WHEAT IN GREAT BRITAIN

by

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WITH EIGHTY ILLUSTRATIONS

Second Edition

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To
SYDNEY PENNINGTON
Late Professor of Agriculture in the University of Reading
In memory of a friendship of twenty-five years.

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CONTENTS

Part I

Part II

LIST OF ILLUSTRATIONS

PREFACE TO THE FIRST EDITION

In the first part of the volume offered here, an attempt is made to present an account of wheat-growing in Great Britain from the earliest times to the present day.

The climate suited to wheat, and the cultivation and yield of the crop, as well as its distribution throughout the country are discussed; reference is also made in succeeding chapters to the principles of classification and differentiation of varieties, and to the mode of origin and improvement of cultivated varieties of wheat.

About two hundred and fifty samples of wheats grown under different names in various districts were obtained through the kind assistance of millers, farmers, seedsmen and others; these have been grown and studied during the last ten years. Many of them sold under different names were found to be alike, but about fifty kinds were discovered which proved to be distinct, and in Part II descriptions and illustrations of these are given.

It is hoped that the volume may be of general interest to agriculturalists and others, and be useful to future generations as a permanent record of the kinds of wheat cultivated in Great Britain at the present day.

I have pleasure in acknowledging the courtesy and assistance of the staff of the Library of the Ministry of Agriculture and Fisheries. My thanks are also due to the following, for specimens of ancient British cereal grains: Mr. Reginald W. Brown, Miss Lilian Blaney, Dr. Graham Callander, Mr. Norman Cook, Mr. St. George Gray, Miss D. M. Liddell, Captain Pitt-Rivers, Mr. W. H. S. Roberts, and Mr. T. Sheppard.

John Percival.

PREFACE TO THE SECOND EDITION

In this edition emendations and additions to the text have been made, together with descriptions and illustrations of a number of new and important varieties of wheat which have been produced by plant-breeders in this and other countries. The majority of these are very welcome accessions to our autumn wheats usually sown in September, October and November, and have a growing period of nine to eleven months. After germination, the young plants remain more or less dormant during the coldest part of winter, but grow rapidly in spring and ripen their grain ready for harvest at the end of July and first half of August. On account of their long growing period, autumn wheats yield proportionally large crops of grain, which, although of moderate or poor quality from the baker's point of view, are nevertheless highly remunerative to the farmer.

Typical spring wheats are sown in February, March and April, and usually have a growing-period of five or six months. The few spring wheats hitherto available in Great Britain have been of little importance because of their low, uneconomic return of grain. The new spring varieties recently introduced into this country are of a very different class, and demand the especial attention of the farmer, miller, and baker. Several have given remarkable yields of grain of superior bread-baking quality, and in some cases, on good well-cultivated land, more than 48 bushels per acre have been secured from seed sown as late as the middle of March. For such results, clean land, adequately manured, and special care in the preparation of a crumbly tilth of the soil for the reception of the seed are essential, the latter condition of much less importance in the management of autumn wheats.

It gives me much pleasure to acknowledge the courtesy of the Minister of Agriculture and Fisheries for the figures relating to the area under wheat cultivation, and the yield per acre of wheat in Great Britain since 1933, and to the Board of Trade for the statistics of the imports and exports of grain and flour during the same period.

I also offer thanks to Dr. T. Moran, Director of the Cereals Research Station, St. Albans, for help in answer to many queries.

For authentic ears and grain of the new varieties of wheat, and details of their origin, I am indebted to Professor Sir Frank Engledow, of the National Institute of Agricultural Botany, Cambridge, and to plant-breeders in this and other countries, not forgetting the praise that is due to the seedsmen for their part in the maintenance of the high standard of purity and uniform grade of seed so essential to the maximum yield of grain needed by the nation in these austere days.

1948. JOHN PERCIVAL.

PART I

CHAPTER I

ANCIENT BRITISH WHEAT

The first cultivators of the land of Britain were Neolithic or New Stone Age immigrants from the continent of Europe, who came here before 2000 B.C., bringing with them domesticated cattle, sheep and pigs, as well as wheat. At that early period dense impenetrable forests and undrained swamps and marshes covered much of the country, the only open ground being found on the hills and chalk downs along which the wanderers made their way towards Wiltshire, Somerset, Gloucestershire, Dorset and other western counties.

The weapons and tools of these early British farmers were made of flint, bone or wood, and as the felling of trees and clearing of woods were beyond their powers, the sites chosen for settlement were usually on the bare hill tops. Small patches of the open grass land were broken up and cultivated with primitive picks and digging implements, made from the antlers of the red deer, or possibly from the crooked branches of trees, each patch, usually rectangular, being cultivated and cropped annually until the soil was exhausted, when it was abandoned and cultivation begun upon a new patch. This primitive method of growing crops of cereals annually on the same land until the return from it is little more than the seed sown, was continued in many remote districts of Scotland and the North of England down to the end of the eighteenth century or later.

In Neolithic times the cereal crop was reaped with sickles made of flint, and after thrashing the grain was frequently stored in small underground pits.

Among the British Neolithic sites which have been investigated, may be mentioned the classic Windmill Hill, near Avebury in Wiltshire, and Hembury Fort in Devon, both of which have yielded numerous querns or small hand stone mills for grinding corn.

At Hembury a few grains of wheat were obtained in 1931, and in the following year a larger quantity was found, mostly in cooking pits which were definitely of Neolithic age; these are the first authentic cereal grains dating from this period which have been discovered in Britain.

Although it is not possible to determine with certainty the kind of wheat grown at this early date from an examination of the grains alone, without portions of the ears or spikelets of the plant, nevertheless, the form and structure of the Hembury grains are suggestive of a primitive type belonging, or nearly allied, to the Bread Wheat Race (*Triticum vulgare*) (Figs. 1, 2, *a*, *b*).

These and all other prehistoric grains, found either loose in the ground or stored in special vessels or pits, are always carbonised; the individual grains, which retain their characteristic shape, as well as some of the finer structural details, are dead and black, consisting of carbon or charcoal. Sometimes such carbonised grains are inaccurately described as charred or burnt, their appearance suggesting the action of fire; the change from normal, recently harvested grains to the carbonised state is, however, a natural process which takes place at ordinary temperatures. The coat and floury interior of ordinary living grains of wheat consist chiefly of cellulose and starch, two carbohydrate compounds of carbon united with the elements of water; they are unstable substances which, under certain conditions, become slowly dehydrated, losing the elements of water and leaving the carbon behind.

As already indicated, the change proceeds at ordinary temperatures; it requires long periods of time for completion, and is doubtless influenced by the action of weak acids, and other substances in the soil or air, but the nature and mode of action of these agents are obscure.

Towards the end of the Neolithic Age, about 2000–1800 B.C., immigrants belonging to a different race began to arrive, and during the long period extending from about 1800–500 B.C. successive waves of new types of invaders entered our eastern and southern counties from the continent. All these newcomers were familiar with bronze, and many of their weapons and implements were made of this metal, although during several centuries after their first appearance here they

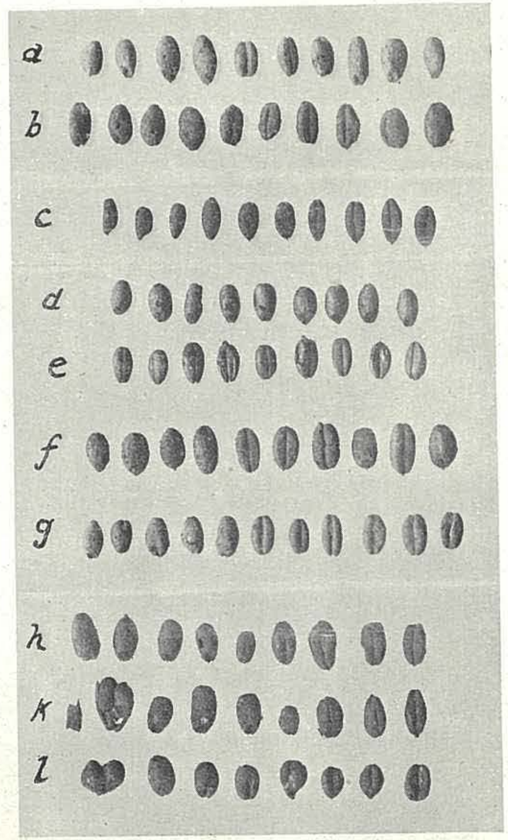

Fig. 1. ANCIENT BRITISH WHEATS. (Nat. size.)
a, *b*—Hembury Fort, Devon. (Neolithic.)
c—Culbin Sands, Scotland. (Bronze Age.)
d, *e*—Hunsbury Camp, Northampton. (Late Celtic.)
f—Little Solisbury, Bath. (Late Iron Age.)
g—Castle Cary, Scotland. (Roman, about A.D. 100–200.)
h—Woodcut, Cranbourne Chase, Dorset. (Romano-British.)
k, *l*.—Iwerne, Dorset. (Romano-British.)

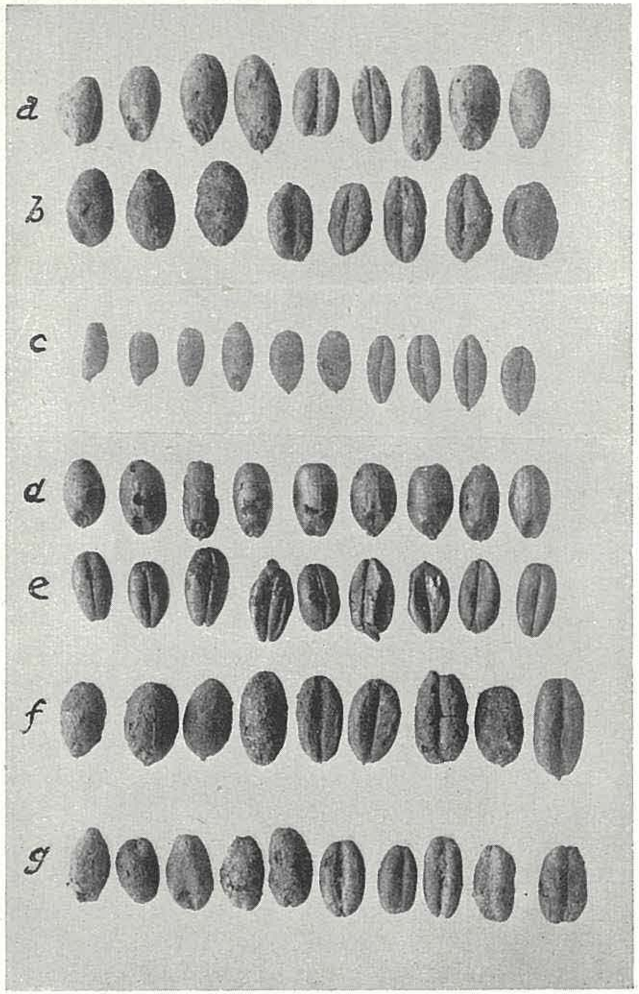

Fig. 2. ANCIENT BRITISH WHEATS.
a-g of Fig. 1 (× 2).

