.23	70.96	80.34	77.96	105.36
Test 4					
Plot Yield	114.78	101.83	106.98	103.81	117.70
Test 5					
Plot Yield	10.44	12.24	12.00	13.52	12.55
% below $\frac{3}{4}$"	9.9	7.7	7.5	8.7	10.02
Test 6					
Row Yield	11.56	11.52	13.28	13.26	8.91
% below $\frac{3}{4}$"	18.7	19.6	14.9	17.0	20.7
Average 1st Crop					
Plot Yield	80.54	77.81	87.78	77.49	90.61
Crates per Acre	134.4	129.7	146.3	129.2	151.0
Average 2nd Crop					
Row Yield	19.54	17.94	18.89	18.65	19.88
Yield below $\frac{3}{4}$"	14.3	13.6	11.2	12.8	15.3
Crates per Acre	97.7	89.7	94.1	93.1	99.4
Final Average					
Crates per Acre	116.0	109.7	120.2	111.1	125.2

1 -- 1931, Portland, Premier, 1st crop.
2 -- 1931, Clarksville, Aroma, 1st crop.
3 -- 1933, Knoxville, Aroma (Poor Soil) 1st crop.
4 -- 1932, Portland, Premier, 2nd crop.
5 -- 1932, Clarksville, Aroma, 2nd crop.
6 -- 1933, Knoxville, Aroma (single rows).
Average yield for 2nd crop is given on basis of single row.

In 1933 an application was made preceding the third harvest on a planting of Aroma at the University. The result of this test strengthens the suggestion that old plantings are more likely to profit from spring applications than are young plantings. No appreciable difference resulted from the application of this material as a single treatment or divided into two or three smaller applications. The only possible conclusion from these tests is that spring applications of nitrate of soda have failed to produce significant increases in yield.

The problem of maintaining satisfactory yields during the second crop is very difficult and the practice of applying fertilizers after harvest in order to increase these yields is quite general among those growers who practice cultivation following the first harvest. Some growers who do not practice cultivation make applications of fertilizer either during the second summer or in the spring before the second crop. Five tests to determine the value of applications of nitrate of soda after harvest are presented in Table 20. In every case except Test 5 which was seriously injured by a very dry growing season following the 1933 harvest the effect of nitrate of soda applied at the time of renovation is indicated distinctly. The exceedingly dry summer following the 1931 crop almost caused the failure in the plots at Clarksville presented in Test 2, but in spite of these conditions the influence of nitrogen can be seen. The soil was in reasonably good condition for cultivation at the time renovation

Table 20. Effect of Applications of Nitrate of Soda After Harvest

Treatment	Test 1	Test 2		Test 3		Test 4			Test 5		Average			
	Plot Yield	% Below ¾"	Plot Yield	% Below ¾"	Plot Yield	% Below ¾"	Plot Yield	Yield 100 Plts.	Yield 100 Plts.	Row Yield	% Below ¾"	Yield 100 Plts.	Row Yield	Crates Per Acre
150# Nitrate at Renovation	130.06	6.5	19.29	14.8	25.50	8.5	34.28	6.13	3.05	11.73	9.9	4.59	16.99	84.6
No Nitrogen	106.98	6.4	14.59	15.3	21.23	7.2	31.81	5.15	2.94	11.84	9.6	4.04	14.34	71.7
150# Nitrate Sept. 1	101.63	7.9	15.29	19.2	24.07	7.7	41.51	6.15	3.46	12.58	11.6	4.80	15.00	75.0

1 -- Harvest 1932, Portland ------- Premier -- 2nd crop, 3 row plots.
2 -- Harvest 1932, Clarksville ---- Aroma ---- 2nd crop, 3 row plots.
3 -- Harvest 1932, Knoxville ------ Aroma ---- 2nd crop, 2 row plots.
4 -- Harvest 1933, Knoxville ------ Aroma ---- 3rd crop, 2 row plots.
5 -- Harvest 1934, Knoxville ------ Aroma ---- 2nd crop, single row, poor soil.

was done and the application was made but there was very little rain following that date and plant growth was very much suppressed. The conditions for renovation in Test 5 were very much less satisfactory. There had been no rain during harvest and the soil was very hard and dry when renovation was done. There were rains during late fall, however, which stimulated plant growth and resulted in reasonable yields as reported in this table. The different soil conditions at the time of renovation and fertilization probably explain the response in Test 2 and the lack of response in Test 5. The influence of nitrate applied in September is less marked than that of applications made at renovation.

During this investigation an attempt was made to compare applications of sulphate of ammonia with nitrate of soda and four such tests are summarized in Table 21. In three of the four tests slightly lower yields resulted from the use of sulphate of ammonia, but the difference was not significant with the possible exception of Test 4. Cottonseed meal as a source of nitrogen was used on two occasions during this experimental work, but in neither case did yields vary appreciably from those where nitrate of soda was applied. In the first test which is reported the percentage of fruits which were below three-quarters of an inch in diameter was determined and there is some indication that applications of nitrate of soda produced the largest average size and that there was very little increase in the size of fruits following the application of sulphate of ammonia.

Observations have been made repeatedly during these

Table 21. Comparison of Different Nitrogen Carriers

Treatment	Test 1			Test 2		Test 3		Test 4	Average		
	Row Yield	% Below $\frac{3}{4}$"	Yield 100 Plts.	Row Yield	Yield 100 Plts.	Row Yield	Yield 100 Plts.	Row Yield	Row Yield	Yield 100 Plts.	Crates Per Acre
No Fertilizer	43.43	20.2	4.51	11.84	2.93	26.78	5.64	39.38	30.36	4.36	151.8
Nitrate of Soda	45.44	16.1	4.99	11.73	3.06	26.65	5.26	41.59	31.35	4.44	156.7
Sulphate of Ammonia	42.56	19.0	5.59	11.26	3.04	31.28	5.22	34.58	29.92	4.21	149.6

1. 1935 -- Knoxville -- Klondyke -- 3rd crop, good soil, applied at renovation.
2. 1934 -- Knoxville -- Aroma ----- 2nd crop, poor soil, applied at renovation.
3. 1932 -- Knoxville -- Aroma ----- 1st crop, poor soil, applied Feb., Mar., and Apr. before harvest.
4. 1932 -- Portland --- Premier --- 2nd crop, poor soil, applied Mar. 1 before harvest.

investigations concerning the effect of nitrogen applications on the carrying quality of strawberries. All of these observations indicate that applications of nitrogen during the spring tend to cause somewhat softer fruit during seasons of abundant rainfall. On June 8, 1932, eight boxes of Aroma berries were taken at random from each series of plots where spring applications of nitrogen were being compared. These were placed in a standard crate and sent to Knoxville by express without refrigeration. They arrived and were examined late in the afternoon of the following day. The boxes in the sample from plots where 300 pounds of nitrate of soda had been applied were entirely unsalable. Those from plots where no spring nitrogen had been applied were in fair condition and would be considered reasonably salable. The sample from plots receiving 150 pounds of nitrate of soda were intermediate in condition. Counts were made to determine the percentage of berries which were soft and it was found that 65 per cent. were soft where 300 pounds of nitrate had been applied, 40 per cent. in the sample from the rows receiving 150 pounds, and 14 per cent. from the plots where no nitrogen had been used. It was observed, however, that the berries were of smaller size in the sample from the no-nitrogen plots and that in all cases the larger fruits were softest. A similar shipment of Premier strawberries was made from plots comparing applications of nitrate of soda and sulphate of ammonia. This shipment arrived with equal promptness and was examined immediately. The first observation indicated that Premier did not

stand shipment as well as did the Aroma. All samples in this shipment appeared unsalable because of the crushed and injured fruits. Counts were made, nevertheless, and 31 per cent. of the fruits were sufficiently firm to hold their shape and be salable in the sample from plots where no nitrogen had been applied, 21 per cent. from the plots where nitrate of soda had been applied, and 24 per cent. from the sulphate plots. There seems to be clear evidence that nitrate of soda when it is applied in the spring before harvest tends to increase the damage during shipment.

Non-nitrogenous Fertilizers

Because of the rather unsatisfactory evidence which was secured from the study on nitrate of soda as a fertilizing material for strawberries and the evidence which has been presented previously that soils suitable for strawberry growing should have a reasonable amount of available phosphoric acid, tests were planned during the seasons of 1934, 1935, and 1936 to determine the value of other forms of commercial fertilizer. The influence of applications of phosphoric acid and potash is presented in Table 22. Seven different tests are reported in this table but only two, 1 and 4, were on distinctly poor soils and tests 2 and 6 were on soils considerably better than the average. It will be observed from this table that in three of the seven trials applications of potash increased yields and in four of the seven trials application of phosphoric acid increased the yields.

In 1936 a planting which included several varieties was

Table 22. Effect of Fertilization at Setting

	P_2O_5 400#	K_2O 100#	P_2O_4 400# K_2O 100#	No Fertilizer
Test 1----Row Yield	9.35	10.48	11.26	8.58
% below $\frac{3}{4}$"	--	--	--	--
Yield 100 Plts.	3.96	4.14	3.86	4.47
Test 2----Row Yield	12.51	14.35	11.82	16.06
% below $\frac{3}{4}$"	3.7	3.4	2.6	3.5
Yield 100 Plts.	3.47	2.98	2.78	3.30
Test 3----Row Yield	21.89	25.56	28.02	22.84
% below $\frac{3}{4}$"	20.1	19.5	19.4	17.7
Yield 100 Plts.	4.76	4.53	3.58	5.56
Test 4----Row Yield	39.01	34.85	40.38	37.32
% below $\frac{3}{4}$"	2.2	2.8	2.3	2.6
Yield 100 Plts.	4.03	4.17	3.85	4.66
Test 5----Row Yield	34.41	25.95	23.19	27.21
% below $\frac{3}{4}$"	17.7	15.2	14.9	17.8
Yield 100 Plts.	3.80	3.82	4.25	4.33
Test 6----Row Yield	26.84	23.20	23.39	19.49
% below $\frac{3}{4}$"	2.9	2.7	2.9	3.4
Yield 100 Plts.	2.85	3.65	3.81	3.71
Test 7----Row Yield	5.92	5.09	5.42	6.26
% below $\frac{3}{4}$"	19.2	17.4	19.9	21.9
Yield 100 Plts.	.45	.35	.45	.51
Average---Row Yield	21.42	19.92	20.50	19.68
% below $\frac{3}{4}$"	10.9	10.1	10.3	11.1
Yield 100 Plts.	3.33	3.78	3.23	3.79
Crates per Acre	107.1	99.6	102.5	98.4

All tests were located at Knoxville, all yields are for the first crop.

1 -- Set 1933, Aroma, poor soil.
2 -- Set 1933, Aroma.
3 -- Set 1934, Blakemore.
4 -- Set 1934, Aroma, sandy soil.
5 -- Set 1934, Klondyke.
6 -- Set 1934, Aroma.
7 -- Set 1935, Aroma, good soil (late freeze).

available. Three rows of each variety in this planting were given applications of phosphoric acid and potash, and three alternate rows were not. These tests were on a soil much above the average in fertility and in no case did the applications of these materials produce a significant increase in yield. As a phase of this investigation, applications of phosphoric acid and potash were made in the row under the bed at the time of setting and also, in a furrow at the side of the plant immediately after setting. This was done in order to determine whether the placing of the material would have a significant effect upon the results. All applications in Test 7 reported in Table 22 were duplicated in this way but in no case was there a significant difference in yields, according to the method of placing the fertilizer. The increased yields which follow applications of these materials on poor soils seem to be due partly to the increased number of plants which are produced and partly to a higher yield per plant. The abnormally low yields reported in Test 7 are due to a late spring frost which destroyed the first bloom and greatly reduced the total yield.

Applications similar to those reported in Table 22 were repeated following harvest. These applications were made during renovation. The results of three such tests are reported in Table 23. These tests were conducted on a soil of moderate fertility or better and in no case is the influence of either phosphoric acid or potash significant. Additional evidence is found, however, that applications

Table 23. Effect of Fertilization at Renovation

Treatment	Test 1			(1) Test 2			(2) Test 3			Average			
	Row Yield	% Below ¾"	Yield 100 Plts.	Row Yield	% Below ¾"	Yield 100 Plts.	Row Yield	% Below ¾"	Yield 100 Plts.	Row Yield	% Below ¾"	Yield 100 Plts.	Crates Per Acre
P_2O_5 450#	30.51	2.17	5.40	36.45	3.62	3.29	40.46	19.8	4.92	35.81	8.53	4.54	179.1
K_2O 100#	25.43	2.33	4.96	36.88	3.92	3.36	40.16	18.1	4.46	34.16	6.03	4.26	170.8
P_2O_5 450# K_2O 100#	25.40	2.22	5.70	39.21	3.24	3.00	39.08	19.3	4.67	34.56	6.43	4.46	172.8
No Fertilizer	32.83	2.54	5.17	35.12	3.42	3.01	40.17	20.8	4.52	36.04	6.93	4.23	180.2
P_2O_5 450# K_2O 100# Nitrate 100#	33.48	1.74	5.09	35.70	2.99	3.15	46.34	17.7	5.19	38.51	5.90	4.48	192.6
Nitrate 100#	35.63	3.08	5.23	42.09	2.93	3.12	45.44	16.1	4.99	41.05	7.37	4.45	205.3

(1) Application to single rows repeated 4 times with 12 no fertilizer rows.
(2) Application to single rows repeated 6 times with 18 no fertilizer rows.
1 -- 1935, Knoxville, Aroma ----- 2nd crop.
2 -- 1935, Knoxville, Aroma ----- 3rd crop.
3 -- 1935, Knoxville, Klondyke -- 3rd crop.

of nitrate of soda following harvest at the time of renovation may be distinctly valuable. A similar test conducted on very poor soil during 1934 is omitted from this table because applications did not directly correspond, but in this test the use of phosphoric acid resulted in an increase of 5.3 per cent. and applications of potash resulted in an increase of 6 per cent. in the total yield. Both phosphoric acid and potash in this test resulted in an increase of approximately 11 per cent.

