Lincoln College

CANTERBURY AGRICULTURAL COLLEGE

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TRENDS OF WHEAT YIELDS PER ACRE IN NEW ZEALAND IN RELATION TO SYSTEM OF FARMING

J. W. Calder, M.Sc., B.Agr., Dip.C.A.C.,
Lecturer in Field Husbandry.

Introduction:

The wheat growing land in New Zealand is mainly confined to parts of Marlborough, the eastern regions of Canterbury and Otago and parts of Southland. This land has been in occupation barely 100 years and during this period a series of changes in the systems of farming have occurred as a result of economic forces and the application of science to Agriculture. These changes in the systems of farming have had a distinct effect on the productivity of the land which in some degree, has been recorded in the yields of wheat.

For this article I have drawn a graph showing the trend of wheat yields (expressed as a five year moving average) and will discuss the causes of the changes in the productivity of the land which are apparent. A similar graph was first drawn by Prof. Copland in his book, **"Wheat Production in New Zealand"** (Whitcombe & Tombs, 1915) and brought up to 1937 by Dr. Hilgendorf in his book, **"Wheat in New Zealand"** (Whitcombe & Tombs, 1939). It will be seen that since 1878 the productivity of our cropping land has gradually improved as a result of the use of suitable land, the system of farming adopted and the application of scientific methods. A continuation of "good farming" methods promises to still further increase the productivity of the land.

Accompanying the graph of wheat yields is an area graph showing the five year average acreage.

Before discussing periods of falling and rising wheat yields which are shown in the graph, I want to present some figures of wheat production in the United Kingdom and compare them with those of New Zealand in recent years.

In 1944 season the United Kingdom grew over 3,000,000 acres of wheat with an average yield of 36.3 bushels per acre. Over the past 10 years the New Zealand average area was less than 230,000 acres and the average yield 33.16 bushels per acre.

It will be recalled that the high yield in the United Kingdom is associated with mixed farming, cropping rotations, thorough cultivation, the widespread use of farmyard manure saved from the straw covered yards where cattle are fed in the winter on foodstuffs largely imported from the great grain growing countries. This is good husbandry from a national point of view. By contrast, the low average yields of the great grain growing countries (Canada 14.6 bushels per acre, United States 13.6 bushels per acre, Australia 11.5 bushels per acre) is associated with "one crop" system of farming, in the almost complete absence of livestock and in the use of fallowing to maintain production. In these regions the land has deteriorated to such an extent that in parts, as a consequence of the system of farming, "dust bowl" conditions have developed.