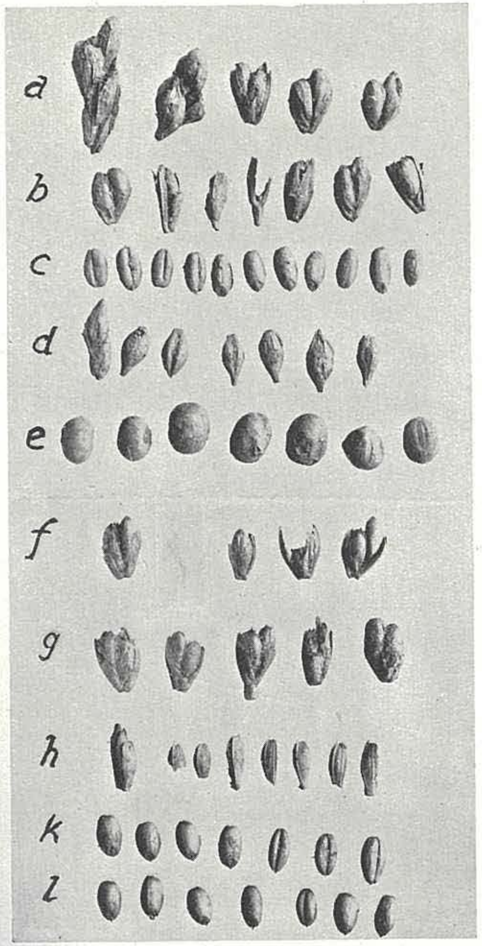

Fig. 3. ANCIENT BRITISH GRAIN. (Nat. size.)
a-e—From Meare Lake Dwelling, Somerset. (150 B.C.–A.D. 50.)
a, b, c—Wheat.
d—Barley.
e—Small Celtic Bean.
f-l—Wheat from Corfe Mullen, Dorset.

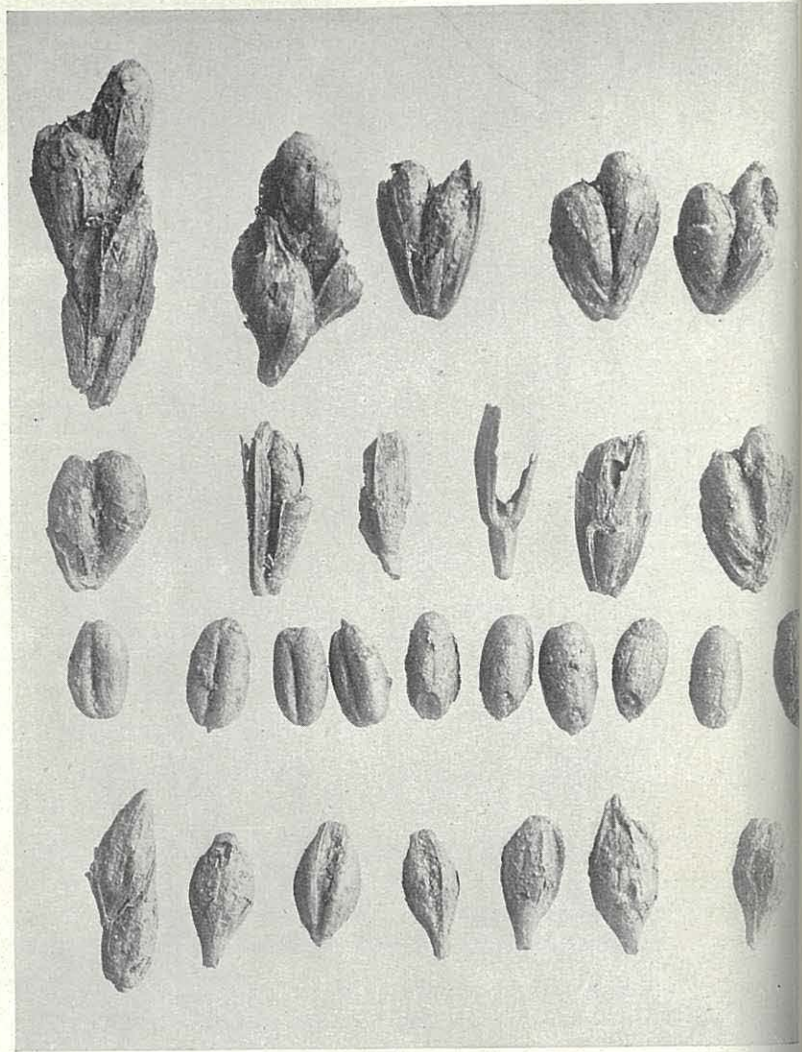

Fig. 4. WHEAT AND BARLEY FROM MEARE LAKE DWELLING, SOMERSET.
a-d of Fig. 3 (× 2½).

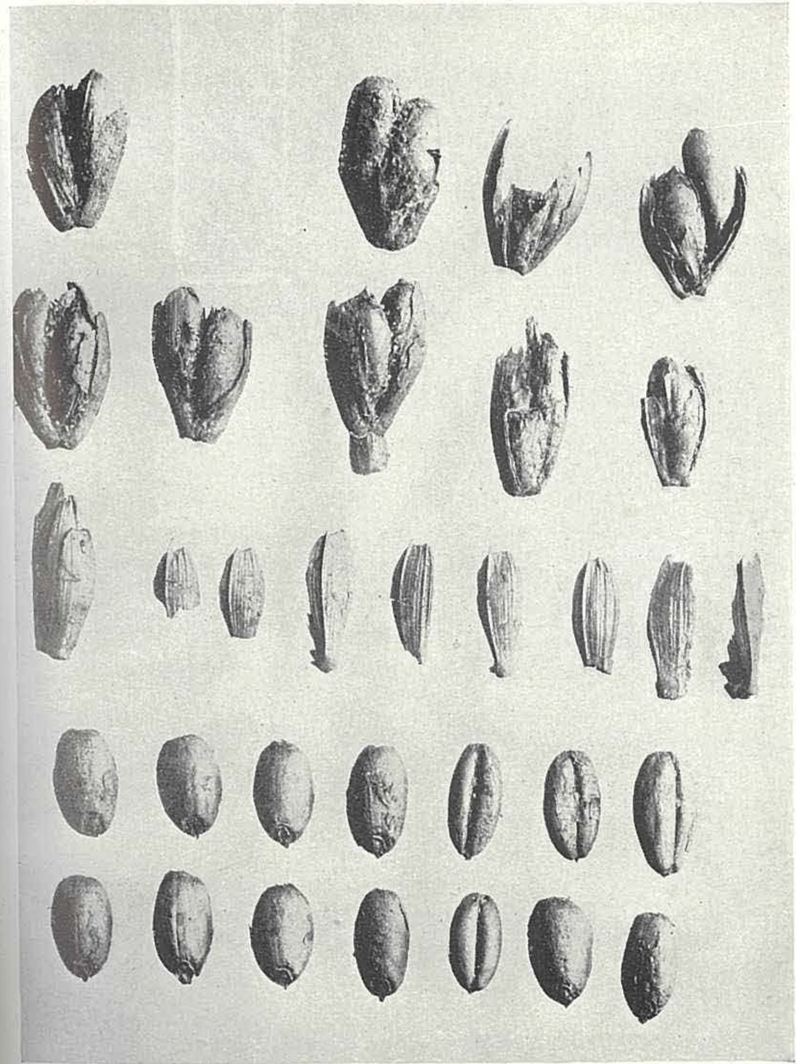

Fig. 5. WHEAT FROM CORFE MULLEN, DORSET.
f-l of Fig. 3 (× 2).

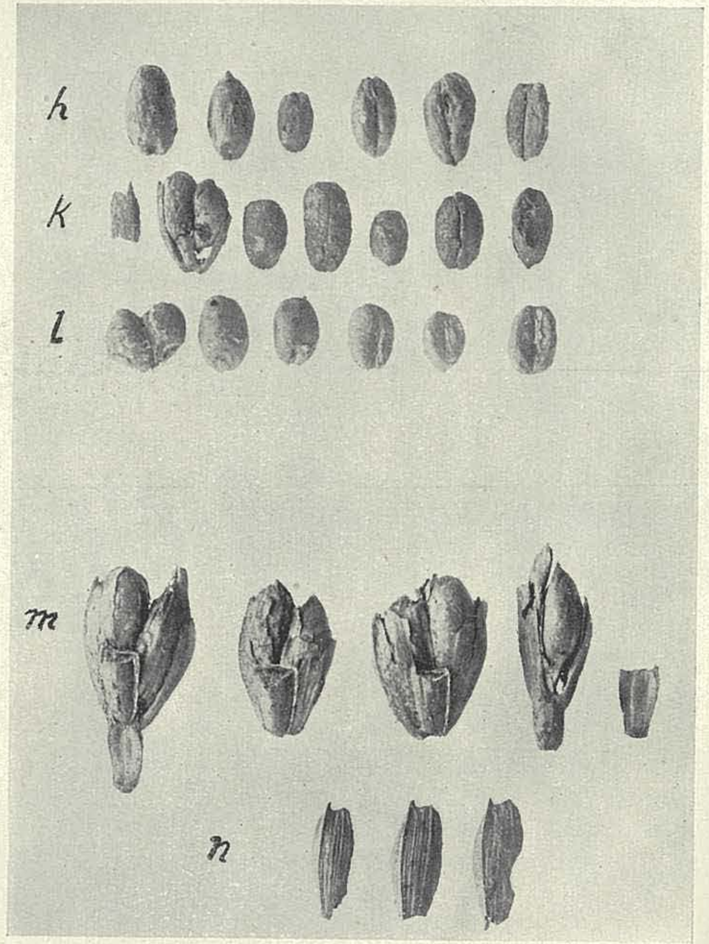

Fig. 6. ANCIENT BRITISH WHEATS.
h-l of Fig. 1 (× 2).
m, n—From Corfe Mullen, Dorset (× 2).

continued to manufacture and use implements of flint. They ultimately spread throughout the country and relics of the Bronze Age have been discovered in abundance over wide areas in England, as well as in many parts of Wales and Scotland.