A large group of commercial growers in Monroe County practice the application of muriate of potash in the spring as growth is starting and are firmly convinced that it is their most profitable fertilizer application. Several growers scattered throughout the state have found such applications profitable, and, in order to secure direct comparisons, field tests were conducted at the University. Seven such tests are reported in Table 24. In every case except Test 3, which was on a very poor soil, distinct increases in yield followed the application of 100 pounds of muriate of potash in the early spring. Results in these tests are more consistent than any which have been reported. Detailed yield records of individual tests show great consistency, and there is no doubt but that under the soil conditions at the University such spring applications of potash are very effective. The average of these seven tests showed an increase of 12.7 per cent. in the yield per 100 plants when spring applications of potash were made.

Table 24. Effect of Spring Potash Application

	No Potash	100# Potash March (as growth starts)
Test 1----% below $\frac{3}{4}$"	19.8	18.6
Yield 100 Plants	7.87	8.68
Row Yield	71.64	80.05
Test 2----% below $\frac{3}{4}$"	11.2	12.8
Row Yield	30.73	36.22
Test 3----Yield 100 Plants	3.54	3.97
Row Yield	26.30	26.13
Test 4----% below $\frac{3}{4}$"	11.1	10.2
Row Yield	17.42	19.50
Test 5----% below $\frac{3}{4}$"	5.8	5.6
Yield 100 Plants	2.33	3.98
Row Yield	25.38	27.44
Test 6----% below $\frac{3}{4}$"	27.7	25.5
Row Yield	28.18	32.34
Test 7----Yield 100 Plants	3.78	3.15
Row Yield	17.29	18.31
Average---% below $\frac{3}{4}$"	15.1	14.5
Yield 100 Plants	4.38	4.94
Row Yield	30.99	34.28
Crates per Acre	154.6	171.4

1 -- 1933, Triplicate, Blakemore, 1st crop.
2 -- 1933, Triplicate, McClintock, 1st crop.
3 -- 1933, Triplicate, Aroma, 1st crop, poor soil.
4 -- 1934, Triplicate, McClintock, 2nd crop.
5 -- 1934, (5 replications) Aroma, 2nd crop.
6 -- 1934, (5 replications) Blakemore, 2nd crop.
7 -- 1934, (10 replications, poor soil) Aroma, 2nd crop.
All tests located at Knoxville.

Conclusions

It is difficult to draw definite conclusions from the tests which have been reported concerning the fertilization of strawberries. Inconsistency is evident in many of these tests, as was found in the records of commercial growers and observations over the state. Certain conclusions, however, appear to be justified. The application of fertilizers is of doubtful value on good land during the first growing year. The only application which has produced uniformly favorable results during the spring before the first crop, is an application of muriate of potash as the plants are beginning growth. On poor soils the application of phosphoric acid and potash during soil preparation before planting, and, under extreme conditions, the application of nitrate of soda during the first growing season may be profitable. There is no evidence that application of nitrate of soda in the spring before harvest is likely to prove profitable on strawberries. After the first harvest applications of phosphoric acid and potash will be profitable only on soils below the average in fertility, but applications of nitrate of soda at renovation will probably stimulate the formation of a larger number of runners and increase yields.

Effect of Mulch Applications

Evidence from Field Records

The application of a mulch to strawberry fields has long been

recommended but it has never been widely practiced in Tennessee. Among the 69 records which are included in this study only 24 report an application of mulch. The average cost of the material applied by these growers was $7.79 per acre, and the labor of applying the mulch amounted to $1.85. In most cases this represents a cash outlay and is an item of considerable importance in relation to other cash expenses. In the analysis of production costs it was found that nearly 30 per cent. of the cash expense was represented by mulch, for those growers who made such an application, and that this expenditure represented approximately 10 per cent. of the total cost of production. Very few growers use mulch material preceding the second harvest. Only nine of the 69 growers who cooperated in this investigation made such an application, and they used less material than was applied following the first growing season. The use of mulch by commercial strawberry growers is limited to a comparatively small section of the state. Of the 24 growers who reported the use of mulch 19 were in Monroe County or the area immediately adjoining that County. Practically none of the growers in West Tennessee follow this practice, and, according to the observations which have been made during the past five years, less than half of the growers in the eastern part of the state made such an application. Considering the 24 records in which mulch was included the value of the practice is not clearly indicated because only ten of these 24 fields produced a yield above the average for the entire group.

Results of Experimental Comparisons

This practice has been so persistently recommended that field tests were planned to secure more accurate comparisons. In 1931 at the substation near Clarksville a test was made, applying straw at the rate of 3000 pounds per acre December 15, February 1, and March 15. Three row plots were used with a guard row between and the test was in triplicate. Unfortunately plots without mulch were not included because of the limited area. The results were quite consistent and the average yield per plot for the application December 15 was 49.54 pounds, for the application February 1 it was 59.11 pounds, and for the application March 15 was 73.03 pounds. All of the plots appeared quite uniform during the growing season and at the time of mulching. The winter of 1930-1931 was mild so that there was no heaving or other winter injury in any plot. At the beginning of harvest those plots which had had the application of straw in March appeared more vigorous and had darker green color than those which had the application in December. It was obvious that spring growth had been delayed by the winter application. The harvest record indicates that those plots receiving mulch in midwinter did not produce as much fruit during the early pickings as did those which had the application in March. The difference in yield is carried with some uniformity throughout the season but is most marked during the early pickings.

During the same season two other tests were conducted, one at Clarksville and one at Portland in order to determine the effect of

different amounts of mulch. The test at Clarksville was conducted on an experimental substation where records could be secured from the very beginning to the very last of the picking season. The test at Portland, on the other hand, was conducted on the farm of a commercial strawberry grower. Accurate yield records were taken but the fruit was handled through commercial channels and, unfortunately, the pickings were stopped at the close of the commercial season. The total yields from these two tests showed opposite results. The test at Clarksville showed an increased yield following the application of mulch and this increase was according to the amount of mulch that was used. These plots were picked twelve times during the season. During the first three pickings the yield was distinctly in favor of those plots which had not received any straw and was least where the largest amount of straw had been applied. The yields for the fourth, fifth, and sixth pickings remained in this order but the difference was very much less marked and the yields for the seventh, eighth, and ninth pickings reversed slightly showing an advantage where the large amount of mulch had been applied. The last three pickings at the very close of the season showed a large increase in favor of heavy mulch applications, and a distinct increase following lighter applications. At least two of these last pickings were after the close of what would be considered the commercial picking season, and since these late pickings were not secured from the planting at Portland the results of the two tests are in reality not contradictory.

The last picking which was recorded from the plots at Portland showed a distinct advantage in favor of mulch applications.

Under conditions which place a distinct premium on early fruits the disadvantage of delayed ripening which follows the application of mulch may be of economic importance. It appears that increased yields following mulch applications cannot be expected unless picking is continued to the close of the harvest season. The experience of commercial growers in Tennessee has been that price decline and the reduced size of the fruit makes these late pickings of doubtful value.

Other tests were conducted from 1932-1934 and the results are summarized in Table 25. The results of these three tests do not indicate any increase in yield following the application of mulch; in fact, the advantage is in favor of those plots which had no such application. They indicate that applications, made in early spring are more desirable than midwinter applications under conditions where serious winter injury is uncommon. When the yields are placed on a basis of 100 plants there seems to be a slight advantage in favor of midwinter applications. Straw applied at the rate of 3000 pounds per acre may, under some conditions, smother plants and reduce the number in the row at harvest.

The advantage which has been claimed, that mulch will reduce the percentage of culls, is supported by these tests since there was a decrease of 30.7 per cent. in culls when an application of mulch

Table 25. Midwinter and Spring Applications of Mulch

Treatment	Test 1			Test 2			Test 3		Average			
	Row Yield	% Culls	Yield 100 Plts.	Row Yield	% Culls	Yield 100 Plts.	Row Yield	% Culls	% Culls	Row Yield	Yield 100 Plts.	Crates Per Acre
Straw 3000# Dec. 1-15	42.31	3.33	7.2	40.71	4.7	2.42	23.26	4.1	4.04	35.43	4.81	177.1
Straw 3000# Mar. 15	40.79	3.28	7.0	41.21	3.9	2.54	29.33	4.4	3.86	37.11	4.77	185.6
No Mulch	43.25	5.32	6.19	49.55	4.8	3.09	26.52	6.6	5.57	39.77	4.64	198.6

1. Harvest 1933, Knoxville ----- Aroma, 1st crop, single rows repeated seven times.
2. Harvest 1934, Knoxville ----- Aroma, 2nd crop, single rows repeated six times.
3. Harvest 1932, Clarksville --- Aroma, 2nd crop, single rows in triplicate.

was made about the middle of March. It is important to consider that the picking season was not extremely wet during any of these years. Therefore, the effect of mulch in protecting the fruit from dirt and field rots during wet weather is not evident in these results. Observations have indicated very clearly that this advantage frequently means the difference between a profitable berry crop and a complete failure. It is not uncommon to find strawberry crops which have been made practically worthless by dirt on the fruit following heavy dashing rains. Conditions where field rots cause serious losses during wet seasons are very common. It is under such conditions that the advantages usually claimed for mulch are most evident.

Selection of Plants for Setting

The importance of securing a good matted row as early in the summer as possible is generally recognized by commercial growers in Tennessee, and the selection of suitable plants for setting is considered by many to be one of the principal factors influencing the results.

Source of Plants

There is a rather general opinion that plants imported from a distance have a distinct advantage over locally grown plants and that it is almost necessary to renew the stock frequently if it is not done every year. It is quite obvious that the presence of serious strawberry pests such as the crown borer, root rot, etc., may

make the use of local plants very unwise. Aside from this factor the value of importing plants seems doubtful and tests were conducted to provide direct comparisons. In these tests plants were secured from reliable sources in Arkansas, Maryland, and Indiana, and for comparison plants were secured from successful commercial growers in Blount, Sumner, and Hamilton Counties, in Tennessee. These tests were begun with the 1930 planting season and were located at Clarksville, Portland, and Knoxville with triplicates at each place. The results of these three tests did not indicate a distinct advantage for any one source and indicated quite strongly that Tennessee grown plants were as desirable if not more desirable than those secured from other states. In 1934 the same test was repeated at Knoxville in order to secure more complete records. This test was placed on a very good soil and was given careful culture throughout the season. All four tests are summarized in Table 26, together with some detailed records from Test 4.

It is interesting that in every test the lowest producing plots were developed from plants imported from outside the state and that in three of the four tests the highest yielding plots resulted from plants secured within the state. It is clear that no single source of plants consistently proved superior to others. Variations in yield are explained very much more accurately by the notes which were made concerning the condition of plants at the time of setting than by the source from which the plants came. For example, in Test 1 the plants from Sumner County, adjoining the county in which

Table 26. Influence of Source of Plants on Yields

Source of Plants	Test 1	Test 2	Test 3	Test 4				Average	
	Row Yields	Row Yields	Row Yields	No. Plants	Row Yields	% Culls	Yield 100 Plants	Row Yield	Crates Per Acre
Arkansas	16.25	16.53	29.79	658	46.24	7.0	7.02	27.20	136.0
Maryland	12.53	17.41	19.01	497	26.48	8.4	5.33	18.86	94.3
Indiana	13.54	15.05	22.63	684	42.25	6.1	6.17	23.37	116.8
Tennessee (Blount Co.)	17.79	18.81	34.92	668	45.85	6.4	6.86	29.34	146.7
Tennessee (Sumner Co.)	18.24	23.68	32.16	653	41.34	6.2	6.33	28.85	144.1
Tennessee (Hamilton Co.)	16.76	18.78	26.80	598	43.65	5.6	7.30	26.49	132.1

1. Harvest 1931, Clarksville -- Aroma, 1st crop.
2. Harvest 1931, Portland ----- Aroma, 1st crop.
3. Harvest 1931, Knoxville ---- Aroma, 1st crop.
4. Harvest 1933, Knoxville ---- Aroma, 1st crop (good soil).

the test was made, were set as soon as they were received without being heeled-in at all. Plants from all other sources were heeled-in when they were received and were given uniform care. During the time the plants were heeled-in they started to grow slightly. Those from Maryland and Indiana especially had developed definite root action and had formed one or two new leaves. The yields indicate that it is an advantage to set the plants as soon as possible and that when plants have been heeled-in long enough to begin growth they are less desirable for setting. Notes concerning the plants for Test 2 are significant in a similar way. Those from Indiana and Arkansas had dried slightly during shipment. In this case, also, the plants for all plots except those from the local county, Sumner, had been heeled-in before they were set in the field. Those from Indiana had started to grow somewhat more noticeably than those from other sources. Almost the same observations were made concerning the plants in Test 3. Local plants from the adjoining county, Blount, were planted almost immediately after they were dug, and those sent from Sumner County arrived so that heeling-in was unnecessary. The other plants were treated uniformly and were heeled-in before setting.