TREND OF WHEAT YIELDS IN NEW ZEALAND

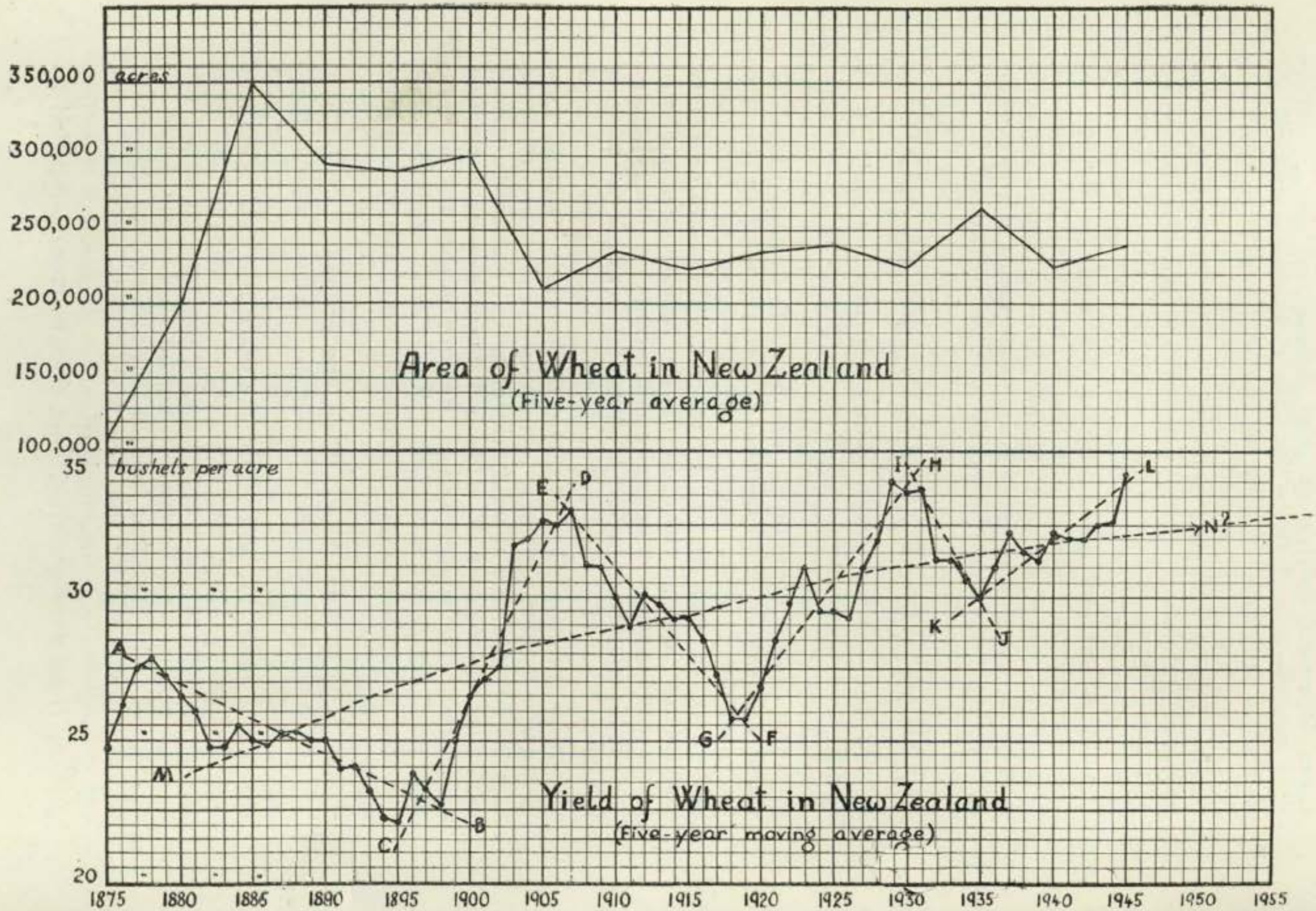
A study of the graph shows a primary trend (M-N) and six secondary trends (A-B to K-L) in which the yields are falling or rising. A change in yield may be brought about by the inclusion or exclusion of sub-marginal land for wheat growing, by improvement or deterioration in the land by good or bad husbandry, by the use of fertilisers and improved varieties, by better cultivation and by better methods of handling the crop. These factors independently or in combination offer an explanation for the changes which are apparent in the trends of wheat yields in New Zealand.

It is admitted that climate, particularly rainfall, may play an important part in determining the direction of these trends, but a study of climatic data in relation to wheat yields by the late Dr. E. Kidson did not disclose a marked correlation. Dr. Kidson was of the opinion that the climatic data available was insufficient for a reliable analysis.

The secondary trends shown on the graph will be discussed first.

Period 1, 1878-1898 (line A-B on the graph)

When the arable land of New Zealand was first settled in the 50's and 60's of last century, pastoral farming was the major industry, and while the price for wool remained high, wheat growing was not attractive. But in the 70's and 80's, wool prices dropped and there was no outlet for surplus sheep, which were often sold at 6/- per dozen or destroyed. The land was held in large areas, was unfenced, was watered only by the rivers, and was provided with very meagre road communication. Because of the low returns from wool growing, land owners were compelled to



350,000 acres
300,000
250,000
200,000
150,000
100,000
Area of Wheat in New Zealand
(Five-year average)
35 bushels per acre
30
25
20
A
B
C
D
E
F
G
H
I
J
K
L
M
N?
Yield of Wheat in New Zealand
(Five-year moving average)
1875
1880
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955

seek other alternatives and wheat was the only other commodity which could be exported to the food consuming countries.