The Bronze Age farmers were more highly skilled than their predecessors, and like the latter sought open land on hills and downs wherever pasturage for their stock and land suited to the cultivation of cereals could be obtained. Competition for eligible sites began, and many of the old Neolothic inhabitants were compelled to seek refuge on other unoccupied areas, especially in the west and north of England, or became mixed and absorbed in the new race.

Crops of wheat were grown, and bronze sickles, stone querns for grinding of grain, and other farm implements belonging to this period, have been discovered in many districts throughout Britain.

Two carbonised grains, narrow and pointed and similar in outline to those of Emmer Wheat (*Triticum dicoccum*), were found pressed into the sides of a food vessel taken from an Early Bronze Age barrow at Hanging Grimston on the Yorkshire Wolds; two impressions of grains of wheat, one of the dorsal, the other of the ventral furrow side, were also found on the base of a cinerary urn of this period (about 1800 B.C.) discovered near Leuchars in Scotland. It is possible that the peculiar association of two grains on each vessel, and especially the impress of the features of the two sides of the grain in the latter instance, may be connected with a sex or fertility rite among these early people.

Wheat grains attributed to the Bronze Age were found at Culbin Sands, in Morayshire, Scotland (Figs. 1, 2, *c*). These are smaller than any other British prehistoric samples, and in outline are suggestive of a primitive form of Bread Wheat (*Triticum vulgare*).

Immigration from the continent into Britain continued throughout the Bronze Age, and from about 500 B.C., or possibly a little earlier, a race of people in a more advanced stage of civilisation, with weapons and implements of iron, landed on our shores and continued to arrive down to the invasion of the Romans under Julius Cæsar.

Possessed of superior knowledge of agriculture, and with plough, harrows and other tools, in the construction of which iron was employed, they were able to cultivate the land more efficiently than their predecessors; in addition, they grew not only wheat, but barley and beans, and in some districts seem to have been acquainted with oats. Some of them established themselves in camps and settlements upon hills and downs, where outlines of their fields may still be traced; others built their houses on piles along the margins of lakes or on artificial island mounds.

Settlements belonging to an early period of the Iron Age have been excavated at Worlebury Camp in Somerset, where barley, beans and wheat were recovered; at Hunsbury in Northamptonshire and at Little Solisbury Camp near Bath, grains which I attribute to Bread Wheat were obtained (Figs. 1, 2, *d*, *e*).

From an Early Iron Age settlement at Fifield Bavant in Wiltshire, wheat, referred to Emmer (*Triticum dicoccum*) by Sir Rowland Biffen, was discovered, as well as Barley and oats.

At Meare Lake Village in Somerset, a later Iron Age settlement dating from about 150 B.C., large quantities of wheat, barley and beans were found. The wheat is a primitive type, each spikelet having only two grains, as in Emmer and Spelt Wheat (*Triticum Spelta*). The mode of fracture of the axis of the ear, the form and width of its internodes, and the broad-shouldered empty glumes are like those of *T. Spelta*, but in shape the grain resembles that of Bread Wheat (*T. vulgare*), having a blunt apex, convex dorsal side without hump, and rounded cheeks to the furrow on the ventral side; I consider it to be a primitive form of the Bread Wheat Race little removed from *T. Spelta* (Figs. 3, 4, *a-c*). The barley was chiefly of the kind known as Bere (*Hordeum vulgare*) (Figs. 3. 4, *d*); the oats, of which many naked grains or caryopses were present, appear to be the Bristle-pointed (*Avena strigosa*), or the Short Oat (*A. brevis*); the beans were the so-called Celtic Bean (*Vicia Faba*, form *celtica*), about the size of a pea, the common sort widely grown by Bronze Age and Neolithic peoples in Central Europe (Fig. 3, *e*).

The crops grown by the Glastonbury Lake-villagers were similar to those at the Meare Lake Village, and a hoard of wheat of uncertain age dug from an ancient underground pit at Corfe Mullen in Dorset in 1926 was of the same primitive type of Bread Wheat as that found at Meare (Figs. 3, 5, *f-l* of Fig. 3 (x2); Fig. 6, *h-l* of Fig. 1 (x2)).

As already mentioned, our knowledge of the kinds of cereals which were grown in prehistoric days in Britain is necessarily based upon the examination of carbonised material unearthed by archæologists, but in later times references to the cultivation of corn in this country occur in classical literature.

Pytheas, a traveller from a Greek trading colony settled at Marseilles who visited Britain in the Early Iron Age (330 B.C.), says that wheat was abundant in the south-eastern parts of the country, and observes that thrashing was carried on under cover in great barns.

At the first Roman invasion (55 B.C.) Julius Cæsar obtained supplies of uncut corn in Kent and Ammianus Marcellinus and Zosimus mention large exports of grain from Britain about A.D. 360, for the use of Roman troops in the Rhineland.

Grains of wheat, often accompanied by barley and oats, have been found on many Romano-British and Roman sites, as at Cranbourne Chase, Silchester, Richborough, Castle Cary and many other settlements throughout the country; I have examined specimens of most of these grains and attribute all of them to forms of Bread Wheat (Figs. 1, 2, *f*, *g*; Fig. 6).

During the more or less settled times of the third and fourth centuries of the Roman occupation, agriculture was greatly extended in the lowland half of the country, roughly east of a line from Durham to the eastern boundary of Devon. But after the departure of the Romans at the beginning of the fifth century, Britain became a land of strife and disorder due to the invasion of Picts, Angles, Saxons, Danes and other enemies, and the native population was engaged in almost continuous warfare for centuries. It can hardly be doubted that under such conditions, agriculture suffered greatly, and much of the land which was cultivated during the Roman occupation became derelict.

The Celtic peasant probably pursued the old system of cultivation to which he was accustomed, but the Saxon invaders introduced the open-field plan of cereal cultivation in parellel strips, a practice which lasted for more than a thousand years, and in many districts was continued to the beginning of the nineteenth century.

There are literary allusions to the growth of wheat, barley and oats in Britain during the dark ages before the Norman Conquest, and there is no doubt that rye, a much less ancient cereal than wheat or barley, was first brought here by the Angles, Saxons or Jutes, for, with barley, it was the common bread corn in North Germany and the adjacent territory in the first century A.D. In a law of Wihtraed of Kent (A.D. 695–6) August was named Rugern, the month of the rye harvest.

Although Saxon cemeteries are common here and many have been investigated, very few of their habitation sites are known, and so far as I am aware no specimens of grain dating from this period have been found.

CHAPTER II

BREAD

As observed in the previous chapter the Neolithic and Bronze Age settlers here grew small patches of wheat and barley, and in the Iron Age beans were also cultivated, as well as a primitive sort of oat. These were the food crops grown at the time of the Norman Conquest, in addition to rye, which was doubtless introduced by the Anglo-Saxons from their continental home, where it was a common bread cereal. Although bread made from rye, barley, oats and beans was in use from early days in this country, wheaten bread was preferred by all classes whenever it was available, and up to and during the Roman occupation of the country wheat appears to have been the chief bread corn.

Next to wheat, rye makes the most palatable bread, and for many centuries after its introduction, bread made from this cereal was extensively eaten. Rye and wheat were frequently mixed in varying proportions and ground to give "maslin" flour, the terms miscelin, maslin, and mestlen being also applied in some parts to the mixed crop of the two cereals, which were sown together.

Certain districts are more suited to the growth of one cereal than another, and in later times this fact led to the use of wheat, barley, rye or oats as the bread corn of particular localities, a state of affairs which prevailed in many country places down to the end of the eighteenth century.

In 1586 Harrison observes that "The bread throughout the land is made of such graine as the soile yeeldeth, neverthelesse the gentilitie commonlie provide themselves sufficientlie of wheat for their owne tables, whilest their household and poore neighbours in some shires are inforced to content themselves with rie, or barlie, yea and in time of dearth manie with bread made either of beans, peason, or otes, or of altogither, and some acornes among, of which scourge the poorest doe soonest tast, sith they are least able to provide themselves of better." He goes on to say that "the price of corne of late years has been so high that the artificer and poore labouring man is not able to reach unto it, but is driven to content himself with horsse-corne, I meane, beanes, peason, otes, tares, and lintels; and therefore it is a true proverbe and never so well verified as now, that hunger setteth his first foot into the horsse manger. If the world last a while after this rate, wheate and rie will be no graine for poore men to feed on, and some caterpillers there are that can saie so much alreadie."

In the last quarter of the seventeenth and first half of the eighteenth century there was a great increase in the amount of wheat grown, and a corresponding increase in the number of those who could afford bread made from this cereal. From the table below, given by Charles Smith in 1758, it is estimated that of the 6 million inhabitants of England and Wales, 62 per cent., or about 3⅝ millions, ate bread made from wheat, the rest using rye, barley or oats as bread corn.

	Number of inhabitants who eat			
	Wheat	*Rye*	*Barley*	*Oats*
In the counties of M'sex, Essex, Kent, Surrey, Sussex, Hants, Berks, Bucks, Herts, Bedford, Cambs, Hunts, Suffolk and Norfolk . . .	1,866,405	185,976	36,741	—
In Wilts, Somerset, Devon, Dorset, and Cornwall .	628,815	—	221,319	—
In Monm'th, Glos., Oxford, Hereford, Worcester, Warwick, Northants, Shropshire, Stafford, Leicester and Rutland .	691,258	156,237	159,236	17,845
In Chester, Derby, Notts, Lincoln, and Lancaster .	200,339	118,795	128,621	290,395
In Yorks, Westmd., Durham, Cumbd., and Northumberland . .	283,996	285,382	37,196	285,986
In North and South Wales	29,344	113,521	127,585	—

Thus, about 3,750,000 ate wheat
880,000 ate rye
739,000 ate barley
623,000 ate oats

Similar diversity in the kind of cereal used for bread in different parts of the country persisted up to the beginning of the nineteenth century. According to the Agricultural Surveys of the counties of Great Britain compiled at the end of the eighteenth and beginning of the nineteenth century, oatmeal and oatcake were almost the only cereal food of the people throughout Scotland, as well as Cumberland, Westmorland, Lancashire, Derbyshire and parts of Yorkshire. In Northumberland, Durham, and many districts of the North Riding of Yorkshire, bread made from rye and maslin continued to be generally used up to about 1810 or later.