When the test was repeated in 1932 these differences were avoided. All plants were handled in the same way and all were quite uniform except that those which had been shipped from Maryland had dried slightly during shipment. By careful handling, however, no re-planting was necessary in any of the plots. Notes which were made late in the growing season indicate very uniform rows throughout the

entire test, with somewhat fewer plants in one row of the Maryland series. The poor showing of this one row is not explained but is responsible for a considerable part of the difference in the final yield. The result of this test certainly indicates the importance of good plants and suggests that it is a definite advantage to secure such plants locally and to set them without delay. There is no indication that the importation of plants from outside the state is an advantage where insects and diseases are not present.

Age and Size of Plants

In order to secure evidence as to the kind of plants which are most desirable for setting, a preliminary test was conducted in 1931 in which a group of original parent plants were selected from a one-year-old row and runners were followed from these parent plants so that the first and third offsets in a runner series could be secured for a planting. Practically all of the parent plants had compound crowns with more than one bud. In this group plants were selected which had an abundant supply of bright new roots, though many old roots were present on the crown. Twenty-five uniform plants in each group were selected and washed free of soil. Their comparative size is indicated by the weights which are recorded in Table 27. After setting, the flower clusters were removed approximately once a week and the total number recorded. On June 21, the number of runners which had formed from the original plants in each row was counted and the average is given in this table. The test was conducted

Table 27. The Selection of Plants for Setting

Plants for Setting	Weight of 25 Plants	No. of Flowers Removed	Number Runners 6/21/31	Yield per Row	% Above 7/8"(1)	Crates per Acre
Parent Plant	25.5 oz.	291	174	36.26	16.5	181.3
First Off-set	5.8 oz.	129	108	34.43	13.1	172.2
Third Off-set	4.7 oz.	120	102	32.00	14.8	160.0

(1) Pickings 6/10 and 6/15 at close of season are included in this count.

in triplicate, both at Knoxville and at Clarksville and the results were quite uniform and consistent. The averages presented in Table 27 are for the planting at Knoxville. The greater vigor of the older and larger plants is indicated in these results but the smallest group which was included proved to be large enough to be quite satisfactory. The total yield favors the larger plants and shows no disadvantage of old plants when they are selected with sufficient care to avoid diseases and to include only well rooted, vigorous specimens.

Practically all nurserymen and commercial growers who supply plants grade out the old crowns and the very small late runners but do include plants varying greatly in size. In order to secure additional evidence as to the advantage of large and small plants, other tests were planned with this in mind. For Tests 1, 2, and 4, reported in Table 28, a large commercial shipment was inspected and a group of plants representing the smallest of the shipment, and another group representing the largest of the shipment was selected for this test. For Test 3 a one-year-old matted row which had never fruited was dug. The old plants and the worthless small plants were discarded, and then from the remainder two groups were selected representing the large and the small sizes. All tests were conducted in triplicate and the results were quite uniform. The yields were definitely in favor of the larger plants. The number of plants was counted, at the beginning of harvest, for Tests 3 and 4 and the greater vigor

Table 28. Large and Small Crowns for Setting

Size of Crown	Test 1	Test 2	Test 3			Test 4			Average			
	Row Yield	Row Yield	No. Plants	Row Yield	Yield 100 Plants	No. Plants	Row Yield	Yield 100 Plants	No. Plants	Row Yield	Yield 100 Plants	Crates Per Acre
Large	15.11	12.44	450	18.07	4.02	1147	58.37	5.09	798	25.99	4.55	130.0
Small	9.47	12.10	354	12.87	3.64	966	55.86	5.78	660	22.58	4.71	112.9

1. Set 1930, harvest 1931 — Clarksville — Aroma.
2. Set 1930, harvest 1931 — Portland ——— Aroma.
3. Set 1932, harvest 1933 — Knoxville ——— Aroma, poor soil.
4. Set 1932, harvest 1933 — Knoxville ——— Aroma, good soil.

of large crowns is indicated by the increased number of plants which had been formed.

Notes on significant differences were made during the growing season. In each case they indicate that the large crowns started more quickly and required less replanting. Following the planting of Test 3 there were a series of rather severe freezes which lifted the small plants and made replanting necessary. Following these freezes in the three rows where small crowns were used 32 plants had been lifted and had to be reset or replaced while in the three rows where large crowns had been set only 10 plants were raised sufficiently to need attention. An unusually dry period followed the setting of Test 4 at Knoxville and during that period the small plants suffered much more severely than did the large crowns. Twelve plants had to be reset in those rows where small plants were used, and only three plants were killed in the others. It seems quite clear that the principal advantage resulting from the use of large plants at setting is their ability to stand unfavorable conditions, to start growth promptly, and to produce a large number of runners. Where soil conditions and weather conditions are very favorable small plants will be entirely satisfactory.

Varieties

The problem of selecting the most profitable variety is one which confronts every strawberry grower and which receives more discussion among growers than any one question. There is a tendency to

blame low yields and low returns on the variety and to seek the solution for all problems by the selection of a new highly advertized kind. There has been a definite tendency to concentrate on one or two varieties in each community so that carlot shipments of single varieties can be made to distant markets. A survey, which was conducted in 1919, including reports from 184 growers, shows that 19 varieties were being grown in the state but the most important of these were Klondyke and Aroma. Lady Thompson and Gandy, also, were reported by ten or more growers. During the time that the writer has been in Tennessee the change in strawberry varieties has been very striking. For many years the West Tennessee strawberry section was almost entirely a Klondyke section. Dissatisfaction with this variety grew because of its tendency toward small sizes shortly after midseason, and because of gradually decreased yields which commercial growers secured in that part of the state. Recently there has been a great tendency to turn to the Blakemore so that at the present time probably more than one-third of the production is of that variety.

The Middle Tennessee strawberry section, located principally in Sumner County, was one of the leading Aroma producing sections until a few years ago when root rot became widely spread in that county. It was found to be almost impossible to produce satisfactory yields of Aroma on badly infected soils. The Premier was introduced and proved very popular for a short time because of its resistance to

root rot and the large production of fruit which growers secured. This variety was soft and did not stand handling as well as the Aroma, and, during recent years, it has been almost entirely replaced by the Blakemore.

East Tennessee production has been divided among several varieties. For many years the Missionary has been grown to a limited extent. The principal acreage, however, was divided between the Klondyke and Aroma. The picking season of these two varieties overlapped in such a way that when Klondyke fruits became too small to pick profitably growers would turn to the Aroma fields for midseason and late shipments. The introduction of the Blakemore has resulted in a reduction of acreage in both Aroma and Klondyke. A very large percentage of the East Tennessee Klondyke acreage has been changed to Blakemore, and in the lower part of the East Tennessee Section, a large percentage of the Aroma, also, has been replaced. A portion of the East Tennessee Section, including Blount and Monroe Counties, have stayed with the Aroma variety almost entirely. Root rot is not established in this section, and growers believe that the advantages of Aroma are greater than those of Blakemore.

During the past few years the introduction of many new varieties, the most important of which are Dorsett and Fairfax, has aroused new interest in this subject. These varieties are being tested by many growers but have not become established in large acreages. During the course of this investigation considerable data have been

secured which indicate important differences among strawberry varieties. For example, in Table 17, Tests 1 and 2 were conducted in the same field and at the same time using different varieties. These tests were conducted at the time that Premier was being introduced and was rapidly becoming so very popular. When the yields reported in this table are converted to the basis of a single row the advantage of Premier is very distinct because it produced an average yield of 40.5 pounds per row under the same conditions that Aroma produced only 17.5 pounds. Unfavorable spring weather was responsible for the comparatively low yield of Aroma. A direct comparison of Aroma and Klondyke can be made in Table 21. Tests 5 and 6 were side by side on quite uniform soil. If all the fertilizer treatments are averaged it will be found that the yield of Klondyke was 27.7 pounds per row while that of Aroma was 23.3 pounds, but the Klondyke produced 16.4 per cent. of fruits which were below the minimum size for U. S. No. 1 while the Aroma had only 3 per cent. below this size. In these tests the yield on a basis of 100 plants as well as on the basis of a single row favored the Klondyke.

During the season of 1931 single rows of Aroma and Blakemore which were growing side by side were carefully picked and the number of berries per pound was determined for each picking during the season. These results are presented in Table 29 and they show that throughout the picking season Aroma was slightly larger than Blakemore. This difference increased as the picking season advanced. Both

Table 29. Size of Fruit

Picking Date	Number Fruits per Pound	
	Aroma	Blakemore
5/21		55
5/25		75
5/26	43	75.5
5/27	47	97
5/29	47	105
5/30	53.5	
6/1	55	150
6/2	60	156
6/4	78	155
6/5	91	
6/6	103	
6/8	130.5	
6/12	176.5	
Average Number	80.36	108.5

varieties declined in size rapidly near the close of harvest, but the Aroma picked over a longer season and held a desirable size much longer. This tendency of strawberry varieties to run down in size as the season advances is one of the most serious problems.

In 1931 plantings of Aroma, Klondyke, and Blakemore were made for other tests in this investigation. The conditions in the field were sufficiently uniform to permit desirable comparisons among the varieties when the plots which had similar cultural treatments are selected. These plantings were continued for a third crop so that a comparison throughout the life of a commercial plantation is possible. The information in Table 30 is taken from the records of these plantings. All of these varieties are considered to be moderate or good plant makers. The Klondyke and Blakemore produced runners more abundantly than did Aroma during the first growing season. The picking season of Klondyke and Blakemore corresponded very closely. They may come-in together or the Klondyke may ripen a few days in advance of the Blakemore. Normally the Aroma is approximately ten days later than the other two and continues to pick a few days longer than either of the others. Conditions were quite favorable for the first crop in 1933 and the production which is recorded represents these varieties at their best. Both Klondyke and Blakemore produced distinctly larger total yields than did Aroma, but only about one-third as large a percentage of the Aroma fruits were below three-quarters of an inch during the entire season. The percentage of fruits which were below

Table 30. Variety Comparison

Variety	No. Plants Total Per Row	First Picking	Last Picking	Row Yield	% Below 3/4" Season	% Below 3/4" Last 3 Pickings	Yield 100 Plants	Crates Per Acre Above 3/4"
		First Growing Season 1932 and First Crop 1933						
Klondyke	865	5/5	5/29	51.87	17.3%	71.4%	5.99	214.5
Aroma	640	5/15	6/2	40.97	6.5%	13.7%	6.50	191.6
Blakemore	915	5/8	5/29	75.84	18.9%	61.0%	8.27	307.6
		Second Growing Year 1933 and Second Crop 1934						
Klondyke	530	5/8	5/28	21.09	21.6%	45.0%	3.99	82.7
Aroma	565	5/17	6/8	17.16	3.05	14.4%	3.05	67.3
Blakemore	—	5/8	5/28	30.54	26.6%	56.0%	—	112.1
		Third Growing Year 1934 and Third Crop 1935						
Klondyke	878	5/4	5/27	41.94	18.6%	35.5%	4.79	170.8
Aroma	1190	5/13	6/5	37.57	3.4%	6.1%	3.15	181.5
Blakemore	1370	5/4	5/27	57.87	13.3%	24.7%	4.21	250.8

three-quarters of an inch during the last three pickings is reported for each variety and this shows an outstanding advantage of the Aroma over the other two. It is interesting to note that in a comparatively thick row where there were probably five or six plants per square foot the Blakemore produced a very large yield per plant.

The second season was very unfavorable. The lack of rainfall following harvest in 1933 prevented vigorous plant growth and there was not sufficient moisture during the spring before harvest to produce an abundant crop on the plants which were available. The same tendency of Klondyke and Blakemore to run down in size during the last few pickings is emphasized again in this harvest. Conditions for renovation following the 1934 crop were very favorable and plant growth was vigorous so that the yield for the third year was almost twice that of 1934.

Throughout the entire life of these plantations Blakemore proved to be most productive and Aroma least. When the yield of fruits above a minimum size of three-quarters of an inch is determined there is much less difference among these varieties. The reports from commercial growers indicate even less difference. Among the production records which were considered in this investigation 24 fields of Klondyke produced an average yield of 67.4 crates while 32 Aroma fields produced a yield of 62.1 crates. A recent survey, which was made by Mr. Harry Carlton of the Tennessee Experiment Station, through the county agents in strawberry producing counties, presents an

estimated total production of 62.8 crates per acre for Aroma, 62.3 crates per acre for Klondyke, and 78.5 crates per acre for Blakemore.