In spite of the difficulties referred to the stations commenced growing wheat on a large scale in the early 70's and the era of the "bonanza" wheat farms commenced, reaching a peak about 1885. Several factors contributed to this change to wheat growing. First the low return from wool already mentioned, second the relatively high return from wheat, thirdly the increasing population and consequent labour supply following the decline of the Otago gold fields, and fourthly the introduction of machinery for handling large areas. The first reaper and binder(a wire-tying machine) was imported in 1877. The next year there were 1,800 of these machines working in Canterbury and the price of wheat was 3/3 per bushel. In 1877 the first American grain drill was imported.

The system of farming was the "one crop" system in vogue in Canada, Australia and the prairie provinces of United States today. Wheat was grown year after year on the same land and when the yields fell to unprofitable levels more land was broken up for wheat. Some of the large stations grew over 5,000 acres of wheat in a season. This system of farming, practiced over a period of 20 years or more, resulted in a gradual decline of average yields as shown in line A-B of the graph. By 1892 the average yield was down to about 25 bushels per acre. No thought was given to conservation of soil fertility. The great depression of the 80's brought a further increase in wheat areas in an effort to meet costs. Yields continued to drop and reached 22 bushels per acre in 1894 and 1895. The outlook for the future was gloomy—wool prices were low, wheat yields and wheat prices were low and the soil was declining rapidly in productivity. There were no other sources of farm income than wheat and wool.

Period 2, 1898-1907 (Line C-D on the graph)

A scientific invention in the form of refrigeration was the major factor drawing New Zealand out of the period of gloom. Refrigeration enabled surplus sheep and fat lambs as well as dairy produce to be shipped to the food consuming countries. Sheep came into their own again. A new system of farming arose out of these changed conditions.

Fat lambs could only be produced on rape and other fattening crops, which were introduced into the cropping rotation together with turnips for wintering the ewes and sown pastures of English grasses and clovers. There was an increasing demand for land by the farm workers from the large stations. The Government introduced the graduated land tax with a view to breaking up the big estates and gradually the land was subdivided into the farms we have today. The first refrigerated cargo of mutton, lamb and butter left Dunedin in 1882. This marks the commencement of a new era but it was several years before the new system of farming, i.e., mixed farming, was widely practiced. It had to wait subdivision of the big runs, fencing, the construction of the water race system and rotation cropping. By the end of the 90's mixed farming was well established and in a few years the yields of wheat increased from 22 bushels per acre to 32 bushels per acre.

Part of this increase in yield is due to the exclusion from wheat growing of sub-marginal land which could now be more profitably used for sheep. The decline in area of wheat from this cause between the 90's and the early years of this Century is in the neighbourhood of 30%. Part of the increase in yield is also due to the better system of farming on the smaller farms, involving the production of forage crops, and sown pasture in rotation with wheat.

Period 3, 1907-1919 (Line E-F on the graph)

In this period of 12 years the yield of wheat shows a decline. The causes of this decline in the productivity of the land is probably the result of a combination of three factors. The first is the rise of dairying based on the export of butter. In 1905 the number of dairy cows in Canterbury was 47,000. In 1920 the number had risen to 88,000. Thus there is an increase of 31,000 dairy cows. This would involve at least 62,000 acres of the heavier land which would be excluded from wheat growing and, therefore, the average yield of wheat would tend to fall. The second factor is an increase of wheat growing on the lighter land to compensate for the loss of the dairying land. By reference to the Area graph it will be observed that the area of wheat increased slightly from 1905, and in view of the rise of dairying the increase is likely to have been made from the lighter land, again assisting the falling tendency. The third factor is probably a recurrence of the declining fertility of the land under the system of rotation cropping and mixed farming. Superphosphate was not widely used, special restorative crops were not grown, disease often decimated yields and varieties had deteriorated in purity and productivity. In effect though mixed farming had stopped the first decline in the productivity of the land "high" farming had not yet been adopted.

Period 4, 1919-1931 (Line G-H on the Graph)

In this period of 12 years the yield again shows a rising tendency. The area in wheat has remained relatively constant and the increase in productivity of the land can be accounted for by the gradual introduction of the results of several scientific investigations applied to wheat growing.