In many parts of Wales, oats were also the common bread cereal, with a small proportion of rye and barley, and barley bread was everywhere used in the Isle of Man at that date.

In the southern counties of England bread made from wheat was in common use in the eighteenth century, Gilbert White remarking that plenty of good wheaten bread was eaten by all ranks of people in 1778.

The demand for wheaten bread by the less opulent classes began in towns; with a rise of a few shillings per week in the wages of the town artisan in the industrial centres of the north of England, rye bread was discarded for wheat. In London, even as early as the seventeenth century, the inhabitants generally ate wheaten bread, and in 1616 the grocers of the city, who provided corn for the poor, complained that the paupers refused barley or rye bread, although there was a scarcity of wheat in the winter of that year.

The change over from rye, oats and barley to wheat as the chief or only bread corn had become complete throughout the country about 1825–30 or earlier, and from this date to the present time the use of wheaten flour for bread making has become universal here.

The nature or character of the bread has, however, undergone considerable changes in modern times which are the result of a change in the process of milling and the public taste and demands.

As early as the eleventh or twelfth centuries several kinds of bread were made which varied in quality and appearance. There was the brown bread made from the whole meal obtained by grinding the wheat grain between millstones, and described in early times as household bread.

A refined white flour prepared by sifting out all the bran from whole meal was a luxury article used in the Middle Ages for biscuits, sugar cakes and other kinds of fancy bread, as well as for wastel or manchet, a white bread only found on the tables of the rich, or at feasts and banquets.

Between the fine white bread made of flour from which all bran had been removed, and the whole-meal, household bread containing all the bran, there was wheaten bread, the statute bread in common use in the sixteenth century, made from wholemeal out of which the coarse, large flakes of horse bran had been sifted.

Various grades or kinds of bread equivalents of those mentioned, made from stone-ground flour, were in daily use down to about 1880, when the process of grinding between steel rollers was introduced.

This is not the place to enlarge upon the new method of milling; it is sufficient to say that although it has enabled the miller to make a whiter flour containing less bran, it may be doubted whether the product is an improvement on the old stone-milled flour.

Some of the whiteness of modern flour is produced by the action of bleaching agents, such as chlorine, nitrogen peroxide, benzoyl peroxide, and "Agene" (nitrogen trichloride), which destroy the carotin, the important natural colouring matter of the flour. The miller and baker also frequently add to the grain and flour certain chemical compounds, chiefly acid calcium phosphate and ammonium persulphate, their so-called "improvers," with the object of amending the milling and baking qualities of the flour.

In some countries bleaching of flour is not permitted, and in my opinion, a purely personal judgment, it would be in the interest of public health if this and some of the other practices mentioned were prohibited. However, I think that the miller may be fairly exonerated from blame in the matter, for it is the public demand for a white and still whiter flour and bread over a long period of time, that has made the practices almost inevitable necessities, if the miller is to remain in business.

CHAPTER III

CLIMATE, CULTIVATION, SOWING AND YIELD

It is the common experience of all who are practically concerned with agriculture that the growth of their crops is dependent upon a very large number of factors; some of these, such as the temperature, rainfall and amount of sunshine of the district in which the crops are grown, are beyond the powers of the farmer to command, while others, such as the cultivation and manuring of the land, the sowing of the seed, the variety of the plant grown, and the general management of the crop during its growth and at harvest, are within his control.

The chief factors which influence the wheat crop in this country are discussed in the present chapter.

CLIMATE

Temperature and rainfall have a marked effect upon the wheat plant; both severe frost and heavy rain are detrimental to the crop.

There are important differences among wheats in regard to their resistance to low temperatures; some varieties withstand a considerable degree of frost, but those grown in this country are destroyed by the cold of continental winters. Although expansion and upheaval of the soil through frost are liable to lift the young plants out of the ground, the temperature here is rarely so low as to do any damage, unless accompanied by wind and the ground is without a protective cover of snow.

The most satisfactory crops are harvested in those districts in which the mean winter temperature is comparatively high, and the annual rainfall between 20 and 30 inches. It is, however, the particular distribution of the rainfall during the growing season, rather than the total quantity that is of such importance. Considerable amounts falling in the early summer, when the tillers or shoots are pushing into ear, are beneficial. On the other hand, heavy rains in autumn and winter are disastrous, for root development and the tillering process are greatly retarded or entirely checked in water-logged soil; the young plants are seriously weakened and the final yield greatly reduced.

The importance of rainful is clearly shown in the returns from the Rothamsted wheat plots:

	Average of ten wettest winters	*Average of ten driest winters*
	Inches	*Inches*
Rainfall (November-February inclusive)	13·01	5·79
	Bushels	*Bushels*
Average yield per acre of plots 6, 7, and 8	26·2	34·9

The extraordinary effect of rainfall and climatic conditions is also very clearly revealed in the yields obtained on the Rothamsted wheat plots in 1863 and 1879 respectively, the best and worst seasons experienced during last century.

YIELD OF GRAIN PER ACRE

Plot	*Manures*	*Best season* (1863) *Bushels*	*Worst season* (1879) *Bushels*	*Difference* *Bushels*	*Average 61 years* (1852-1912) *Bushels*
3	No manures	17¼	4¾	12½	12·6
2	Farmyard manure . .	44	16	28	35·2
5	Mixed mineral manures .	19⅝	5⅝	14	14·5
6	Do. + NH_4 salts (43 lb. N.)	39⅝	10½	29⅛	23·2
7	Do. + NH_4 salts (86 lb. N.)	53⅝	16¼	37⅝	32·1
8	Do. + NH_4 salts (129 lb. N.)	55¾	20⅝	35⅛	36·6
9	Do. + nitrate of soda (86 lb. N.)	55⅝	22	33⅝	—

MONTHLY TOTALS OF RAINFALL

	1862	1878
	Inches	*Inches*
October	4·05	2·99
November . . .	1·37	4·54
December . . .	1·75	1·60
	1863	**1879**
	Inches	*Inches*
January	3·99	2·85
February	0·74	3·80
March	0·91	1·18
April	0·97	2·79
May	1·00	3·48
June	4·61	5·55
July	0·71	4·24
August	2·86	6·56

In the season 1862–3 the winter was very mild and February, March and April were dry months, but during the growing period in May and June there was abundant rain, after which the weather was warm, dry and bright up to harvest; the total rainfall from October to the end of July was about 20 inches.

The disastrous harvest of 1879 was preceded by exceptionally wet and sunless weather; more than 15 inches of rain fell between October and the end of February, and from October to the end of July the rainfall was 33 inches, rain falling on 65 of the 92 days of May, June and July; August, the harvest month, was also excessively wet.

SOILS

Wheat is a very accommodating plant so far as soil is concerned, provided that the climate and other conditions are favourable.

Its growth is not satisfactory on loose sands or peaty soils, but it can be successfully cultivated on light land if adequately manured, and in former times, when the price of wheat frequently rose to a very high figure, soils of this nature often carried remunerative crops. The best yields, however, are obtained on soils containing a considerable amount of clay, and it is on these that the greatest amount of wheat is grown at the present day in Great Britain.

CULTIVATION

In remote parts of Canada and other virgin wheat-growing regions, settlers often break up the land and take a crop from it annually for two, three, or more consecutive seasons, after which the ground is allowed to lie fallow for a year or longer before the process is repeated. In prehistoric times, cultivation and cropping similar to this was practised by the earliest agriculturalists in Britain. Open grassy hill tops were usually selected for settlement by single families or small groups, and portions of the ground were broken up and sown with corn and beans. After being cropped for two or three years, by the end of which time the ground became exhausted or covered with weeds, it was abandoned and a new patch was chosen for cultivation. Later, it was discovered that land previously worn out by cropping, if allowed to lie waste for a number of years, recovered so much of its fertility that it could be successfully cropped as before.

Ultimately, village settlements were established, and the agriculture connected with them was confined to fixed areas on which a well-defined system of cultivation and cropping was pursued. At first the cultivated land was divided into two fields, each of which was cropped and fallowed for a year alternately. Later, the three field system became the common practice, and was continued from Norman or earlier times down to the end of the eighteenth century, and in many localities into the nineteenth century. Each field was cropped alternately in the following manner:

	On heavy soils	*On light soils*
First year.	Wheat.	Wheat.
Second year.	Beans or peas sown in spring.	Oats or barley sown in spring.
Third year.	Fallow.	Fallow.

Sometimes more than two crops of the same or different kinds were taken in succession before the fallow, as in the sixteenth century example given by Tusser, namely: Barley, peas, wheat, fallow; but, sooner or later, the land became so full of weeds that a cleaning process was necessary before another crop could be raised.

During the fallow year the ground was subjected to repeated ploughing and harrowing, from the harvest of the last crop to the autumn of the following year, when wheat was again sown. In the ordinary course, the land was ploughed

and harrowed four, five, six or even more times, and two different opinions were entertained in regard to the date when the first ploughing should be given. The most common practice on stiff clays was to plough first in autumn, in order to secure the ameliorating effect of the frosts of winter; others, anxious to obtain winter pasturage for sheep on the stubble, deferred the first ploughing to spring or early summer.

On the heavy wheat soils of many parts of the Midlands, the order and time of the several ploughings were: First ploughing in autumn; the second in March, and the land harrowed in order to encourage the germination and growth of annual weeds; the third in early May, when the seedling weeds were destroyed, followed by the harrow to extract the couch and other perennial weeds, which were collected and removed, or burnt; the fourth ploughing in June or July, after the application of farmyard dung, where manure was needed; and lastly, at the beginning of September or October, at which time the grain was immediately sown and harrowed in. In other districts, especially where the soils were of a lighter nature, three ploughings in the fallow year were considered sufficient to clean the land.