In 1935 plantings of Dorsett, Fairfax, Blakemore, and Aroma were made under similar conditions. Weather conditions were quite favorable during that season and all varieties produced plants liberally. At the close of the season the number of plants per row was determined for each variety and it was found that Blakemore had produced the most, 1840, Aroma was next with 1300, then Dorsett with 1124, and Fairfax with 661. Unfortunately a very severe freeze during the blooming season of 1936 made it impossible to secure representative yields from these plantings. Indications are that the yield from Dorsett would correspond favorably to that of Blakemore and that the Fairfax would be less productive than Aroma.

Season of Runner Formation

The labor and expense involved in the care of a strawberry plantation is greatly increased after runners begin to set. Most growers are of the opinion that it is very important to secure a good matted row as early in the summer as possible. Nevertheless, many of them have harvested excellent crops following unusually dry seasons during which most of their plants were formed in September. During the growing season of 1930 some runner plants were staked and dated in order that the importance of early runners could be established. In this preliminary work only a few plants were included,

but the yields indicated definitely that there was comparatively little difference between plants which were formed in June, July, and August. Aroma plants formed as late as September 9 produced a yield equal to that of plants set in July or August and greater than that of the June-set plants. Following this preliminary work runners were staked during the growing season of 1932 and the yields were secured from individual plants the following spring. The results are presented in Table 31 and the yields indicate that runners set before early September have practically an equal chance. In fact, very early runners, set in June, are frequently stunted by dry weather during the summer and develop leaf spot or other troubles which reduce their productiveness. Quite satisfactory yields resulted from runner plants set during September, and those set as late as October 11 were reasonably productive. During the season of 1932 Aroma continued to set plants through late October and November while Premier formed practically no plants after early October. This variety characteristic is recognized by commercial growers, and very dry weather during July and August is considered more serious with fields of Premier than with Aroma.

Additional evidence is presented in Table 32 which shows that the number of runners formed before the middle of July is not a significant factor in determining the yields of the following spring. From the record of a planting of Premier at Portland, which had had uniform cultivation and fertilization, 15 rows have been selected

Table 31. Effect of Age of Runners on Yield

1933 Aroma				1933 Premier			
Date Runners Set	No. Plants	Yields, pounds		Date Runners Set	No. Plants	Yields, pounds	
		Total	Per 10 Plants			Total	Per 10 Plants
6/2/32	63	7.80	1.24	7/15/32	14	2.85	2.03
7/2-8/32	83	8.53	1.03	8/ 4/32	28	6.63	2.37
7/18-22/32	94	11.88	1.26	9/12/32	25	3.27	1.31
8/2-8/32	59	5.65	.96	10/11/32	21	1.74	.83
8/10-25/32	81	8.09	.99				
9/12/32	83	7.85	.95				
10/11/32	69	2.23	.32				
11/3-8/32	30	.22	.07				

Table 32. Relation of Early Runner Production to Yield

No. Runners 7/16/32	Yield lbs. per Plot	No. Runners 7/16/32	Yield lbs. per Plot	No. Runners 7/16/32	Yield lbs. per Plot
190	82.50	206	102.10	216	95.40
176	93.45	202	78.70	217	70.80
183	94.25	202	86.45	218	106.90
187	131.90	199	86.00	247	115.00
189	95.05	209	120.25	255	95.50
Average	Average	Average	Average	Average	Average
185	99.43	204	94.70	230	96.72

Three rows in each plot, 1/60 acre.

and grouped according to the number of runners which had formed by July 16. The yield records of these individual rows are presented in this table. There is no significant difference in the yields which were produced by rows which had formed the fewest runners by mid-July and the group which had produced most runners by that time. Unfortunately the total number of plants which were present at harvest was not determined, but it is evident that the yield was not influenced by so-called early set runners. These results indicate that cultivation may continue without regard to the establishment of a matted row until midsummer, but that the soil should be kept in a condition which favors the establishment of runners during late July, August, and early September. Normal weather conditions in Tennessee favor plant formation during this period and very early runners are frequently killed by the midsummer drought.

It is important, however, that cultural conditions during late summer and fall favor the development of large, strong crowns. In the spring of 1934, before harvest, a matted row of Aroma plants was very carefully examined. Plants in a section of this row were staked and harvested in three groups according to the size of the crown. When these groups were harvested it was found that 100 plants with large crowns produced 265 berries weighing a total of 3.38 pounds, and that only 18.3 per cent. of these berries were less than three-fourths inch in diameter. One hundred crowns of medium size in this row produced 125 berries weighing a total of 1.8 pounds, while 100

small crowns which had a diameter of approximately one-fourth inch produced only 24 berries weighing .35 pound. Competition with grass or weeds, a hard packed soil, or any condition which does not favor the development of strong crowns during the fall is sure to result in low yields the following spring.

Stand of Plants in the Matted Row

Strawberries are produced by the matted row system in Tennessee, and sometimes the plants become very crowded in these rows so that there is serious competition for moisture and plant food materials. Tests were attempted in 1930 to determine the value of thinning plants at the close of the growing season in order to avoid this competition. Plantings of Aroma were made at the substation near Clarksville and at the University for this purpose. The dry growing season of 1930, however, prevented the development of a thick matted row so that when thinning was attempted in the fall it was found that practically none of the plants were closer than three or four inches apart in the row. Nevertheless, one series of rows was thinned to six inches, another was thinned by dragging a section harrow across the row in order to pull out the small late formed plants which were not well established, and other rows were left as they had grown. The yields which were secured in 1931 indicate that too many plants were not present in any of the rows. The yields were reduced by thinning and were reduced in proportion by the severity of the work.

This test was repeated in 1932 under more favorable conditions. The same plan was followed and the hand thinning was done quite carefully in order to secure a uniform distribution of plants. The results of this test are presented in Table 33. These results indicate that crowded plants do compete with each other so that the yield per plant is reduced and to some extent the number of small berries is increased. Nevertheless, in every case the largest total yields were secured where there were the most plants.

Another attempt to secure evidence along this line was made by studying plants which had been set in beds according to the hill system where no runners were allowed to become established. In these tests which were conducted in 1931 it was found that increasing the distance between the plants from 8 to 12 inches decreased the number of plants in a given area approximately 55 per cent. and resulted in a decrease of only about 22 per cent. in the yield. This indicated that the yield per plant was distinctly increased by the wider spacing. Such a condition was found to be true when yields were tabulated from runner plants which had been spaced accurately during the 1932 growing season. It was found by this work that increasing the spacing of runner plants from 8 to 12 inches increased the yield per plant approximately 35 per cent. It is interesting to know that increasing the spacing of runners from 4 to 8 inches increased the yield per plant between 75 and 80 per cent. Evidently there was definite competition among the plants when they were crowded in the row.

Table 33. Effect of Thinning the Matted Row on Yield and Size of Fruit

Treatment	Record of Individual Rows											
	Row No.	No. Plants	Total Yield	% Below ¾"	Row No.	No. Plants	Total Yield	% Below ¾"	Row No.	No. Plants	Total Yield	% Below ¾"
Thinned with Horse Tool	1	693	42.31	3.22	5	852	46.05	4.99	9	599	36.79	4.46
Thinned to 3" with Hoe	2	749	44.01	4.97	6	660	36.05	5.07	11	526	37.51	4.03
Thinned to 6" with Hoe	3	554	36.39	5.47	7	564	32.41	3.81	10	490	30.58	3.43
Not Thinned	4	1010	51.51	7.69	8	653	41.11	5.31	12	584	38.49	3.49

Treatment	Average				
	Number Plants	Total Yield	% Below ¾"	Yield Per 100 Plants	Crates Per Acre
Thinned with Horse Tool	713	41.72	4.22	5.83	208.6
Thinned to 3 inches with Hoe	645	39.19	4.69	6.07	195.9
Thinned to 6 inches with Hoe	536	33.13	4.24	6.18	165.6
Not Thinned	749	43.70	5.49	5.83	218.5

Test located at Knoxville, Aroma variety, first crop, set 1932.

During the harvest of 1933 twelve rows of Aroma plants were selected which had had the same cultural treatment during the preceding season. The plants were counted during the blooming season and the rows are arranged in Table 34 according to the stand of plants. It is very significant that the yield per row corresponds closely to the number of plants in the row and that there is a distinct tendency for the yield per 100 plants to increase as the number of plants per row decreases. The number of plants per square foot in these rows varied from approximately six to two, in other words, each plant in the thick rows had about 24 square inches of ground while those in the row with 254 plants had nearly three times that much area. It is clear that rows were not secured in this test which were sufficiently thick to cause an actual reduction in total yield.

During the harvest season of 1935 short sections of Aroma rows were selected and very careful yield records were taken. In one section of row ten feet long there were 111 plants which represented approximately $3\frac{1}{2}$ plants per square foot. The yield from this section was 5.85 pounds or 7.27 pounds per 100 plants. A second section having 168 plants or about $5\frac{1}{2}$ plants per square foot, produced a total yield of 6.08 pounds or 4.10 pounds per 100 plants. A third section with 275 plants representing between 9 and $9\frac{1}{2}$ plants per square foot produced 5.33 pounds or 1.94 pounds per 100 plants. Under the conditions of soil and weather in 1935 the total yield was decreased by crowding when as many as nine plants per square foot were present.

Table 34. Effect of Stand of Plants on Yield

Row No.	No. Plants	Row Yield	Yield 100 Plants	Row No.	No. Plants	Row Yield	Yield 100 Plants
26	754	50.02	6.63	6	422	33.23	7.81
14	647	44.53	6.88	10	401	20.10	5.01
20	616	45.76	7.42	7	364	39.36	8.06
2	584	35.34	6.05	12	325	27.21	8.37
17	542	35.39	6.52	11	261	18.72	7.17
5	525	39.21	7.46	9	254	20.42	8.04
Average	611.3	42.54	6.83	Average	337.8	24.84	7.42

Aroma, Knoxville, good soil--set 1932, first harvest 1933.

The yield per 100 plants declined steadily as the stand of plants increased. These results suggest that under favorable conditions maximum yields will be produced when there are from five to six Aroma plants per square foot of row. The proper spacing will, no doubt, vary according to soil conditions, weather conditions, and different varieties.

Under Tennessee conditions, with the soils which are usually used for strawberries in this state, I am convinced that there is much greater danger of growing too few than too many plants in the row. Growers who have particularly favorable conditions will naturally space plants further apart at setting, and under unusual conditions may profitably thin the matted row at the close of the growing season.

Observations which have been made in different parts of the state and records which have been studied during this investigation indicate widely different practices among growers in different parts of the state. One of the most striking of these differences is in regard to planting distances. In West Tennessee it is customary to set plants about 15 to 18 inches apart in the row while in Middle Tennessee practically all growers set plants from 30 to 36 inches apart. This is true in spite of the fact that the Klondyke, which is a liberal plant producing variety, is grown in West Tennessee while Aroma and Premier, neither of which are particularly abundant plant makers, have been important in Middle Tennessee. Since the

introduction of Blakemore into Sumner County in Middle Tennessee most growers have planted 36 to 42 inches apart. Similar variations occur in the eastern part of the state. On much of the ridge land berries are set as close as 18 inches apart, while in Blount and Monroe Counties 30 inches is considered standard. In order to secure direct comparisons plantings were made at the University in 1934 including Aroma, Premier, and McClintock, a new variety which was being introduced by this Experiment Station. Aroma plantings were made both on a very poor soil and on one of moderate fertility. In these tests the original plants were set 18 - 30 - 42 inches apart. A severe drought occurred during the growing season of 1934 so that plant production was limited in all of these tests. There is no doubt but that this condition gave a distinct advantage to the close spacing which does not occur in more favorable seasons. The results of these tests are presented in Table 35 from which it may be seen that in no case did an excessive number of plants develop and that the yield per acre corresponded closely with the number of plants which were present at harvest.

Relation of Climate to Yields

The fact that Tennessee has so long occupied a position of prominence among the strawberry producing states is proof that, in general, the climate is favorable for this crop. Nevertheless, the yields which are produced and actually marketed depend in no small

Table 35. Effect of Planting Distance on Stand of Plants and Yield

	Planting Distance in the Row		
	18 inches	30 inches	42 inches
Test 1---Number plants	343	275	293
Yield per row	13.11	12.74	11.77
Yield 100 plts.	3.82	4.63	4.02
% below $\frac{3}{4}$"	2.8	3.0	3.4
Test 2---Number plants	350	245	153
Yield per row	22.02	21.36	9.12
Yield 100 plts.	6.29	5.86	5.96
% below $\frac{3}{4}$"	35.0	35.0	30.0
Test 3---Number plants	369	260	197
Yield per row	19.88	17.46	15.48
Yield 100 plts.	5.39	6.70	7.86
Test 4---Number plants	433	379	295
Yield per row	15.53	14.40	13.76
Yield 100 plts.	3.58	3.82	4.66
Average--Number plants	374	289	234
Yield per row	17.64	16.49	12.53
Yield 100 plts.	4.77	5.25	5.62
Crates per Acre	88.2	82.1	62.6

Each test is triplicate with averages in table.
1 -- 1934, Aroma, Knoxville.
2 -- 1934, Premier, Knoxville.
3 -- 1934, Aroma, Knoxville (poor soil).
4 -- 1934, McClintock, Knoxville (poor soil).

measure upon the weather conditions during the growing season and especially during the harvesting season. Winter injury is not a factor of importance in Tennessee except in unusual years or on special soils. Instances where heaving has caused serious damage are not uncommon, and yet they are limited to certain soil types which are subject to this trouble, and such soils are not usually selected for strawberry growing in this state. Strawberry plants will continue active growth quite late in the fall and occasionally a sudden freeze will catch them while they are still active and will cause some damage.