(1) The widespread use of **Superphosphate** following the results of field trials by Lincoln College and the Department of Agriculture. (2) The introduction of **tractor cultivation** allowing earlier and more thorough cultivation of the land.

(3) The introduction of **improved varieties** of wheat. This work was commenced by Lincoln College in 1915 but it was some years before the effects were felt. The first stage was the development of purified varieties of the standard wheats and College Hunters, College Velvet, and College Solid Straw Tuscan were widely grown. Later, cross breeding of wheat was undertaken and the wonderful heading variety, Cross 7, was bred. It gradually gained premier place among New Zealand wheats. The Wheat Research Institute was established to undertake the breeding of new varieties.

(4) The **control of wheat disease.** Prior to this period the smuts and take-all were causing considerable losses each year and the College and the Department of Agriculture made a scientific study of disease control. As a result the smuts have been almost completely controlled by the use of mercury dusts and by hot water treatment. and Take-all has been reduced considerably.

(5) The introduction of the **Certified Seed.** As a means of ensuring a high standard of purity and freedom from disease the Certification Scheme for seed wheat was introduced. This scheme has been responsible for an ex-

tremely high standard of purity and productivity of New Zealand varieties which compares more than favourably with that of other countries. Four organisations are concerned in the operation of the scheme. The Wheat Research Institute produces new cross bred varieties; the Agronomy Division produces nucleus lines of seed; the College produces bulk lots of Pedigree seed for distribution to merchants and farmers, and the Department of Agriculture carries out the field inspection of the crops and supervises the dressing and sealing of the seed.

It will be seen that in this period an intensive series of scientific projects were started and these in combination are suggested as factors responsible for the increase in productivity over the period.

Period 5, 1931-1935 (Line I-J on the Graph)

There is a slight drop in yields over this period of four years and the cause is probably primarily of an economic nature. There was a severe economic depression in Agriculture over the period and in an effort to meet this, the area of wheat increased. This is shown clearly in the Area graph. The increased area would probably be drawn from submarginal land. In addition farmers economised on fertiliser, seed and cultivation. These factors would all tend to reduce yields.

Period 6, 1936-1945 (Line K-L on the Graph)

Here again a rising tendency is apparent. The factors operating here are those which have been discussed in previous rising periods. In addition there is another factor which is likely to be far reaching in its effect and may continue to cause a rise in productivity of the land until our wheat yields are not less than those of the United Kingdom or even those of Holland, which has an average yield of 45 bushels per acre.

The factor concerned here is the use of the **high producing pasture**, heavily limed, regularly top dressed with superphosphate and containing vigorous clover to build up the nitrogen content of the land. The development of the high producing pastures and their incorporation in a rotation system of mixed farming, is the outstanding change in farming in Canterbury since the introduction of refrigeration enabled mixed farming to be practised. The development is partly a result of the high returns obtained from our high quality pasture seeds and has been made possible by the wide-spread use of lime at the rate of one and two tons per acre. This type of pasture is more effective than any other method in building up the fertility of the soil. As a result the productivity of the land has increased and yields of wheat are rising. There is still room for considerable development along these lines and we may expect the yields of wheat to continue to rise. Along with the development of pasture, has been a development in the use of lupins as a green manuring crop and this has also contributed in no small measure, to the rise in yield.

This brings us to a consideration of the **Primary Trend** (Line M-N on the Graph). It will be seen that through all the ups and downs the general tendency in wheat yields is upwards. Thus over the period of 70 years the productivity of our wheat producing land has increased in contrast to that of the great wheat growing countries where the productivity has declined. This is an index of the ability of the farming industry in New Zealand to husband the land as good farming demands and with a continuation and intensification of "high" farming methods the productivity of the land will continue to rise.

We may be called upon to produce more wheat. At present we barely grow 200,000 acres. But the same forces which have wrought changes in the past are still active and if wheat growing is ever more profitable than other systems of farming, a considerable increase could occur. There are at least 3½ million acres of land in New Zealand where wheat could be grown. If one-fifth of this area were grown in wheat each year we could grow up to 700,000 acres. With the large area the yield would probably drop from the present average of over 33 bushels per acre.