In spite of the obvious defects of a system of management which resulted in the loss of a crop every third season, and the expense of the cultivations which a bare fallow entailed, it was deemed absolutely unavoidable, since no method was known by which land could be kept clean without it, particularly where the soil was heavy. Moreover, a fallow was not only considered merely a means of freeing the land from weeds, but to the mediæval, metaphysical mind it was regarded as equally vital for the purpose of giving the land a just "rest" from the weariness of continuous cropping.

On the decay of the open-field system and the enclosure of the arable land, enterprising tenants and land-lords were given the freedom to initiate and carry out trials of new methods of cultivation and cropping. The introduction in the seventeenth century of the turnip as a farm crop, led to modification of the common views regarding the meaning and need of bare fallow, for it was soon discovered that on light land, at any rate, a useful crop of turnips could be grown between the autumn of one year and that of the next, and at the same time the land could be largely freed from weeds by horse or hand hoeing during the growth of the crop; similarly, rape and other green crops were utilised later in the same manner on somewhat stiffer soils, where these had been drained.

At the present time, on soils which are comparatively dry and of a texture which permits of time for adequate cultivation and the preparation of a good seed bed, wheat may be taken after a cropped fallow, or even after another cereal. It is grown after beans, in some districts after turnips, mangolds or potatoes, and since the introduction of cultivated grasses and clovers, wheat now commonly follows leys in the rotation, in which case the only preparation needed for it is a single ploughing and harrowing of the soil before drilling the seed.

The practice of summer fallowing has declined very considerably in Great Britain during the last century, the annual average of bare fallow in the five years 1926–30 was 391,561 acres or less than half the average of the years 1866–70, which amounted to 839,014 acres per annum. The figures show that there is still an appreciable area of cultivated land in bare fallow, and were the stiff, inadequately drained clays now laid down to permanent grass to be again forced into wheat growing, the practice would be found imperative, though doubtless at longer intervals, for it remains still the only efficient method of thoroughly cleaning foul land.

An indication of the gradual reduction of the yield from unmanured land subjected to continuous cropping is provided by the results obtained on the somewhat heavy soil of the classic Broadbalk Field at the Rothamsted Experimental Station.

Here, on Plot 3 of the field, wheat has been grown annually since 1839, during which period no manure has been applied to the land; the average annual return of this plot for periods of eight and ten years from 1844–1931 is given as follows:

	Bushels per acre
1844–51 (eight years)	17·2
1852–61 (ten years)	15·9
1862–71	14·1
1872–81	10·4
1882–91	12·6
1892–01	12·3
1902–11	10·9
1912–21	8·5
1922–31	9·0

Similar results have also been obtained on the lighter soil of Stackyard Field at the Woburn Experiment Station, where wheat has been grown on two unmanured Plots, 1 and 7, annually since 1876.

The following are the average annual yields for ten-year periods during the fifty years 1876–1926:

	Plot 1 *Bushels* (60 *lb.*) *per acre*	*Plot 7* *Bushels* (60 *lb.*) *per acre*
1877–86 . . .	16·8	17·4
1887–96 . . .	12·7	14·5
1897–06 . . .	8·6	10·8
1907–16 . . .	9·4	10·4
1917–26 . . .	6·8	7·6

Experiments to determine the effect of bare fallow were begun in 1925–6, on the continuous wheat plots of Broadbalk Field, Rothamsted, each plot being divided into five sections, upon which a cycle of fallowing rotations were initiated in 1931; the following are the results hitherto recorded for the unmanured plot.

Plot 3. Unmanured, and carrying a crop of wheat annually since 1839. Average crop for 74 years, 1852–1925 = 12·5 bushels per acre.

	Sections *I*	*II*	*III*	*IV*	*V*
1926 . .	Fallow	Fallow	Fallow		
1927 . .	Fallow	Fallow	Fallow		
1928 . .	29·9	27·9	Fallow	Fallow	Fallow
1929 . .	9·1	9·1	Fallow	Fallow	Fallow
1930 . .	5·0	6·9	22·5	27·1	22·4
1931 . .	Fallow	5·9	5·7	4·3	10·8
1932 . .	17·6	Fallow	8·5	10·8	9·4

Although long continued experiment will be necessary before a comprehensive view of the effects of fallowing is possible, it is nevertheless clear that even the worn-out land of this plot, on which wheat had been grown for about ninety years without manure and yielding no more than 9 or 10 bushels per acre, recovered so much of its fertility by a rest of 2–4 years, that it gave a crop of 22–27 ·9 bushels per acre, and Section I of the plot, which in 1930 only produced 5 bushels per acre, yielded 17 ·6 bushels per acre after a single year of bare fallow.

Another point which emerges from the results already obtained is the fact that the good effect of a bare fallow of worn out land is almost exhausted by the growth of a single crop; thus, the land immediately after fallowing yielded 22–27 ·9 bushels per acre, while in the next season the crop fell to the low level of worn out land.

MANURING

The arable land of Great Britain, and indeed of Western Europe generally, has been so repeatedly cropped annually from a very early date that an application of some kind of manure or fertiliser is absolutely necessary if remunerative yields of grain are to be obtained.

In former times, after a thoroughly-cleaned, well-worked fallow, the land gave good crops without manure; later, an application of lime was given to the fallow to stimulate returns, and the addition of 12–15 tons of farmyard manure per acre to the land before sowing of wheat was deemed essential for profitable results.

Nowadays wheat receives much of its needful plant food-constituents in an indirect manner. When grown after mangolds or potatoes, considerable unused residues from the manures applied to them are often left in the ground and serve for the succeeding wheat crop. For the production of heavy yields of grain, such residues are frequently supplemented by applications in autumn of 1½–2 cwt. of superphosphate or other phosphatic fertiliser, and a similar amount of kainit (potash fertiliser), followed in spring by a dressing of 1 cwt. of nitrate of soda or sulphate of ammonia; the later nitrogenous fertilisers are found of great service, especially on land of moderate fertility, or after a severe winter. After turnips fed off with sheep, and after beans or clover leys which leave the land fairly rich in nitrogen, only the phosphates and potash fertilisers are needed.

SOWING: METHODS AND AMOUNT OF SEED

In regard to the sowing of wheat there are three methods, namely, (1) broadcasting by hand or machine, (2) drilling, and (3) dibbling.

Broadcasting by hand is the most ancient method of sowing cereal grains and before the introduction of the drill in the eighteenth century was universal in Britain. In the case of wheat, the seed is scattered by hand or machine, and then covered by harrowing, or on lighter land by a thin furrow turned by the plough. Sometimes the seed is cast over the land last ploughed with a furrow set on edge, the soil being lightly harrowed afterwards; in this case much of the seed rolls down the sloping sides of the furrows in to the hollows, and the young plants come up in rows almost as regularly as when the field is drilled.

Drilling, in which the grain is deposited in rows usually 8–10 inches apart, is the method of sowing now most commonly adopted on all soils except the stiffest clays. The process was first advocated by Jethro Tull in his *New Horse-Houghing Husbandry*, published in 1731, but little attention was given to the innovation even at the end of the eighteenth century. Controversy on the relative merits of broadcasting and drilling of cereals continued into the nineteenth century, and highly skilled farmers at a later period were content to remark, "I get good results by broadcasting, why drill."

Many farmers after making trials of the use of the drill abandoned it; difficulties connected with the design of the implement, the amount of seed to be used, and the width of the rows in particular cases, delayed the practice of drilling, and it was not until after many years of experience that these problems were settled and the merits of the system clearly recognised.

In broadcasting by hand the grain is scattered unevenly, and much of it is wasted, being either left uncovered, insufficiently covered, or buried too deeply for healthy growth; with the drill, however, the seed is delivered at a steady rate and deposited at a fairly uniform depth in the soil, ensuring greater regularity of germination and growth. Moreover, less seed is required, and drilled crops provide greater opportunity for the cultivation of the soil, and the destruction of weeds between the rows by the horse or hand hoe; these advantages were sufficient to recommend the adoption and secure the success of the method.

At the beginning of the seventeenth century, Sir Hugh Platt in *The New and Admirable Arte of Setting of Corne* (1600), and Edward Maxey in his *New Instruction of Plowing and Setting of Corne* (1601), advocated the "setting" or "dibbling" of wheat, rather than broadcast sowing, which latter practice they maintained was a great waste of valuable food grain, the dire want of which was frequently experienced in those days. Maxey recommended half a bushel of seed per acre, instead of the customary 2½–3 bushels, which he states were sown in some districts, and calculated that in the 9,000 country parishes in England 900,000–1,000,000 quarters of wheat could be saved annually.

This method of raising a wheat crop does not, however, appear to have been seriously adopted in the seventeenth century, but, in the times of scarcity experienced at the end of the eighteenth and beginning of the nineteenth centuries, dibbling was frequently practised. The dibble at this period was a short wooden tool with a crossbar handle at the top, and a blunt point at the bottom shod with iron or steel. With one in each hand, the dibbler walked backwards making two rows of holes 5–9 inches apart, the holes in the lines being 3–5 inches asunder. He was followed by women and children, often his wife and offspring, who dropped 2–3 grains into each hole, the total amount used being from one to one and a half bushels (60–90 lb.) or less per acre. In 1796, large areas of wheat in Norfolk and Suffolk were dibbled, as much as 150–200 acres on many farms being sown in this way, especially on the heavier lands, where sowing was unavoidably late or where the soil was comparatively shallow.

It was claimed that dibbled crops were as good or better than those broadcasted, but the saving of 1–1½ bushels of seed per acre over the common method of sowing, justified the practice. From a national point of view it was of great importance, since a bushel of wheat was sufficient to support a man for two months. The practice, however, was of limited application, for it could only be carried out where abundant and cheap labour were available, and is only of interest nowadays in exceptional circumstances.

TIME OF SOWING

On the Cotswold hills of Gloucester, the downs of Hampshire, Wiltshire and Dorset, and in other western districts on light soils, wheat is sometimes sown as early as August after the first copious rainfall in that month; unless this opportunity is seized the land is liable to become too dry for germination, and the appearance of the young plants is greatly delayed.