Precipitation During the Growing Season

Precipitation, especially the distribution of rainfall, is by far the most important climatic factor affecting strawberry yields. The average total precipitation for the year is 48.3 inches at Knoxville, and for the whole state the total rainfall averages 49.79 inches. In normal years the rainfall is distributed with reasonable uniformity but frequently there are periods of drought which cause serious damage to strawberry fields and are responsible for greatly reduced production. In practically all cases the planting season can be adjusted according to weather conditions so that favorable soil moisture, which is so important for the vigorous start of strawberry plants, can be secured. Planting may be done during the last half of February, March, or early April with quite satisfactory results if the soil conditions at the time of setting are favorable.

The renovation of a strawberry field after harvest is much more frequently delayed or entirely prevented by unfavorable weather conditions. Strawberry growers are inclined to give-up complete renovation, however, when with proper methods the fields could be renewed profitably. The previous discussion concerning the importance of renovation soon after harvest emphasizes the necessity of taking advantage of the first rain after the close of the picking season. Favorable soil conditions greatly reduced the labor necessary for the proper renovation of a strawberry planting. This was illustrated during the season of 1933 when a group of experimental plots were thoroughly renovated while the soil was quite dry. This work required 32 man hours per acre. In 1934 conditions were very much more favorable and this same group of strawberry plots were renovated with 24 man hours of labor per acre. This represents a reduction of 37.5 per cent. and may explain, in part, why renovation of the field for the second crop pays much better some seasons than others.

Sufficient evidence has been given in the previous discussion to show clearly the tremendous importance of a uniformly good stand of plants and the value of proper cultural practices in securing this result. Even the best cultural practices cannot overcome the handicap, however, of abnormal weather conditions. Excessive rain may increase the growth of weeds and grass so that the expense of caring for a strawberry plantation is very greatly increased. Where certain

types of plants such as Johnson grass, Bermuda grass, etc., are present it may be practically impossible to prevent serious competing growth during wet seasons. The opposite extreme, too little moisture, is equally as serious. The season of 1931 was abnormally dry throughout the entire state. At the substation near Clarksville, the drought was unusually severe. The total precipitation for August, September, and October amounted to only 4.56 inches which was only 12.7 per cent. of the total precipitation for the year. From July 21 to October 27 there was only one rain amounting to more than .5 of an inch, and from August 29 to October 27 there were only three days with rain. The inevitable result of such a drought was a poor stand of plants and a very greatly reduced yield in 1932. Under normal conditions the second crop of a strawberry plantation is somewhat less than the first, but under these abnormal conditions the yield was reduced from an average production per plot of approximately 72 pounds in 1931 to less than 20 pounds in 1932. Such extreme conditions do not frequently occur, but limited precipitation during midsummer is one of the principal causes of low strawberry yields in Tennessee.

Rainfall During Harvest

The rainfall during the picking season even more directly affects the production. An interesting summary of precipitation during the picking season is presented in Table 36. The average picking season in East Tennessee extends for about 25 days, from early in May

Table 36. Distribution of Rainfall During Picking Season

		East Tennessee		Central Tennessee	West Tennessee	
		Knoxville	Chattanooga	Nashville	Memphis	Jackson
Number of days Without rain* 1922, 1936	Average	18.1	18.4	18.6	16.0	14.4
	Least--(Year	1922, '28	1928	1924	1935	1930
	Least--(Number	12	10	13	12	11
	Most--(Year	1925, '32	1925	1925	1922,'25	1924,'26,'28
	Most--(Number	23	23	23	19	17
Number of days With rain* .05" or more	Average	8	7.5	7.4	5.2	7.2
	Least--(Year	1925	1925	1925	1925,'32	1928
	Least--(Number	3	3	3	2	3
	Most--(Year	1928	1928	1924	1935	1929,'30
	Most--(Number	14	16	13	9	10
Number of Rainy periods (2 days or more)	Average	2.71	2.6	3.65	1.8	1.7
	Least--(Year	1931	1931	1925	1926,'28	1928
	Least--(Number	1	1	1	--	--
	Most--(Year	1923	1922,'27	1929	1922,'29 '30,'33,'35	1922,'29 '30,'35
	Most--(Number	5	4	5	3	3
Total Precipitation during Harvest	Average	3.47	3.44	3.48	3.21	3.99
	Least--(Year	1932	1931	1931	1932	1931
	Least--(Amount	1.12	.24	1.23	.25	1.54
	Most--(Year	1928	1928	1933	1935	1933
	Most--(Amount	7.43	7.52	9.01	7.32	7.10

Source -- United States Weather Bureau, Knoxville, Tenn. (14 year average 1922-'35 inclusive).
*Days with less than .05 inches of precipitation are considered without rain.
Average Picking Season based on growers records.
East Tennessee 5/11-6/5; Central Tennessee 5/5-5/30; West Tennessee 4/30-5/20.

until early in June. The harvest season in Middle Tennessee is just a few days, perhaps a week earlier, and that in West Tennessee is approximately two weeks earlier. The data presented in this table show that under average conditions there is not sufficient rain during the picking season to seriously interfere with the harvesting of the strawberry crop. Usually, however, there are two or three good rains with a total precipitation of between three and four inches and such conditions are quite favorable. Periods of excessive rainfall such as occurred in the East Tennessee Section during the harvest of 1928 always cause serious losses. That season there was rain on more than half of the days during the picking season, and the total precipitation was more than double the average. Such conditions cause soft berries which do not stand shipment, and result in large field losses so that the harvest records do not represent the actual production.

Seasons of extreme drought during harvest, such as was experienced throughout the state in 1925 and again in 1931 and 1932, are responsible for equally severe losses. The amount of loss which results from such abnormal weather conditions is difficult to measure. Notes were made during this investigation in many fields where production cost records were being kept. These notes show estimated losses ranging from 10 or 15 per cent. to as high as 50 or 60 per cent. due to the drought of 1931 and 1932. Such notes as the following are common and indicate the severity of the damage:

> "The dry season has ruined the size. There is a very heavy set of fruit but not more than one-third was picked."

Another quotation:

> "Fruit very small. About 35 per cent. of the berries failed to mature normally,"

and again:

> "Extremely dry. Did not attempt to pick culls. Left probably 50 per cent. in the field."

Occasional notes indicate damage from excessive rain though there has not been an extremely wet year during the entire period of this investigation. During the season of 1934 one grower reported a loss of approximately 33 per cent. of his crop due to rain and lack of proper management during the picking season.

The yields which are reported from the field tests in this investigation reflect quite clearly the influence of weather during the harvesting period. The seasons of 1932 and 1936 were extremely dry. During both of these years there were only three rains during the picking season and the total precipitation was only about one-third of the normal. The 1933 season was dry also but there was not so serious a deficiency, and during 1934 and 1935 conditions were quite normal and approached the average both in distribution and total precipitation during harvest.

Spring Frosts or Freezes

Spring frosts are the cause of serious damage under some conditions, but the strawberry has a long blooming season and it is

quite unusual for the crop to be destroyed in this way. Some varieties of strawberries such as the Klondyke, and, to a less extent, the Blakemore produce blooms on tall fruit stalks which are held high among the leaves or above them so that frost injury is frequent. Other varieties such as the Aroma have very short fruit stalks so that most of the flowers are protected by the foliage and there is less injury from ordinary spring frosts. It has been shown in previous discussions that the application of a mulch will considerably delay blooming and reduce the danger of loss from this cause.

Two instances of injury have occurred during the field tests in this investigation. In 1932 at Portland the temperature dropped to 12 degrees on March 9 and to 31 degrees on March 23. Growth had started and fruit stalks were developing rapidly at the time of the severe freeze on March 9 because of a rather extended period of mild weather which preceded the sudden drop. As a result the tender foliage was killed and a very large percentage of the flower clusters were damaged. Notes which were made in this planting as late as April 22, shortly before fruits began to ripen, indicated that the effect of the freeze and late frost was still evident. The following quotation is taken from these notes:

> "Most of the plants have a cluster of dead buds. All have many dead leaves. Most have a cluster of buds nearly ready to open, with an occasional bloom."

The variety in these tests was Premier and it produced a very satisfactory second crop of blooms so that the total yields were reasonably good.

In 1936 there was a killing frost at Knoxville, April 8, about eight or ten days later than the average last killing frost, and at that time early blooming varieties were nearly in full bloom. Counts were made shortly after this frost and it was found that 72 per cent. of the blooms which were open on Blakemore were injured and 84 per cent. of those which were open on Dorsett were injured, while only 50 per cent. of the Aroma blooms showed any frost damage. In addition to the relative percentage of blooms which were killed it is important to note that there were less than half as many blooms open on the Aroma as on either the Dorsett or Fairfax.

Counts were made during the present blooming season, 1937, on April 24, to get additional information on relative blooming dates. It was found that at this time Aroma had only a very few blooms open. Less than 100 flowers could be found on a 60 foot row. Dorsett was blooming freely with an average of approximately 1200 blooms per row and Blakemore was blooming even more abundantly with approximately 1600 blooms per row. All of these rows had been mulched with 3000 pounds of straw per acre and the mulch was allowed to remain over the row as long as was possible without injury so that the blooming season was considerably delayed. The loss which results from spring frost is not entirely due to reduced yields. A large part of this loss is due to the production of many imperfectly formed berries which growers call buttons. These berries are culls and must be graded out at harvest or the grade of the entire crop will be reduced.

Field Losses at Harvest

During the course of this investigation it has become very clear that losses which occur in the field during harvest are of tremendous importance and that they greatly reduce the amount of fruit on which the grower secures a return. These losses frequently amount to a very large percentage of the total production but it has been found practically impossible to measure them in any satisfactory way.

A recent survey which was made by Mr. Harry Carlton, of the Tennessee Experiment Station, through the County Agricultural Agents in 16 of the leading strawberry producing counties gives some interesting estimates as to the proportion of the 1935 crop which was lost. It was reported by these agents that an average of 8.4 per cent. of the total production was not sold. This represents approximately 56,000 crates and is an item of real importance. The maximum loss was 30 per cent. reported in Meigs County in East Tennessee, and 25 per cent. reported in Haywood and Madison Counties in West Tennessee. Even though these estimates are based only upon observations and are not supported by actual data, they give a fairly good picture of the seriousness of this problem. Losses due to frost injury and to weather conditions during harvest have been emphasized in the preceding discussion. While many of the best growers report practically no field losses even in years when conditions are not favorable other growers who have practiced equally good cultural methods report losses

amounting to from 10 to 25 per cent. of the total crop. No doubt, unfavorable weather conditions are responsible for the largest percentage of field losses, but many other causes are of significance.

Selling Price

During the seasons 1932-1935, inclusive, the selling price was so low that profits were very doubtful. Under such marketing conditions a large percentage of the fruit was left in the field when the selling price dropped to so low a point that the grower could not handle the fruit and receive any return for the cost of production. The seriousness of this situation is clearly shown by the records of 15 Aroma fields, in Monroe County, for the 1933 crop. Seven of these 15 growers report very little loss of fruit in the field. Four growers report that from 10 to 20 crates per acre were given away, and three of the 15 growers estimate that 25, 30, and 50 per cent., respectively, of the fruit was left in the field when picking was stopped because of unsatisfactory prices. Similar conditions have existed throughout the state during this period.

Carelessness in Picking and Handling

Careless picking and insufficient supervision of pickers is frequently a very important cause of field losses. In 1934 and again in 1935 observations were made in an excellent field of Aromas where lack of proper field management, careless picking, and similar causes, resulted in the loss of fully one-third of an excellent crop. A

large percentage of the strawberries in Tennessee are picked by the owner's family with the help of the neighbors, and very little real supervision is given to the pickers. Very often, under such conditions the work is done very well because all who are engaged in it are interested in the crop. Large growers, on the other hand, employ many pickers who have no interest in the crop, and who are inclined toward careless work unless very careful supervision is given. Ripe berries may be left in the field and they may be brought in as overripes at the following picking. Green or imperfectly formed berries may be picked in large numbers and fruits which are on the vine may be damaged by crawling or walking carelessly along the rows. Such losses can largely be avoided by proper supervision. Many growers have found that a field boss should be employed to supervise about 15 pickers, and that a careful check of individual work should be made in order to eliminate those who are careless.

Delay in picking is a very common cause of serious loss. Table 36 shows that during a picking season, even in a normal year, there are two or three periods during which it rains on two or more consecutive days. In very wet years these periods may extend for four or five days so that it is almost impossible to get the berries picked before they become overripe. Such unfavorable weather conditions make it necessary to provide sufficient labor to harvest the entire acreage in a minimum of time. It is desirable to harvest every day during the main picking season when weather conditions favor rapid

ripening. The serious increase in the proportion of overripe berries which results from infrequent picking was illustrated in the careful classification of culls on the plots at Clarksville, during the 1932 picking season. The fruit was being sold locally so that the berries which were reported as overripe were not lost in this particular instance. Commercial growers who are shipping to distant markets are inclined to follow the same plan of picking only every other day, and frequently allowing two days to pass between pickings. With this schedule it was found that 61 per cent. of the culls which were found at a picking made May 23, 1932, were due to overripes. A similar determination was made at the next picking on May 25 and it was found again that 56.3 per cent. of the culls were due to overripe fruits.