[This review of the past has illustrated the effects of various economic and scientific forces on the productivity of the land. At the present time we see that the high producing pasture, fitted into a rotation system of farming, has the power to safeguard the fertility of our wheat growing soils.

In subsequent articles I propose to discuss the establishment and management of high producing pasture, small seed production and certification of small seeds.]

SOIL SURVEY

Dr. M. M. Burns, F.N.Z.I.C., Lecturer Soils and Fertilisers

The diversity of the parent soil materials and of the climate in New Zealand have combined to produce a great many different kinds and qualities of soils. The extent of each kind is very restricted and its distribution is often discontinuous. Because of the diversity of types and because the soil has an important bearing on farming practices it is desirable to map the distribution of each soil type. This mapping is called soil surveying and is undertaken in New Zealand by the Soil Bureau of the Department of Scientific and Industrial Research. This Division has completed the broad survey for the North Island and for most of the South Island, but to date only a few isolated sections have been described fully in publications of which copies are available.

Since the soil maps and reports can be of great value for many class projects this article will deal with the mapping and naming of soils.

Naming Soils

Soils, like people, have names and the practices adopted may be compared. Each soil has three names: a group name, which is used internationally, c.f. race for people; a series name which designates, usually, soils with similar profiles in a specific locality, c.f family name; and finally a type name based on the texture of the topsoil, c.f. christian name.

The group name is applied to soils with similar broad features, e.g., podsols, meadow soils, etc., the series name to soils derived from similar parent materials and with comparable profiles, e.g., Lincoln series and the type name is used to separate the soil members of each family on the basis of texture of their topsoils, e.g., sand, loam, silt loam and clay loams. Thus, a silt loam soil in Lincoln with a seasonally high water table would be called the Lincoln silt loam and would belong to the meadow group of soils. The actual proportions of clay, sand and silt which are used to designate different soil types are given on a separate chart.

Mapping Soils

The steps which are taken in the preparation of a soil survey map may be considered as follows—

1. The preparation of a good base map of the area.
2. The selection of the main series of soils for sampling and for accurate profile description.
3. The mapping of the soils by sampling with an auger.
4. The completion of the final map.

The Base Map

The Surveyor requires a map of a suitable scale which shows the main roads, drainage channels and surface features. This map is usually prepared from Lands and Survey maps, County maps, or Geological Survey maps. These are likely to be replaced by Army maps and properly corrected aerial photographs. After the base map has been obtained it is mounted and folded for field use.

Representative Profiles

The unit for the classification of soils is the profile. The Surveyor, after he has decided by inspection of road cuttings, post holes and shingle pits, on the range of types present in the whole area then exposes a vertical face representative of each series. This is described fully and samples are taken of each layer for chemical and mechanical analysis. From this typical profile the Surveyor obtains a clear picture of each soil series and builds up a good working knowledge of the area and of the main soils in it. He then takes borings with a soil auger* at regular intervals on a compass bearing between two easily identified landmarks. The frequency of the sampling is determined by the accuracy required and the variation of the soil. In good market garden land check boring may be made every chain, while in thin, stony land the interval may be many times greater than this. As each sample is collected from the auger the texture is checked by rubbing it between thumb and finger, and the name of the soil and its texture

*This is usually made from an ordinary $\frac{5}{8}$ inch wood bit on which the cutting shoulders and tip have been ground smooth, welded to a "T" handle about 30 inches long.

are entered on the correct position on the map. The procedure is repeated regularly as the surveyor works back and forth across the area.

When the area has been completed and the transitions between types carefully checked, the map is ready for colouring. Soils of each series are coloured in a main colour such as red, green or blue and the textural types within the series are shown by changes in the intensity of colour or by shading.

Information on Productivity

The soil map alone would not be of much value so, during the mapping, full information is gathered about the fertility status of the soil through the analysis of selected samples and about its actual productivity under different management practices, its suitability for different crops and its response to lime and fertilisers.