In most districts throughout Great Britain, winter wheats are sown between September and January, the particular time being dependent on the exigencies of the farm. Where land can be cleaned, adequately cultivated, and a good seed-bed prepared, sowing from the beginning of September to the first week of October gives the best results; earlier than this and later give reduced yields of grain. It is imperative that the farmer should clearly recognise that every week's delay beyond the best period for the district, leads to a reduced crop at harvest, and maximum yields cannot be expected when sowing is delayed until December or January.

It must be noted, however, that varieties of wheat vary in their response to delay in sowing; a few sorts often give useful results when sown as late as the middle of February, but the common prolific winter wheats sown after this date produce ears so late that they do not ripen in that season, in which case the plants continue to tiller during summer and autumn, and finally send up ears in their second year of growth; these ripen in August at the same time as those of wheats sown normally in the preceding autumn.

The irretrievable loss to the farmer when the ordinary seedtime is missed was experienced in 1873. The autumn of 1872 was exceptionally wet, and sowing almost entirely checked over large areas with the result that a larger extent of wheat was sown in the spring of 1873 than ever recorded before in this country. The wheats sown were Rough Chaff, Golden Drop, Browick Red, Squarehead, and other typical winter wheats then commonly grown, and the sowing was delayed in the majority of cases until near the end of February and throughout March. All the sowings as late as February gave disastrous results, except those of April Bearded wheat, which gave returns of four quarters per acre in many places; the seed, however, of this variety rose to a high price and was insufficient for the demand.

Before the sixteenth century spring wheats were either unknown here or were very scarce. Harrison in 1596 says that "summer wheat" was very rare, and only known "in the north about Kendall, where they call it March Wheat." Spring or summer wheats, as opposed to the ordinary winter kinds, are, however, mentioned by Hartlib (1652), and occur in lists of English wheats given by Bradley (1728) and later by Varlo (1786) and others. Some of these writers state that such wheats can be sown as late as February with good results; it is probable that these were of the intermediate type, like Japhet or Red Marvel, for the true short-lived, rapid-growing spring wheats which are capable of giving good crops ripening in August when sown as late as the middle of April, do not appear to have been cultivated here until about the end of the eighteenth and beginning of the nineteenth century, when they were introduced from Siberia and other parts of Russia and the continent. Their yields are low in comparison with those given by typical winter forms whose growing periods extend over ten or eleven months; nevertheless, in time of scarcity when wheat rose to a very high price, their cultivation became remunerative.

AMOUNT OF SEED

Nothing is known about the amount of wheat sown per acre by prehistoric British farmers, but it is likely that it was not very different from that used by Roman agriculturists,

which, according to Varro, Columella, Palladius and other writers, was about 2 bushels (120 lb.) per acre; the sowing of this amount was a common practice in Great Britain down to modern times.

The records of the manors of the bishoprics of Winchester show that the average was 2½–3 bushels per acre in the thirteenth and fourteenth centuries, and in 1523 John Fitzherbert in his *Boke of Husbandry* states that two bushels was sufficient to sow an acre of wheat or rye. Maxey in 1601 says that 2½–3 bushels was customary then, and Mortimer a century later, in *The Whole Art of Husbandry* (1707), observes that "They commonly sow two bushels of Wheat upon an acre; But if new broke up Ground, 2 bushels and a Peck."

The reports of the agriculture of each county in Great Britain, published at the end of the eighteenth and beginning of the nineteenth centuries, show that 2–2½ bushels were very commonly sown at that date, but in certain districts farmers were then increasing the amount to 3 or even 4 bushels (180–240 lb.) per acre, especially when broadcasted.

At the present day the quantity used varies from 2–4 bushels (120–240 lb.), the particular amount depending on the kind and nature of the soil, and on the time and method of sowing. On good wheat soils in a high state of fertility, where the drill is employed and the sowing can be carried out in September or early October, 2 bushels give good returns, but on lighter soils, or where land is in a low condition, 3 bushels yield better results; when sowing is delayed until November or later, 3–3½ bushels should be used. As noted elsewhere, it is profitable policy to be liberal with seed; unsatisfactory results due to the use of too much seed are very rare, but reduction of crop on account of niggardly practice in this respect is by no means uncommon.

TILLERING

Single grains of wheat, when sown in fertile soil in a clear space, often give rise to plants each of which at harvest may consist of 40, 50, or even 100 straws or more, and a corresponding number of ears filled with grain. In these instances a single main shoot coming from a grain produces several branches or "tillers," which in turn branch similarly; these secondary tillers produce still more branches, and the process may be repeated during autumn and early spring until the end of March or beginning of April, when it ceases and the growth in length of the straw and the development of the ear commences. The extent of tillering or shoot production depends on a variety of conditions; it proceeds most freely when the conditions of growth are favourable, as on well-cultivated, well-drained fertile soils, and is checked by competition with other plants, thick sowing and the presence of weeds greatly reducing it.

That a single grain in favourable circumstances may give rise to a plant yielding several thousands of grains is an amazing fact which has attracted attention in all ages. If one grain yields at harvest 3,000 grains, 1 bushel of seed will, under similar conditions, yield 3,000 bushels, but to obtain such a return it is usually overlooked that a vast amount of ground is needed, not one acre, but many acres, for in order that plants may tiller as much as indicated, a large extent of clear space and root room must be given to each.

With a view of taking advantage of the natural tillering of the wheat plant, and the desire to save useful bread corn, many advocates of thin seeding have arisen during the last two centuries. Experiments with a seeding of 1 peck (15 lb.) of grain, instead of the usual 2½–3 bushels (150–180 lb.), have been tried, and in many cases returns of 40 bushels per acre or more have been recorded, but such favourable results have only been secured on comparatively small areas of exceptionally clean land in a high state of fertility. Farmers have abundant evidence from their own experience that by sowing less than two bushels per acre in ordinary practice they run grave risk of very serious losses at harvest; it is found that increased tillering, rarely, if ever, makes up for the reduction in the number of plants which thin seeding entails.

The widespread practice of sowing 2½–3 bushels per acre, which has been followed during the last century or longer, is doubtless the best for ordinary farm conditions in Great

Britain, and on fields thus sown and giving good yields at harvest it is found that 65 per cent. or about two-thirds of the plants on the field possess but a single straw, while 95 per cent. have not more than three straws each. The number of straws per square yard varies between 150 and 400, and good crops are rare when the number falls below about 300; it is sound policy to secure this number by a liberal use of seed rather than trust to the tillering habit to make up for deficiency of seed.

SIZE OF SEED

On warm, well-manured, fertile soil, under exceptionally favourable climatic conditions, small, or shrivelled grain has sometimes given good crops, and Sir Joseph Banks more than 100 years ago, and others at later dates, have recommended the use of tail corn, rather than good milling wheat for seed. It is, however, false economy even in times of scarcity to adopt this practice, for many experiments have shown that in ordinary practice large well-filled grains give more certain and higher yields at harvest than small grains. The embryos of large, plump grains have a superior amount of floury endosperm for their nourishment in the early stages of growth, and the good start they get in this way is seen in the vigorous growth and healthy development throughout their whole life; those in small grains are starved at the outset, and although on clean ground in good condition they may recover somewhat, on ordinary land they give rise to comparatively weak plants yielding little grain.

CHANGE OF SEED

From very early times the practice of securing a change of seed in the cultivation of wheat and other cereals has been recommended, and the custom is still considered essential for good crops by the majority of farmers.

It is believed that continued growth of any single variety of wheat on the same farm for long periods leads to deterioration of the plant and loss of yield.

Walter of Henley, in his *Husbandry*, written in the thirteenth century, says, "Change your seed every year at Michaelmas, for seed grown on other ground will bring more profit than that which is grown on your own. Will you see this? Plough two selions at the same time, and sow one with seed which is bought and the other with corn you have grown: in August you will see that I speak truly."

From the records of the Berkeley estates in Gloucestershire it is learned that in 1326 the seed wheat was changed every two or three years, that from the higher ground being sown in the valleys and *vice versa*.

Wherever the practice is followed, a clay soil farmer endeavours to obtain a change of seed from chalk or light gravelly land; similarly, the fenland farmer exchanges with his neighbour on the chalk; changes from the warm southern to the colder northern counties, or from an early to a late district are beneficial.

It is conceivable that the continued cultivation of the same stock of seed on soil in which there is a deficiency of some essential plant nutrient (not nitrogen, phosphorus, potash or lime) may have a cumulative effect and lead to a deterioration of vigour of the plant; such an effect would be avoided by a change to a different type of soil in whose composition there is no lack of the essential nutrient. Similarly, a small difference in climatic conditions may have a marked effect on the vitality of the plant when continued over a long period which could be avoided by change to another district. Whatever the explanation of the necessity for a change of seed, the belief in the benefits to be derived from it are not likely to be questioned by the farmer.

RIPENING AND HARVEST

The emergence of the ear of the wheat plant from the upper leaf-sheath usually takes place in the south of England in the early part of June, after which flowering begins in five or six days, all the ears on a plant completing the process in three to eight days according to the weather at the time. Fertilisation follows and the grains begin to develop, the fully ripe stage being generally reached in eight to nine weeks after the first appearance of the ear, the particular time taken

depending on the kind of wheat and the climatic conditions of the locality.

The changes involved in the development and ripening of the grain continue without a break, but four stages of progress may be recognised, namely, the milk-ripe, yellow-ripe, ripe, and dead-ripe stages.

In the milk-ripe stage the leaves and ears are green; the grain is also green, and a milk-like liquid is easily squeezed from it. When the crop has attained the yellow-ripe stage, the straw assumes its golden-yellow tint and is smooth and shining: the leaves are no longer green, and the chaff of the ears has assumed its characteristic yellow, reddish or brown tint. The grain has lost all traces of green colour, and instead of being milky when crushed between the finger and thumb, it is soft like dough. The ripe and dead-ripe stages follow, the straw becoming dull and brittle and the grain harder. Experience has shown that, in this country, the best time to cut the crop is when it has reached the yellow-ripe stage.

Different kinds of wheat, sown on the same day in a particular locality, vary in the time taken to reach the earing and ripening stages, some being as much as ten to fourteen days earlier than others.

In any particular district, however, each kind produces its ears very near to a definite fixed time, which deviates little from season to season, and this is true even if the seed is sown any time between August and December.