Delay in handling the fruit from the time it is picked until it is placed under refrigeration or on the market, and especially the exposure of the fruit to the sun, are important causes of loss in many strawberry fields. Careless handling by graders and packers frequently reduces the quality of the fruit as it appears on the market and therefore reduces the returns. If pickers can be supervised carefully and taught to grade in the field so that it is unnecessary to turn the cups in the packing shed much of this loss can be avoided. During periods of high prices growers in Tennessee practice this method of harvesting to a considerable extent, but when prices approach the point where profits are doubtful such careful supervision is discontinued.

Size of Berries

Reference to Table 30 shows the great importance of size as a cause of culls. In this table the proportion of the total yield during the last three pickings of the season which was below the minimum size for U. S. No. 1 varied from 6.1 per cent. with Aroma in 1935 to 71.4 per cent. with Klondyke in 1933. The proportion of small berries for the last three pickings during the entire life of the plantation averaged with Klondyke 50.6 per cent., with Aroma 11.3 per cent., and with Blakemore 47.2 per cent. Considering the proportions of berries which were below the minimum size during the entire picking season Aroma averaged 4.3 per cent. for the entire life of the plantation, while Klondyke and Blakemore averaged approximately 19 per cent. These large losses due to size may reflect unfavorable weather conditions or careless cultural methods, and are of tremendous importance to the strawberry growers of this state.

Classification of Culls According to the Cause

During the season of 1932 all of the culls which were produced on a series of plots at the University were carefully analyzed in order to determine the relative importance of different causes. A summary of this information for the season is presented in Table 37. It is important to remember that the 1932 picking season was extremely dry and, therefore, the percentage of berries which were culled because of size is very high. During the blooming season in 1932 there was a killing frost which caused the formation of an unusually large

Table 37. Classification of Culls

Variety	Total Yield Per Row	Weight of Culls	% of Total Yield	% of Total Culls which were:				
				% Below $\frac{3}{4}$"	Rots	Buttons	Misc. Injury	Over Ripe
Aroma	6.10	1.02	16.6	14.8	14.2	39.1	19.6	13.6
Blakemore	9.74	1.66	17.2	24.6	10.7	59.3	19.3	13.0
Klondyke	9.64	1.87	19.4	29.3	9.5	62.8	23.2	12.7

1932 Picking season.

number of buttons. The most important single cause of culls during this picking season was this late spring frost. The culls which are listed as due to mechanical injury are largely the result of bird pecks. Most commercial growers simply do not pick such fruit and have no measure of the amount which occurs in the field. The low total yields which are reported are due principally to the reduced stand of plants following an abnormal summer drought during the growing season of 1931. In this analysis berries which showed more than one defect were listed in both groups so that the total percentages exceed 100 in most cases. A considerable percentage of those berries which are listed as buttons were also below three-fourths inch in diameter but showed definite evidence of frost damage. The comparison of varieties which can be made in this table is interesting and fairly represents these varieties as they are grown in Tennessee. A larger percentage of culls are due to size with Klondyke than with Aroma and a smaller percentage are due to rots. The Klondyke fruit stalk is quite strong and holds the fruit up off the ground so that field rots are comparatively unimportant. The fact that Aroma shows a distinctly smaller percentage of buttons than Blakemore and Klondyke may be due to a later blooming season and to the protection of Aroma flowers by the foliage.

FACTORS WHICH AFFECT THE SELLING PRICE

The profits which are realized from strawberries or any cash crop depend not only upon the cost of production and the yields which are secured but also upon the selling price. In some respects this factor is less under the control of the individual grower than are those factors which determine the cost of production or the yields per acre.

Competition Among Widely Separated Producing Areas

During the very early life of strawberry growing, production was limited to areas closely adjacent to centers of population. Since the development of refrigeration and the perfection of the refrigerator cars the producing areas have spread widely and they have become competitors in all of the important markets. More recently the development of an extensive system of improved highways together with the very rapid expansion of commercial trucking facilities has further complicated this problem. The recent survey which was made by Mr. Carlton through the County Agricultural Agents in 16 strawberry producing counties indicates that in 1935 from 70 to 75 per cent. of the production in East Tennessee moved to the markets by trucks and in West Tennessee from 40 to 50 per cent. of the crop was handled in this way. Truck movements are very much less accurately reported and market information is, therefore, less reliable than it was a few

years ago when practically all perishable products moved into the larger markets over the railroads. These improved means of transportation have brought widely separated areas into direct competition.

It is customary to divide strawberry producing states into four groups according to their shipping season. The marketing season for states in different groups, however, frequently overlaps sufficiently to be an important factor in the market supply. The real competition which Tennessee strawberries meet in the markets is indicated more clearly in Table 39 where the weekly shipments are shown for the period during which Tennessee strawberries are moving. The states in the extreme eastern part of the United States such as North and South Carolina and Virginia are not listed in this table even though they are included in the second early group and are moving their crop at the same time. Strawberries from these eastern states move into northeastern consuming centers almost entirely and do not occupy any important place in the consuming centers of the middle west where practically all of Tennessee strawberries are sold. California movement is not indicated in this table for the same reason. Comparatively, a small proportion of California strawberries move into the important markets of the middle west under normal conditions. A study of Table 39 shows in a very striking way that Tennessee strawberries meet the heaviest competition of the entire season. The peak of our movement, based upon a five year average, comes during the middle of May, and the total shipments for the

Table 38. Classification of Strawberry Producing States According to Season of Marketing

Early Group	Second Early Group	Intermediate Group	Late Group
Alabama	Arkansas	California	Indiana
Florida	Southern California	Delaware	Iowa
Louisiana	Georgia	Illinois	Michigan
Mississippi	North Carolina	Kansas	New York
Texas	South Carolina	Kentucky	Ohio
	Tennessee	Maryland	Oregon
	Virginia	Missouri	Pennsylvania
		New Jersey	Utah
		Oklahoma	Washington
			Wisconsin

Table 39. Weekly Carlot Shipments from Tennessee and Competing States with Total for United States

State	April				May				June			
	1-7	8-14	15-21	22-28	29-5	6-12	13-19	20-26	27-2	3-9	10-16	17-23
Total U. S.	290.0	402.8	516.4	886.6	1299.2	1457.8	1348.8	1352.2	876.0	327.0	57.6	34.4
Mississippi	.8	2.4	7.0	17.4	26.4	19.6	18.6	.4				
Louisiana	195.6	288.4	383.2	534.4	498.8	514.6	84.4	4.6				
Alabama	13.0	24.8	52.4	107.6	125.6	88.6	63.2	35.0	7.6			
Arkansas			5.0	63.6	227.2	426.2	302.2	123.4	17.2	.6		
Tennessee (total)				8.0	155.4	304.2	341.8	194.2	51.8	7.4	1.0	.6
Missouri						5.2	89.8	193.4	202.0	42.8	4.2	.2
Kentucky				.2		2.8	106.8	410.4	250.2	27.4		
Indiana								.4	57.6	44.8	9.0	.2

5 year average 1932-1936, inclusive.
Taken from the "Weekly Summary of Carlot Shipments" United States Department of Agriculture, Bureau of Agricultural Economics.

entire United States are heavier at that season than at any other time. The principal volume of competition which our fruit meets during mid-season comes from Louisiana, Arkansas, Alabama, and Missouri. The Mississippi crop is declining rapidly as our season approaches its peak and though both Louisiana and Alabama are past the peak of their season the volume of shipments from these states is a very important factor in midwestern markets. The shipping seasons of Arkansas, Tennessee, Missouri, and Kentucky occur most nearly at the same time. The peak movement from Tennessee and Arkansas comes during almost exactly the same period. Missouri and Kentucky reach their peaks after the heaviest volume from Tennessee has moved.

Strawberry production in Tennessee is divided into three rather distinct districts. The marketing season for East, Middle, and West Tennessee strawberries is shown in Table 40. The movement starts several days earlier in West Tennessee and usually a few days later in Middle Tennessee than in the eastern part of the state. During recent years the Blakemore has been introduced into West Tennessee in considerable quantities so that the shipping season from that section extends as late as that from either Middle or East Tennessee. So large a proportion of the strawberries from both East and Central Tennessee move by truck that the table probably does not show either the earliest or latest shipments from these sections.

The comparative importance of different states which compete

Table 40. Weekly Carlot Shipments from the Important Districts of Tennessee with the Total for the State

	Sections of Tennessee			State Total
	East	Central	West	
April 22-28	--	--	8.0	8.0
May 29-5	24.4	--	131.0	155.4
6-12	48.4	1.2	254.6	304.2
13-19	88.2	45.0	208.6	341.8
20-26	55.8	66.8	71.6	194.2
27-2	8.2	28.2	15.4	51.8
June 3-9	.6	5.0	1.8	7.4
10-16	--	--	1.0	1.0
17-23	--	--	.6	.6

Five year average 1932-1936, inclusive.
Taken from the "Weekly Summary of Carlot Shipments" U. S. Dept. of Agriculture, Bureau of Agricultural Economics.

with Tennessee is indicated in Table 41 where the acreage is listed for the years 1928 to 1936, inclusive. The general trend in acreage has been remarkably uniform in this group of states. The only significant difference is that the earlier states including Tennessee have for the most part shown a decline in acreage during the past three years, while states to the north have remained quite constant. Both Missouri and Arkansas show a slight increase for 1936. Considering both the acreage and season of shipment Tennessee can expect the greatest competition from Arkansas, Louisiana, Missouri, and Kentucky.

Price Trend During a Period of Years

Comparison of Tennessee and Competing States

The fluctuation in acreage which is shown in Table 41 corresponds closely to the general profitableness of the crop during that period. Acreage changes are less abrupt than fluctuations in selling price and usually lag one or two years behind. In Table 42 the trend in strawberry prices is given for Tennessee and competing states. Throughout the entire period from 1928 to 1936, inclusive, the average seasonal price in Tennessee has been below that in the other states, and the average price of Louisiana strawberries has been distinctly higher than that from any other state. The unusually high price which is reported for that state may be due in part to the efficiency of their marketing system and to the fact that a

Table 41. Acreage of Strawberries in Tennessee and Competing States

State	Acreage								
	1928	1929	1930	1931	1932	1933	1934	1935	1936
Mississippi	800	840	900	920	1,320	1,560	940	600	500
Louisiana	23,200	24,000	22,000	20,500	23,000	18,800	19,400	18,800	14,800
Alabama	4,600	4,900	5,200	3,500	4,300	4,800	4,400	3,200	2,700
Arkansas	25,000	26,400	20,000	12,800	23,000	27,000	29,300	10,400	12,400
Tennessee	19,600	18,300	14,000	11,400	16,800	20,500	19,000	16,800	15,600
Missouri	26,500	22,000	12,800	9,600	11,400	9,600	10,100	6,000	8,600
Kentucky	8,200	5,400	4,000	3,300	5,400	10,000	9,300	8,200	8,200
Indiana	2,200	2,400	2,400	2,100	2,500	3,000	3,000	2,700	2,700
U. S. Total	207,600	201,380	176,010	154,570	190,210	195,700	196,500	168,300	171,520

United States Department of Agriculture, Bureau of Agricultural Economics
Crop Reporting Board--Strawberries--TC - 36: 1233.

large part of their production is marketed early in the season before the crop matures in competing states. In the table, averages are given in parentheses with the Louisiana figure omitted in order to get a true representation of the trend in the average prices from the competing states. Following a series of very good years during 1929, 1930, and 1931, there was a period of extremely low prices but a gradual improvement seems to be evident during the seasons of 1935 and 1936. The average price of Tennessee strawberries has fluctuated during this nine-year period from $1.05 to $3.10 per crate with an average for the period of $1.90. The average price for all competing states except Louisiana has fluctuated from $1.24 to $3.67 with an average of $2.46 per crate. In Table 43 the average price, as reported by the commercial growers cooperating in this investigation, is presented together with the highest and lowest price which was reported by individual growers during each season. In every instance there is a very wide spread between the highest and lowest price reported by individual growers. The individual records show a rather uniform distribution of prices between these extremes. The same serious drop is indicated by these records as was shown in Table 42 for the entire state and the competing states.