The completed soil maps of a district are usually published as supplements to a bulletin in which a full description of each soil type is given together with notes on its use in agriculture.

What Are Soil Maps Used For?

The maps provide valuable information on the actual extent of each type of soil, its characteristics and of its distribution. This information is basic for any plans for development or for subdivision, e.g., irrigation and conservation.

Some soils are known to be ideally suited for the production of certain crops and the extension of these crops or the introduction of new crops is based on the soil maps. Thus, the area of land suitable for the growing of tobacco in Nelson, for the extension of orchards in Hastings and for the possible production of sugar beet in Canterbury is known.

The distribution of soil types is also used extensively in experimental work. All manurial trials which are put down by the Department of Agriculture are grouped so that the results obtained can be measured for each soil type rather than for each district. It will not be long before recommendations for the liming and manuring of crops will be made on the basis of crop and soil type. Indeed, one of the first benefits derived from the Soil Survey was the recognition of the one or two soil types which were responsive to potash fertilisers among the many unresponsive types of the Waipa County.

Sources of Information*

The Soil Bureau has completed the surveys for the North Island and for the most of the South Island, but the publication of maps and reports is behind the field work. The best examples of the bulletins and maps published are those covering Waipa County and Heretaunga.†

Projects

1. Obtain maps of your district:—

(a) County maps,

(b) Lands and Survey Department maps,

(c) Army maps,

(d) Aerial photos,

and from these prepare a suitable base map for field mapping.

2. Select a small area containing two or three different kinds of soil and dig a representative profile of each down to the parent material (or to 36 inches). Describe each horizon of the profile noting texture, colour, insects, roots, presence or absence of concretions (ironstone) or water, compactness, structure. Take samples for mechanical and chemical analysis.

3. Map the distribution of each soil type and then comment on each type with regard to productivity, response to lime and fertilisers, suitability for different crops, pasture plants and weeds, and relate soil type to the kind of farming practised on it.

*Information on soil types in your district may be obtained by writing to the Director, Soil Survey Division, Molesworth Street, Wellington.

†"Soils and Agriculture of part of Waipa County." Bulletin No. 76, Department of Scientific and Industrial Research. Cost 5/-. "Land Utilisation Report of the Heretaunga Plains." Bulletin No. 70, Department of Scientific and Industrial Research. Cost 6/3.

SOIL SURVEY

COMPOSITION OF TEXTURAL TYPES ADOPTED BY SOIL BUREAU

Types: Based on Ignited Fractions

Sands—	
Gravelly sand .	More than 50% coarse sand More than 15% fine gravel
Coarse sand .	More than 50% coarse sand Less than 20% silt and clay
Medium sand .	More than 65% coarse and fine sand Less than 20% silt and clay
Fine sand . .	More than 65% fine sand Less than 20% coarse sand Less than 20% silt and clay
Loams—	
Sandy loam .	More than 20% coarse sand, or more than 55% coarse and fine sands More than 20% and less than 50% silt and clay
Fine sandy loam	More than 25% fine sand More than 20% and less than 50% silt and clay
Loam . .	More than 40% silt and clay Less than 25% silt
Silt loam .	More than 25% silt Less than 25% clay
Clay loam .	More than 50% silt and clay Less than 25% clay
Sandy clay .	More than 50% coarse and fine sands Less than 50% silt and clay, more than 35% clay
Clay . .	More than 50% silt and clay More than 35% clay
Heavy clay .	More than 50% clay
Silts—	
Silt . .	More than 40% silt and clay Less than 5% clay
Sandy silt .	Less than 35% silt and clay Less than 5% clay More than 15% silt More than 50% coarse and fine sands
Coarse sandy silt	More than 35% coarse sand
Fine sandy silt .	More than 50% fine sand
Stony . .	More than 25% stones
Peats—	
Peat . .	More than 70% loss on ignition
(Sandy, loamy, etc.) peat	50%-70% loss on ignition
Peaty (loam, sand, etc.)	35%-50% loss on ignition

GREAT FARMERS

I.