For the same kind of wheat, the time of ripening and harvest in different parts of the kingdom is determined largely by climate and elevation. In warm districts of Kent, Sussex, Surrey, Middlesex, Devon and South Wales, ordinary winter wheats sown in September or October are sometimes harvested as early as the end of July or the first week of August; in other parts of the southern and midland counties, harvest usually begins during the first ten days of August, becoming later in the northern English counties, while in many parts of Scotland the crop is not ready for cutting until the latter half of August or beginning of September, and may be delayed until October in the coldest and most northerly districts.

YIELD PER ACRE

As previously observed, wheat, like all other cultivated crops, is dependent for its growth upon a great many factors, some of which are at the command of the farmer, while others, such as climatic conditions, he cannot control; the latter unfortunately often turn out to be of greater importance than the rest. On the same farm under exactly similar treatment, the returns of the wheat crop in one season may be more than double that of the next, and very great variation in the yield per acre has been the common experience of farmers in all ages. Nevertheless, a study of the question shows that there has been a steady improvement in the yield from the earliest times down to the present day, due to the increased knowledge and skill of the farmer.

Nothing is known of the yields secured by the Neolithic, Bronze and Iron Age cultivators in Britain, neither have we any knowledge of the returns from the land during the Saxon period. In these early days the yields must have been very low, for the land was cropped annually until exhausted, or cultivated under the two- or three-field system, in which there was frequent repetition of the same cereal, as well as poor methods of tillage and lack of fertilisers.

It is not until the twelfth, thirteenth and fourteenth centuries, when careful accounts of the working of estates began to be kept, that records appear of the yields of wheat and other crops.

Gras, in *The Evolution of the English Corn Market*, gives the following figures from the records of the Manors of the Bishopric of Winchester:

	1208–9 *32 manors*	1299–1300 *42 manors*	1396–7 *43 manors*
Acres	6838	3353	2366
Bushels sown per acre	1·85	2·68	2·07
Yield per acre (bushels)	4·34	10·8	6·98

Walter of Henley, in his *Husbandry*, written early in the thirteenth century, when the two- and three-field systems of cultivation were practised, says, "on an acre it is necessary to sow at least two bushels" and "at three times your sowing you ought to have six bushels"; moreover, he noted that "if the return of your grange only yields three times the seed sown, you will gain nothing unless corn sells well."

In the treatise on "Hosebonderie" dating from near the beginning of the fourteenth century, the unknown author states that "one can in many places reasonably sow four acres with a quarter of seed (8 bushels), ... in many places it requires a quarter and a half to sow five acres with wheat, rye and beans," which "ought by right to yield to the fifth grain," or 10 bushels, but observes that on poor soil in unfavourable seasons the land may not yield more than what was sown, and in some instances even less.

In the records from the estates of Merton College, Oxford, for the years 1333 and 1334, mentioned by Rogers (*Agriculture and Prices*, Vol. I, 50), the yield of wheat was about 8 bushels per acre at Cambridge, Maldon, Farley, and Cheddington, at Cuxham 13 bushels, and as high as 16 bushels at Welford and Holywell; on the other hand, the crop at Gamlingay was little more than 4 bushels per acre or twice the seed sown.

Down to the beginning of the sixteenth century, a yield of 8–10 bushels per acre of wheat was considered a normal crop, but later there was much improvement in cultivation and returns increased. William Harrison, in his *Description of Britaine*, in 1577, says, "our countriemen are growne to be more painfull, skilfull and carefull through recompense of gaine than heretofore they have been"; and, continuing, remarks that "the yield of our corne-ground is much after this rate following. Through out the land (if you please to make an estimat thereof by the acre) in meane and indifferent yeares wherein each acre of rie or wheat well tilled and dressed, will yield commonlie sixteene or twentie bushels."

Edward Maxey (1601) observes that the "usuall increase upon an acre in the common fields barren land, commonly is not above two quarters (16 bushels) one yeere with another," though he says that good land, well-cultivated will give five or six quarters per acre.

Norden in 1607 also asserts that in Somersetshire on ground well-tilled, "they have sometimes in some places 4, 5, 6, 8, yea 10 quarters in an ordinary acre."

During the Civil War, from 1642–47, the country was very unsettled, cultivation of the land greatly neglected, and

Samuel Hartlib in his *Legacie* (1651) gives 12–16 bushels as a good crop of wheat at this date. Later in the century, however, the turnip and clover crops were introduced from Holland, and where their cultivation was adopted the fertility of the land was increased, and better crops of cereals secured. After the restoration in 1660, a new period of agricultural prosperity set in, and, as mentioned later, farmers produced enough wheat to supply the needs of the country in addition to a large surplus for export. Progress continued during the succeeding eighteenth century, and the average crops throughout the country became 20–25 bushels per acre, as recorded in the County Agricultural Surveys which were made at the request of the Board of Agriculture at the end of the eighteenth and the early years of the nineteenth centuries.

Further improvement is recorded in the first half of the nineteenth century, and Caird and others estimated the yield at 26 or 27 bushels per acre in 1850. From this date the return per acre has steadily increased up to the present time, the average of the last ten years for Great Britain having risen to about 32 bushels per acre.

The increase of 4–5 bushels in the general average from 26–27 bushels in 1850 to that of 32 bushels reached during the last ten years or so, may not be a really significant difference, for during the period mentioned there was a great diminution in the wheat area, and it is likely that land less suited to the crop has been used for other purposes, leaving the wheat to be grown only on the best land which has always given high yields.

The average annual yields per acre in Great Britain during the fifty years 1880–1930, fluctuated between a minimum of 26 bushels in 1893 and a maximum of over 35 bushels in 1921, which was the hottest summer on record.

The average yield in Wales, with its damp climate, over a period of the last ten years is about 27 bushels per acre, or 5–6 bushels less than that of England; the corresponding average for Scotland is 38–39 bushels, 6–7 more per acre than England, a result associated with good soil and cultivation, and a comparatively low rainfall in the area in which the wheat is grown, together with the influence of longer daylight during which assimilation is active.

Assuming that little or no important changes in climate have occurred within historic time, the general increase in the average yield of wheat from 8 or 10 bushels commonly obtained in mediæval times to the present-day average of 32 bushels per acre is to be attributed to improvement in the methods of cultivation and the application of manures. The period in question witnessed the extensive enclosure of land, and gave the farmer freedom from that unchangeable routine of common-field cultivation which was such a potent check to individual effort; the introduction of the process of drilling of cereal crops, the discovery of the value and use of nitrates and other fertilisers, and the very great improvements in the implements of cultivation, were also adopted during this period.

In addition to the factors mentioned which have led to an increase in the yield of wheat in historic times, the influence of the discovery of more prolific varieties of the plant should also be considered. The earliest forms of wheat produced only two grains in each spikelet of the ear, and it would appear that in prehistoric times the kinds cultivated in Britain ripened not more than two grains in each spikelet, as indicated in Chapter I. Primitive wheats with three-grained spikelets have been found in Swiss Lake Dwelling deposits of the Iron Age; it is, however, not known at what date the ear of Bread Wheat first began to bear spikelets in which three, four or more grains were ripened as at present. I am of the opinion that this increased productivity is the result of the repeated action of improved environment of well-cultivated fields, and is comparatively modern in this country, probably not much earlier and possibly later than the Norman Conquest.

The maximum crops of wheat recorded in field culture in this country are in the region of 80–90 bushels per acre. In 1918 Yeoman wheat gave a return of 96 bushels per acre, on a field of 3½ acres at Wye in Kent; the soil was a deep, rich loam which had been heavily manured in the previous year for a crop of beetroot. In 1844, on a field of 5¼ acres in the parish of Haisborough in Norfolk, Spalding wheat yielded 90 bushels per acre; in 1797 Richard Bradley states that the largest crop experienced up to that date appeared to be 10 quarters of 80 bushels per acre, and records of 50–60 bushels were frequent throughout the eighteenth century. In 1601 Maxey observes that 6–8 quarters (48–64 bushels) per acre were obtained in many places "on well-dunged land sown with choicely picked seed."

From the examples quoted and much similar evidence, it is clear that during the last 300 years there has been little or no change in the yields of wheat which can be obtained from well-cultivated land; given fair soil and a favourable season, the only condition for success is good cultivation and adequate manuring, both of which are within the power of the farmer to provide.

CHAPTER IV

DISTRIBUTION OF WHEAT CROP; EXPORT; IMPORT

In the prehistoric Neolithic, Bronze and Iron Ages, wheat, often with barley, was grown in many parts of England and Wales, and wheat grains attributed to the Bronze Age have been found in Scotland as far north as Morayshire. Wheat grains have also been discovered on many Roman sites in England and southern Scotland, and the cereal was no doubt cultivated in all districts in which the Saxons, Danes and Normans settled.

Records of the cultivation of wheat in England are frequent from the eleventh and twelfth centuries onwards, and wheat and rye were the ordinary winter cereals on all the arable land in England in the sixteenth, seventeenth and eighteenth centuries. It did not, however, become commonly distributed in the remote parts of Wales, or the north of England and Scotland, until after the middle of the eighteenth century, although small amounts were grown in the Midlothians of Scotland as early as the fifteenth century.

The demand for wheat in place of rye, barley or oats as bread corn grew rapidly after the middle of the eighteenth century, and its cultivation during the nineteenth century spread to every part of Great Britain.

As previously mentioned, the cultivation of this cereal is most satisfactory in districts with a comparatively low rainfall, but in former times, especially when the price rose to a high figure, wheat was grown in all parts of the country, the increased value being sufficient to make small yields remunerative. Even during the last sixty years, down to 1930, wheat has been grown annually in every county of England and Wales, and as late as 1870 in every county of Scotland except the Shetland Isles; even in 1930 it was still cultivated in twenty-seven of the thirty-three counties of Scotland.

Official statistics concerning the cultivation of various farm crops were first collected in 1866, in which year the area devoted to wheat in Great Britain was 3,385,394 acres, namely, 3,161,431 in England, 113,862 in Wales, and 110,101 acres in Scotland. The largest acreage of wheat hitherto recorded in Great Britain was 3,688,357 acres in 1869, when England grew 3,417,054, Wales 135,562, and Scotland 135,741 acres; from that date to the present time there has been a decline to 1,180,903 acres in England in 1931, 15,794 in Wales, and 50,024 acres in Scotland, making a total reduction of 1,246,721 acres for Great Britain, or a decrease of over 63 per cent. This extraordinary reduction of the wheat area has been brought about chiefly by the great fall in price of the cereal.