Correlation with Economic Conditions

The fluctuation in strawberry prices which was shown in Tables 42 and 43 cannot be explained, however, entirely on a basis of the quality and condition of the fruit or the volume which moved

Table 42. Price of Tennessee Strawberries and Those from Competing States (1928-1936 inclusive)

State	1928	1929	1930	1931	1932	1933	1934	1935	1936	Average
Mississippi	4.30	3.35	2.65	2.75	1.85	1.05	1.60	2.40	2.65	2.51
Louisiana	6.30	4.70	5.40	4.40	2.70	2.90	3.05	3.75	4.00	4.13
Alabama	3.80	2.40	3.10	2.90	1.50	.95	1.40	2.10	2.55	2.30
Arkansas	2.40	2.60	3.60	2.55	1.90	1.45	1.30	1.95	2.30	2.23
Tennessee	1.90	2.40	3.10	2.50	1.25	1.05	1.10	1.65	2.15	1.90
Missouri	2.60	2.60	4.55	3.00	2.00	1.60	1.75	2.75	3.35	2.69
Kentucky	2.40	2.60	4.30	3.75	1.90	1.20	1.65	2.30	3.05	2.57
Indiana	2.40	3.10	3.80	2.50	1.60	1.20	1.90	2.20	3.40	2.45
Competing States	3.46 (2.98)	3.05 (2.77)	3.91 (3.67)	3.12 (2.91)	1.92 (1.79)	1.48 (1.24)	1.81 (1.60)	2.49 (2.28)	3.04 (2.90)	2.70 (2.46)
U. S. Average	3.34	3.22	4.00	3.27	1.93	1.72	2.00	2.33	2.86	2.74

United States Department of Agriculture, Bureau of Agricultural Economics
Crop Reporting Board--Strawberries--TC - 36: 1233.

Louisiana is omitted from average given in () in order to give a more true comparison between Tennessee and most of the competing states.

Table 43. Price Trends from 1930 to 1934

Year	Klondyke			Aroma		
	Lowest	Highest	Average	Lowest	Highest	Average
1930	$2.24	$3.00	$2.68	$2.33	$4.01	$3.23
1931	1.93	3.50	2.62	2.26	3.04	2.66
1932	1.23	2.57	1.63	1.66	2.51	1.97
1933	.90	1.15	.98	1.09	1.45	1.28
1934	Not sufficient records			1.10	1.66	1.29

Based on the average of the records from commercial growers co-operating in this investigation.

into the consuming centers during the shipping season. A more fundamental factor influenced these seasonal trends. In Table 44 information is presented which shows a very striking correlation between the price of strawberries, which was received by the grower, and general economic conditions throughout the country. In order to secure a picture of the general economic conditions index numbers representing the general business activity, employment, commercial pay rolls, and non-agricultural income were secured from tabulations in the Annalist and publications by the United States Department of Agriculture. From a very satisfactory condition in 1929 there was a continuous decline in general economic conditions to 1933 which was the low point by all three methods of measuring the conditions. The season of 1933 was also the low point in the seasonal strawberry prices. The improvement since that time has indicated an equally close correlation. There can be no doubt but that the ability of people to buy is a dominant factor in determining the selling price of strawberries.

Fluctuation in Price During a Season

A study of the individual records in this investigation shows that the fluctuation in the price during the picking season is a factor of tremendous importance. The average price of the first picking is, in almost all cases, the highest. The decline in price corresponds roughly with the increase in volume and the progress of

Table 44. Relation of Strawberry Prices to Economic Conditions

Year	Strawberry Price (1) Per Crate	Business (2) Activity	Index of (2) Employment	Index of (3) Payrolls	Non- (4) Agricultural Income
1928	$ 1.90	105.3	97.4	100.4	--
1929	2.40	114.8	105.1	110.9	107
1930	3.10	101.6	95.2	95.0	100
1931	2.50	89.8	79.9	72.5	85
1932	1.25	66.2	64.7	47.6	67
1933	1.05	74.1	62.1	41.9	63
1934	1.10	85.2	81.0	65.5	70
1935	1.65	82.7	81.8	68.4	75
1936	2.15	94.3	84.8	76.1	85

(1) Average price received by growers for the crop marketing season. U.S.D.A. Bureau of Agr. Econ., Crop Reporting Board, Strawberries - TC - 36: 1233.

(2) The Annalist. Published by the New York Times Co. Vol. 47, p. 943, June 1936, and Vol. 49, p. 599, April 1937. The average of the indexes for March, April, May, and June is recorded.

(3) The Annalist, Vol. 45, p. 162, Jan. 18, 1935, Table 7, Recent Economic Changes in United States, and Vol. 47, June, 1936. (Average 1923 - 25 = 100)

(4) The Demand and Price Situation, March, 1937, U.S.D.A. Bureau of Agr. Econ., Washington, D. C.
(Average 1924 - 29 = 100)

the shipping season. During midseason the largest pickings averaged only 75 per cent. as high in selling price as did the first picking. The price at the close of the season after the size and quality of the crop had declined was only 50 per cent. as high as it was at the start. In only 12 cases out of the 67 reports which are available the prices during late season were as high as at the beginning. In all but three of these cases the Aroma variety was being marketed late in the picking season. This decline in price toward the close of the picking season causes many growers to leave a considerable percentage of their fruit in the field during seasons of low prices.

To present a more complete picture of the fluctuation which occurs in strawberry prices, information is presented in Tables 45 and 46 concerning the market conditions in two of the leading strawberry consuming centers. In Table 45 the Cincinnati strawberry market is presented, for the season during which Tennessee berries were moving in 1932. Similar information for the Chicago strawberry market in 1935 is given in Table 46. Two important price fluctuations are conspicuous in these data. There is a continuous and frequently a very extreme fluctuation in price from day to day and, also, a wide variation in the quotations on any given day. Many factors contribute to these price fluctuations and the importance of at least three such factors may be seen by a study of these market reports.

The influence which the variety of fruit has upon the price is very evident. In both markets Klondyke and Blakemore consistently

Table 45. Cincinnati Strawberry Market, Tennessee Season 1932

Date	Arrivals		Total* Supply	Condition of Stock	Price Range	Variety	Notes
	Tenn.	Total					
5/2	2	8	17	Ordinary quality & condition	Mostly $2.00	West Tenn. Klondyke	Ala. $2.50-$3.00, poor quality $1.50-$2.00
3	--	5	14	Ordinary Quality	$2.00-2.25	Klondyke	Ala. $2.50-3.00, few 3.25 Poorer $1.00-2.00
4	5	8	18	Mostly ordinary quality	$1.75-2.00	Klondyke	Poorer $1.50
5	1	17	38	Mostly ordinary quality	$1.50-2.00	Klondyke	Poorer, as low as $1.00
6	3	11	34	Mostly ordinary quality	$1.50-2.00	Klondyke	Poorer, as low as $1.00
7	3	19	38	Wide range	$1.50-2.75	Klondyke	Ala. U.S. No. 1 $2.25-2.75, poor to fair quality and condition. $1.50-2.00, low as 50¢
9	3	12	30	Wide range	$2.00-2.35	East Tenn. Klondyke	Few of best $2.50
10	--	8	24	Fair quality	$2.00-2.25	Klondyke	Few $2.75 Ordinary quality $1.70-1.85
11	1	4	9	Wide range Ordinary	$2.00-2.25	Klondyke	Poorer $1.75
12	4	19	39	Wide range Most ordinary	$1.50-2.00	Klondyke	Few $2.25, poorer $1.00
13	2	9	29	Mostly Ordinary	$1.50-2.00	Klondyke	Poorer $1.00
14	6	14	27	Wide range	$2.25-2.50	Klondyke	Tennessee generally good, few higher, poorer $1.75-2.00
15	Not reported						
16	7	9	18	Generally good quality, cond.	$2.25-2.50	Klondyke	Few Aromas from Tennessee Poor quality lower

Table 45 (Continued). Cincinnati Strawberry Market, Tennessee Season 1932

Date	Arrivals Tenn.	Arrivals Total	Total* Supply	Condition of Stock	Price Range	Variety	Notes
5/17	1	3	8	Generally good quality, cond.	$2.25-2.40	Klondyke	
18	4	4	9	Generally good quality, cond.	$2.50 $2.25	Aroma Klondyke	Poorer Aroma and Klondyke low as $2.00
19	8	8	16	Generally good quality, cond.	$2.50-2.60 $2.25-2.50	Aroma Klondyke	Poorer Klondyke low as $1.75-2.00
20	5	8	14	Generally good quality, cond.	$2.50-2.75 $2.75-3.00	Klondyke Aroma	Eastern district of Tennessee
21	10	11	21	Generally good quality and condition	$2.50-2.75 $3.00-3.25 $3.85-4.00	E.T.Klon. E.T.Aroma Port.Aroma	East Tennessee Aromas poorer $2.00-2.25. Portland A. U.S. No. 2 mostly $3.25
Not reported 5/22							
23	8	10	20	Generally good quality and condition	$2.00-2.50 $2.50-3.00 $3.25-3.50	E.T.Klon. E.T.Aroma P. Ar. & Pr.	East Tennessee Klondykes low as $1.50. Poorer A. $1.75-2.25. Aroma & Premier low as $3.00
24	10	1	27	Generally good quality	$1.75-2.00 $2.25-2.50 Mostly 3.25	E.T.Klon. E.T.Aroma P. Ar.& Pr.	Poorer East Tennessee Klondykes $1.50. Poorer East Tenn. Aromas $1.75-2.00. Portland $3.50-3.00
25	11	12	26	Generally good condition and quality	$1.50-1.75 $1.50-2.00 Mostly 3.00	E.T.Klon. E.T.Aroma P. Ar.& Pr.	Poorer, 2.50-2.75
26	11	13	30	Generally good condition and quality	$1.25-1.50 $1.50-1.75 $2.50-2.75	E.T.Klon. E.T.Aroma Port.Aroma	Poorer, low as $2.00
27	8	13	32		$1.25-1.60 $1.50-1.75 $2.00-2.25	E.T.Klon. E.T.Aroma P. Ar.& Pr.	Mostly around $1.50 Poorer $1.75

Table 45 (Continued). Cincinnati Strawberry Market, Tennessee Season 1932

Date	Arrivals Tenn.	Arrivals Total	Total* Supply	Condition of Stock	Price Range	Variety	Notes
5/28	10	13	31	Ordinary quality	$1.25-1.50 $1.50-2.00	E.T.Klon, Ar. Port.Ar.& Pr.	Few higher Poorer $1.00-1.25
Not reported 5/29							
Not reported 5/30							
5/31	13	19	34	Mostly ordinary quality	$1.00-1.25 $1.50-1.65	E.T.Klon, Ar. Port.Aroma	Very poor, 50¢
6/1	6	8	18	Mostly ordinary quality	$1.00-1.25 $1.50-1.75	E.T.Klon, Ar. Port.Aroma	Low as $1.25
2	2	4	12		$1.75-1.80 $1.35-1.40	US#1 P.Aroma US#2 P.Aroma	
3	3	7	15	Generally good quality, cond.	$1.75-2.00	Port.Aroma	Poorer $1.50
6	12	15	22	Generally good quality, cond.	$1.50-1.65	Port.Aroma	U.S. No. 2 $1.25
7	1	1	6	Generally good quality, cond.	Mostly 1.60	Port.Aroma	U.S. No. 2 $1.25
8	5	5	11	Generally good quality, cond.	Mostly 1.50	Port.Aroma	
9	3	3	8		$1.50-1.60	Port.Aroma	Poorer $1.40

* Indicates broken cars on track.
Compiled from United States Department of Agriculture, Bureau of Agricultural Economics, Washington Daily Market Report; Strawberries.

Table 46. Chicago Strawberry Market, Tennessee Season 1935

Date	Arrivals		Supply on Track	Total Supply	Price Range	Variety	Notes
	Tenn.	Total					
4/30		6	10	16	$3.25-3.50	Klondyke and Blakemore	Truck receipts.
5/1	4	5	12	21	$3.25-3.75 Fair $2.75-3.00	Klondyke and Blakemore	
5/2	2	10	10	22	$3.25-3.50 Fair $2.75-3.00	Klondyke and Blakemore	Few poorer lower
5/3	2	10	10	22	$3.25-3.50 Fair $2.75-3.00	Klondyke and Blakemore	Few poorer lower
5/7	2	5	24	31	$1.75-2.25	Klondyke and Blakemore	Poorer low as $1.50
5/8	4	6	11	21	$2.00-2.25 Poorer $1.25-1.50	Klondyke and Blakemore	Some leaky
5/9	6	4	4	14	$2.00-2.50 Poorer $1.50-1.75	Klondyke and Blakemore	Mostly ordinary
5/10	8	8	8	24	$3.00-3.50 Fair $2.00-2.50	Klondyke and Blakemore	Mostly ordinary
5/14	6	2	12	20	$3.75-4.00 $2.00-3.00 $3.75-4.00	Premier Klondyke Blakemore	Ordinary, soft
5/15	13	9	15	37	$3.00-3.25 $2.00-2.50	Premier Klondyke	Ordinary, small
5/16	14	10	25	49	$1.75-2.50 $2.50-3.00	Klondyke Blakemore	Best $2.00-2.25
5/17	9	17	18	44	$2.00-2.50 $1.75-2.25	Blakemore Klondyke	
5/21	8	26	23	57	$2.50-3.00 $2.25-2.50	Klondyke Blakemore	Fair as low as $2.00

Compiled from: Miscellaneous Report, Market News Service, United States Department of Agriculture, Bureau of Agricultural Economics, 21-24 Fruit Exchange Building, Cincinnati, Ohio.

sell at a lower price than Premier and Aroma. Except when one of these varieties is first appearing on the market they are usually grouped in market reports.