JETHRO TULL

(In response to requests from teachers we will publish a series of articles describing briefly the life and work of some of the pioneer farmers who have contributed so much to the modern knowledge and practice of agriculture. This article is summarised from "English Farming—Past and Present," by Lord Ernle.—Editor.)

Born 1674, died 1740. Scholar, musician, traveller, lawyer. In 1699 he settled on a farm at Howberry, near Wallingford. (This farm is now one of the most highly cultivated pieces of land in the world.) In 1709 he moved to the borders of Berkshire and Wiltshire. At Howberry he invented the drill. He found himself at the mercy of his own farm hands. . . from his experience he verified the truth of the saying:—

"He who by the plough would thrive
Must either hold himself or drive."

By observation and experiment he learned the differences between good and bad seed as well as the advantages of care in selection, cleaning and change of seed. He proved that a thin sowing produced the thickest crop and discovered the exact depth at which the seed throve. (The above refers to sainfoin with which he wished to plant his whole farm.) "So I caused channels to be made and sowed a small proportion of a seed covered exactly." This was a great success. But it was also an innovation. His labourers struck in a body. Tull refused to be beaten. He set his inventive faculty to work to contrive an engine to plant sainfoin more faithfully than hands would do. He got the idea from the organ. The groove, tongue, and spring of the sounding board suggested the idea of delivering the seed through notched barrels. He tied brush harrows behind to cover the seed. His many mechanical achievements were less valuable than the reasons which he gave for their employment. His implements were speedily superseded; his principles of agriculture remain.

During his foreign travels he was struck by the cultivation of the vine yards in France. There were frequent ploughings till the grapes were ripe. He argued that with farm crops tillage was equally necessary. Once crops were sown nature began to undo the effect of previous cultivations. The earth consolidated and so shut out air and water from the roots. Food supply decreased at the moment when growing plants needed increased nourishment. The use of farmyard manure kept the land friable to a certain extent but also stimulated weed growth. Cultivation would make the land friable and kill weeds. He tried wheat and turnips sown in rows and intercultivated. The wheat was too slow to mature and was affected by blight, but for turnips the method was admirable. He also found that "Drill husbandry" was a substitute not only for fallows but also for farmyard manure which was dreaded as a weed carrier. Without fallows or manure he grew on the same land by constant tillage for thirteen years in succession heavier crops from one-third the quantity of seed than were grown by his neighbours following the accepted routine. By this discovery he anticipated one of the most startling discoveries of the Rothamsted experiments.

The chief legacies which Tull left were clean farming, economy in seeding, drilling the seed, and the maxim that "the more the irons were among the roots the better for the crops." It was along these lines that agriculture slowly advanced. It was a long while before the value of experiments could be impressed on the open field farmers, who sowed their seed broadcast, thickly, and at varying depths.

Due largely to Tull's work agriculture became a fashion in society. Tull's system was discussed at Court and explained to George the Second. Queen Caroline subscribed to the publication of "Horse Hoeing Husbandry." Pope loved "to play the philosopher among the cabbages and the turnips." Walpole opened the letters of his farm manager before he broke the seal of correspondence on State affairs. Bolingbroke read Swift's letters with eyes uplifted to Heaven, not in admiration for the author, but in fear of rain. The main principles which Tull laid down in "Horse Hoeing Husbandry" proved to be the principles on which were based a revolution in agricultural work. The greatest individual improver which agriculture had ever known be sought to discover the reasons which would explain observed results of any particular practice. He was thus led to strike out for himself new and independent lines of investigation. Chemistry of plant life was in its infancy, the science of vegetable physiology was almost an untrodden field of knowledge. By minute observation of nature and stubborn tenacity of purpose Tull advanced far. He lived in a solitary farm house remote from such scientific aid as the age afforded or from friends in whom he could confide. His microscope was feeble, his appliances were self made, and his experiments were thought out for himself. His labourers tried his patience beyond endurance. Ill health and misfortune made him irritable. His book was venomously criticised and shamelessly plagiarised. Yet he never lost confidence that "My practice will one day become the general husbandry of England."

"Writing and ploughing are two different talents; and he that writes well must have spent in his study that time which is necessary to be spent in the fields by him who will be master of the art of cultivating them."