The volume of the fruit which is available in the market on a given day can be seen to have a distinct influence on the price though this effect is less definite than might be expected. In 1932 at Cincinnati, when the daily supply of berries amounted to from 30 to 40 cars the price was distinctly lower than when more limited supplies were in the market. The same condition can be seen in the report of the Chicago market in 1935. There are sufficient exceptions in both reports, however, to indicate that, except with great extremes, other factors may overbalance the influence of the volume which is available.

Influence of Quality on Selling Price

The quality of the fruit which is offered for sale appears to be by far the most significant factor in determining its selling price on any given day. Throughout the season in both of these markets prices are reported distinctly lower for poor quality fruit and frequently mention is made of premiums being paid for fruit of unusually high quality or good condition. The following quotations which are taken directly from the daily market report of the United States Department of Agriculture, Bureau of Agricultural Economics, for

May 21, 1932, show the tremendous influence which quality has upon selling price:

> "Cleveland Market - "TENNESSEE, 24-quart crates, Aromas, small size, generally ordinary condition, showing soft $1.75-2.75, mostly $2.25-2.75; Klondykes small size, ordinary condition best $2.00-$2.50, poorer $1.50; Premiers, Portland Section, fine quality and condition $4.25-4.50, mostly $4.25."
>
> "Chicago Market - "TENNESSEE, 24-quart crates Klondykes U. S. No. 1, $2.50-3.00, poorer $2.00-2.50."
>
> "Cincinnati Market - "TENNESSEE, Eastern District, 24-quart crates Aromas $3.00-3.50, poorer $2.00-2.25; Klondyke $2.50-2.75."
>
> "KENTUCKY and TENNESSEE, Portland Section, 24-quart crates Aromas, U. S. No. 1, $3.85-4.00, poor quality and condition lower; U. S. No. 2, mostly around $3.25."

The market reports show clearly that the quality and condition of the fruit influences the selling price in seasons of active demand and comparatively high prices as well as in seasons of generally low prices. The following quotations are taken from the Miscellaneous Report of the Market News Service for the Chicago Strawberry market during the 1935 season:

> May 1st: "TENN: 24 qt. crates Klondykes and Blakemores, best $3.25-3.75; fair quality, fair color $2.75-3.00."
>
> May 7th: "TENN: 24 qt. Klondyke and Blakemores, fair, many poor color, mostly $1.75-2.25, few best high as $2.50, poorer low as $1.50."
>
> May 9th: "TENN: 24 qt. crates Klondyke and Blakemores, generally fair quality, pale color, many soft, mostly $2.00-2.50, few best $2.75-3.00, poorer leaky $1.50-1.75."

May 14th: "TENN: 24 qt. Premiers $3.75-4.00; Blakemores good quality $3.75-4.00; showing soft, fair $3.00-3.50; Klondyke fair to ordinary soft $2.00-3.00."

Similar quotations are found in the report of the Cincinnati market during 1936:

May 21st: "TENN: PORTLAND SEC: Aromas $3.25-3.75; Blakemores and Premiers U. S. 1, $2.50-3.00; conb. $1.75-2.25, poorer $1.25."

May 14th: "TRUCK: 24 qt. crates. TENN: PORTLAND SEC: Blakemores and Premiers U. S. 1, $4.00; U. S. 2, $3.50; DAYTON SEC: Blakemores and Premiers $3.25-3.50; Klondykes $2.75-3.00; MITCHELLVILLE SEC: Blakemores and Premiers $4.00-4.25."

The Possible Development of Freezing as an Outlet for Surplus Fruit

Until very recently the strawberry crop has been considered entirely as a perishable fresh fruit which should be harvested, handled, and distributed with the greatest care and promptness. Interest in the development of new outlets for the fruit has centered during recent years in the development of a frozen product. Mr. H. A. Baker is credited with making the first successful commercial pack of frozen strawberries in the northwest, about 1911. Following this early success there was rapid expansion of the industry until 1930 when approximately 81,897,514 pounds of strawberries were frozen. The decline in volume since 1930 has corresponded in a general way with

decreased production and low prices. Until the present time the principal development of this industry has occurred in the northwest. During the last few years, however, considerable interest has developed in Tennessee and attention has been directed to the possibilities of further development by the work of the Tennessee Valley Authority in cooperation with the University of Tennessee. The large volume of strawberries which are left unharvested in Tennessee because of declining prices, and the losses which result from small sizes during the picking season have been discussed previously. If the further development of the freezing industry in Tennessee can furnish an outlet for surplus fruits when the fresh fruit market drops below a reasonable price, and in addition can provide an outlet for fruits below the minimum size required for the U. S. No. 1 grade, then it will prove to be an important stabilizing factor and will be of real economic importance. Such a possibility is clearly indicated by the work of the Tennessee Valley Authority in cooperation with the University of Tennessee. In his report of this work Kelly suggests that a price of $1.40 to $1.50 per crate can be paid for strawberries which are to be frozen, even with the present undeveloped condition of the industry. A considerable part of the package cost can be avoided when berries are delivered to a local buyer for freezing. Under such conditions the price which is suggested is sufficient to bring a reasonable profit

with proper cultural practices under normal conditions. Among the varieties which are produced commercially in Tennessee the Klondyke and Blakemore are desirable for freezing but the Aroma is unsatisfactory.

DISCUSSION

Strawberry profits are not determined by the same factors under all conditions. No single one is of first importance but profits depend upon a favorable balance of many factors. As this study has progressed four things have come to stand out clearly.

First and most important, profits depend on securing relatively large yields per acre at a low cost per crate.

Second, though yield is greatly influenced by climatic conditions, more especially the amount and distribution of rainfall, it nevertheless depends in large measure on the kind of soil, its preparation, and its proper management after planting. Apparently the preparation and later management are as important as the kind of soil. If the plant bed is so prepared before setting that a good stand of plants is promptly obtained and then so handled that heavy, matted rows are formed, large yields of good grade berries may be expected. In this connection good physical condition apparently plays a more important part than high natural fertility, the use of fertilizers or mulching materials. On the other hand poor soils are certain to result in a poor stand of plants. This means that fundamentally the problems of production center around the establishing of the plantation and its care during the first season, even during the first few weeks of that growing season. The old adage, "Well begun is half done," applies literally in the strawberry enterprise.

Third, the most effective way to keep production costs low is through the preparation of the plant bed and the early care during the first season. This early care will increase yields and will help to avoid more expensive care during the later season. Again an old adage, "A stitch in time saves nine," applies.

Fourth, though income and profits depend, in large measure, on the selling price and they in turn depend in large measure on the market supply and demand, size and grade of berries are important in establishing price. Both size and grade are largely under the growers control, partly through the same factors that determine yields and partly through care in harvesting operations.

SUMMARY

Tennessee is one of the leading strawberry producing states, being among the first three in both acreage and production. The strawberry is an important cash crop on many farms in the state. It is a "family crop" because it is adapted to small acreages and requires a large amount of hand labor.

The economic depression has prolonged the period of low returns so that the industry has passed through a serious crisis during the past six years. The present investigation extends through that period of low returns. The information reported in this publication is based upon an analysis of production records which were secured from commercial growers in the leading strawberry producing counties and upon field tests which were planned to check the importance of many factors, influencing strawberry profits.

It is recognized that profits depend upon three general factors, namely, the cost of production, the yield per acre, and the selling price. These three phases of strawberry growing have been given consideration.

The records show that the cost of production represents nearly half of the total cost for the first crop, but harvesting and handling the fruit after it was mature accounted for approximately three-fourths of the cost for the second crop.

The costs of production include overhead, cash outlay, and

labor. The principal item of overhead or fixed cost was a charge for the use of the land. The depreciation of equipment was a very small item because expensive tools were not required for strawberry growing. Most of the cash expenses were incurred during the establishment of the plantation. The cost of plants and fertilizer were the principal items. A comparatively small percentage of the growers applied mulch in the spring before harvest but this represented a cash outlay for most of the growers who made such applications. Labor represented the largest expense in the production of strawberries. An average of 163.6 man hours and 63.9 horse hours per acre were required for the care of the plantation before the first crop. Less than one-third as much labor was required for the care of the plantation between the first and second crops. The establishment of the plantation required 30.2 per cent. of the total labor during the first year.

The harvesting and handling costs included two large items. Picking represented 48.2 per cent. and the cost of the packages represented 30.6 per cent. of the total cost after the fruit was mature. Grading, picking, supervision, and hauling are other items which were included in the total.

Strawberry yields depend upon many factors, no one of which was found to be of first importance under all conditions. The adaptability of the soil is a factor of first importance in most cases. A sandy or gravelly loam in good physical condition, with abundant

humus, moderately fertile, and well drained is considered to be the ideal soil for strawberry production. The care which the soil has received during the years preceding the setting of the plantation is of great importance. Thorough tillage during these years leaves the soil in good physical condition, maintains the humus supply, and reduces the problem of weed control. Under the conditions in this state the acidity of the soil was not often a limiting factor.

For the production of high yields cultivation should be thorough, timely, and continuous through the first growing season. Neglect or delay is not economical of labor. The depth of cultivation is comparatively unimportant under normal conditions, but it should be adjusted according to the type of soil and the available moisture. Tillage after the first crop will increase yields but it may increase greatly the cost per crate if soil conditions are unfavorable. The method of cultivation following the first crop should be determined according to the conditions in each field.

Fertilization is a factor of minor importance and is of doubtful value on good soils. The application of nitrogen is profitable only when applied at the time of renovation following harvest, or possibly on very poor soils when applied in the time of setting. Spring applications of nitrogen before harvest are not profitable in Tennessee. Applications of phosphoric acid and potash during the growing season are helpful only on soils which are below the average in fertility. Potash applied in the spring as growth is starting

gave the most consistently favorable results. General rules for the fertilization of strawberry fields are impossible. Both the study of commercial production records and field tests showed great inconsistency.

Mulch is applied by comparatively few strawberry growers in Tennessee. The application of artificial mulch delays harvest and does not consistently increase yields. The protection of the fruit from dirt and from field rots is probably the most important advantage of mulch, but conditions during the period of this study did not permit the securing of data on this subject.

The selection of suitable plants for setting is a factor of some importance. The source of the plants, however, is unimportant so long as they are free from insects and diseases and are in good condition at the time of planting. Plants of large size are not essential but they have a distinct advantage under unfavorable conditions and will usually start growth more vigorously after setting.

The question of strawberry varieties is unsettled. The Klondyke and Aroma have been the leading varieties in this state for many years but they are being replaced by other kinds at the present time. Blakemore is firmly established in all of the producing regions in Tennessee. Several newer varieties are being tested for commercial production.

Commercial strawberry growers in Tennessee use the matted row system of culture. The time of runner formation and the development

of the matted row is not important before late August provided soil conditions are favorable for the development of large crowns during the fall. Thorough cultivation is essential for the development of vigorous crowns under ordinary conditions.

The stand of plants in the matted row is one of the most important factors affecting strawberry yields. Many other factors are important only as they influence the stand of plants. For example, the application of nitrogen at the time of renovation, the method of renovation which is practiced, the size of plants which are set, and even the method of cultivation are of importance principally because of the influence they have on the number of plants which are developed. Total production increases with the stand of plants under normally favorable conditions until eight or nine plants per square foot are present. Crowding beyond that point results in reduced total yields. The yield per plant declines as the stand increases and the proportion of large fruits decreases in the same way. Probably the best stand varies with conditions, but under the conditions of these tests five or six plants per square foot produced the most profitable yields. Variety characteristics influence the most desirable spacing of plants in the matted row.

Climate is a very important factor but is largely outside the control of strawberry growers except as a consideration in the selection of a suitable site for the planting. Winter injury is not serious except on certain soil types and these are not usually selected

for strawberry growing. Spring frosts or freezes are often serious. Examples for such injury occurred in 1932 and in 1936 during this investigation. Excessive rain during the growing season causes weeds and increases the expense of thorough tillage. Excessive rain during harvest increases field losses by causing soft berries and preventing regular picking. Drought is a more common cause of injury. A dry growing season reduces the stand of plants and, if severe, prevents the development of large, vigorous fruiting crowns. Drought during the harvest season reduces the size of fruits, and, under extreme conditions, prevents many fruits from maturing.

Field losses are tremendously important in determining strawberry profits but are very difficult to measure. Unsatisfactory prices which caused a large quantity of fruit to be left in the field was found to be a very important item during the period covered by this investigation. Most of the losses which occur in the field, however, may be charged to carelessness in picking and handling the fruit or to the serious running down in size of the fruit as the season advances. Variety characteristics, weather conditions, and poor culture are important causes of this running down in size.

The selling price of Tennessee strawberries has been below that of fruit from competing states during the period of this investigation. Tennessee strawberries move into the markets during the period of heaviest shipments. The greatest competition comes from Arkansas, Louisiana, Missouri, and Kentucky.

The most important factor affecting the selling price of strawberries is the ability of the consumer to buy. The price trend follows the economic cycle very closely.

The fluctuation in strawberry prices from day to day is influenced by the volume of fruit which moves into the markets, by the varieties which are offered for sale, and by the quality of the fruit. The most important factor affecting the selling price on any given day is the quality and condition of the fruit. There is usually a variation of 50 cents per crate and frequently a range of as much as $1.00 per crate, according to the condition of the fruit.

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