During the years of the First World War, large areas of grass land were ploughed up, and over 2,000,000 acres were sown each year with wheat in 1915, 1918 and 1919, the highest figure of 2,635,704 acres being recorded for Great Britain in 1918.

Similarly, during the last World War of 1939–45, much grassland in Great Britain was ploughed up and sown with wheat, the greatest area of 3,450,528 acres being thus cultivated in 1943.

The chief wheat-growing region of England lies east of a line extending from Hampshire to Durham with an average annual rainfall of about 25 inches; west of this line the wheat crop is less satisfactory, the rainfall being too high for production and ripening of the grain. In Wales, Devon and Cornwall, with an annual rainfall of 45 inches or more, wheat yields are always low, the crop being usually injured by north-west winds during the cloudy days of spring, and often lodged later.

In Scotland the best wheat land is found on the alluvial soils of the Carses along the banks of the Forth and Tay, and on the low lying ground in the east of the country as far north as Aberdeen, in which region there is a comparatively low rainfall approximating to that of the best wheat-growing counties of England.

In the mountainous parts of Scotland and the north of England, wheat does not grow satisfactorily at an elevation above 500–600 feet, but succeeds fairly well up to 250–300 feet; in Wales, in Montgomeryshire, it is occasionally grown

at an elevation of 900–1,000 feet, and in Pembrokeshire up to 1,100 feet above sea-level.

Headrick, in the *General Survey of the Agriculture of Angus or Forfarshire* (1813), records the occurrence of a field of wheat at Lochlee in the Grampians in 1809, at an elevation of about 1,000 feet; the crops, however, at these heights are always poor.

Reference to the statistical returns of the Ministry of Agriculture show that in 1870 Lincolnshire had the greatest wheat acreage in England—namely, 310,159, acres; this was closely followed by Yorkshire with a total of 296,303 acres. Four more counties each growing over 120,000 acres of wheat were Norfolk with 194,414, Essex 183,601, Suffolk 147,141, and Cambridge with 122,682, the combined total of the six counties amounting to 1,254,300 acres, or 38 per cent. of the whole area devoted to wheat in England at that date. Later returns show that these counties were still the leading areas for wheat growing in 1930, the acreages for the individual counties then being Lincoln 179,455, Yorkshire 151,279, Norfolk 82,623, Essex 91,204, Suffolk 85,960, and Cambridge with 81,552 acres, or a total of 672,073, almost 50 per cent. of the area devoted to the crop in England now.

Comparison of the wheat areas in other English counties shows that between 1870 and 1930 there was a diminution of more than 80 per cent. in Middlesex, Surrey, Shropshire, Worcester, Devon, Cornwall, Northumberland, Cumberland, and Westmorland, the most striking reduction being observed in Cumberland, which in 1870 grew 25,262 acres, but in 1930 only 218 acres. During the period mentioned the smallest decreases—namely, about 33 per cent.—occurred in Huntingdon, Cambridge, and Hertfordshire, the other great wheat-growing counties of Bedford, Suffolk, Lincoln and East Yorkshire, showing in each case a diminution to about 40–45 per cent. of the area devoted to the crop in 1870.

In 1870 each of three counties in North Wales grew over 15,000 acres of wheat—namely, Montgomery 22,082, Denbigh 18,737, and Flint with 15,808 acres, the returns in 1930 being Montgomery 5,118, Denbigh 1,908 and Flint 949 acres, a reduction from a total of 56,627 acres to 7,975 acres, or a loss of about 86 per cent.

In 1930 the wheat area in North Wales was 90 per cent. less than it was in 1870, sixty years previously, except in Montgomery, in which the decrease was about 80 per cent.; a similar reduction of 80–90 per cent. took place in all the counties of South Wales except Cardigan, where the loss was about 76 per cent.

In Scotland the four counties with acreages over 10,000 in 1870 were Fife with 20,021, Perth 15,557, Angus or Forfar 13,705, and East-Lothian or Haddington with 12,633 acres; in 1930 these counties were still the chief wheat-growing counties in Scotland, but with greatly reduced areas—namely, Fife with 11,493, Perth 7,475, Angus 11,924, and East-Lothian with 5,282 acres, a reduction of from 61,916 to 36,174 acres, or a loss of over 40 per cent.

A few counties of Scotland which cultivated small areas of wheat in 1870 grew only a few acres or none at all in 1930. In many counties the reduction reached 80–90 per cent., but comparatively small changes of 9–18 per cent. only were recorded during the period in Midlothian, West-Lothian, Forfar and Kincardine.

In the earliest times the farmsteads, hamlets and villages of the country were dependent entirely on home production for the food which was needed, and the corn grown in normal seasons was sufficient for the requirements of the population. It is likely that export of a certain amount of surplus corn from the southern parts of England to Gaul occurred before the Roman invasion. That the British at that time grew considerable amounts of grain is clear from the fact that Cæsar's invading army obtained in a few days enough corn to support four legions of soldiers and 1,700 cavalry for a fortnight.

Later, Zosimus, Julian, and Ammianus Marcellinus record the export of corn from Britain in A.D. 359–60, for the use of Roman troops in the Rhineland.

In A.D. 875, Thorolfr of Norway sent to England for wheat (*Egelssaga*, cap. 17 and 19), and records are extant of the export of corn from this country at the time of Henry II. Nevertheless, export of grain was more or less sporadic until late in the seventeenth century, for, as noted elsewhere, yields were very low owing to the primitive methods of cultivation and the greatly reduced fertility of the land through repeated cropping.

There was no special incentive to grow more corn than was sufficient for the immediate needs of the country, and an Italian visitor in A.D. 1500 (Camden Soc., 1847) writes that "Agriculture is not practised in this island beyond what is required for the consumption of the people; because were they to plough and sow all the land that was capable of cultivation, they might sell a quantity to the surrounding countries."

In normal seasons production generally balanced consumption, and only in exceptional years was there any surplus to carry over from one harvest to another. A single bad season led to hunger and, when followed by a second, famine was the result. Violent fluctuations in yields were frequent and complaints of the scarcity of food were common from the eleventh to the seventeenth centuries; sometimes there occurred periods of ten or twenty years during which there were almost regular successions of cold wet seasons, as in the reign of Edward II, and in the latter half of the sixteenth century there were few good harvests. In these days, road transport from a district where good crops were reaped, to one with a great deficiency was often impracticable, and importation difficult, impossible, or too slow to bring relief, and many died of starvation. At a later period, as in the bad seasons from 1772–5, and again in the years of scarcity which began in 1792 and continued with few interruptions to 1817, importation had become easier, and in a series of bad harvests which would have resulted in starvation one or two hundred years before, the worst effects of hunger could be relieved.

At the time of the Norman Conquest, with a population of $1\frac{1}{2}$–2 millions, the area of arable land in the 9,250 manors mentioned in Domesday Book has been variously estimated at $6\frac{1}{2}$–10 million acres.

In 1601 Maxey put the cultivated land at $6\frac{3}{4}$–9 million acres, while Gregory King calculated that the land under the plough in England and Wales in 1688 amounted to about 11 million acres. If these estimates are accepted, it would appear that on the three-field system of cropping the area sown with the autumn crops of wheat and rye during this period was in the region of $2\frac{1}{2}$–$3\frac{1}{2}$ million acres, giving an average yield of 8–10 bushels per acre.

Apart from the effects of low yields and bad seasons, some of the scarcity of food about which complaints were so frequent in the Middle Ages was doubtless due to an increase in the population, which had risen from $1\frac{1}{2}$ or 2 millions to a probable 5 millions in the sixteenth century.

With the improvements in cultivation and cropping which took place in the seventeenth century, the country entered a new era. Up to this date imports of corn were generally allowed only in times of scarcity, and exports were prohibited or checked except after rare abundant harvests, when the price of bread was reasonable. In 1673, however, a duty of 5*s.* per quarter was granted on the export of wheat when the price was at or less than 48*s.* per quarter, and similarly 3*s.* 6*d.* per quarter on the export of rye when it was selling below 32*s.* per quarter. Under the stimulus of this bounty the cultivation of wheat was very greatly increased and England became a great exporting country.

During the sixty-eight years from 1697–1765, more than 14 million quarters of wheat were exported, while only a little over 280,000 quarters were imported: during this period in only four seasons was there such a scarcity as necessitated an increase of imports over exports.

After 1765, however, the rapid growth of population in industrial centres led to a greatly increased demand for agricultural produce; the arable land, which was estimated by Gregory King at about 11 million acres, remained at nearly the same figure up to the early part of the nineteenth century, Comber, in 1808 estimating it at 11,489,000 acres, and Couling about twenty years later (1829) at 11,143,370 acres.

In 1771 Arthur Young put the wheat area in England and Wales at 2,785,808 acres, and Billingsley in his *View of the Agriculture of Somerset*, assumed an annual sowing of about 3 million acres; Capper in his *Statistical Survey* in 1800, states that about 2 million acres were sown with wheat, and Comber in *An Enquiry into the State of National Subsistence* (1808) gives the wheat area of England and Wales as 3,160,000 acres.

Thus, while the population of England and Wales had risen from about 5 millions in 1600 to 8,872,900 in 1801, when the first official census was taken, the arable land and wheat area remained at nearly the same figure. From this it is clear that importation became imperative, and from 1793 to the present day importation of wheat, practically the only bread corn now used, is a vital necessity.

The importance becomes clearer when it is understood that Great Britain has now to provide bread for nearly 45 millions of inhabitants, nearly 35 millions more than in 1801.

In the eleventh century some $2\frac{1}{2}$–$3\frac{1}{2}$ million acres were devoted to wheat and rye, while in 1931 less than $1\frac{1}{4}$ million acres were sown with wheat.

In 1869 the arable land of Great Britain was 17,603,000 acres, of which 3,688,357 acres were in wheat, the greatest area hitherto recorded for this crop.

The arable land in 1931 had declined to 12,634,358 acres, a decrease of 28 per cent., and the wheat area was reduced to 1,246,721 acres, the lowest area yet recorded and less than half the area devoted to bread corn 700 or 800 years ago.

In his *View of Agriculture of Middlesex* (1807), J. Middleton, commenting on the amount of wheat eaten by the inhabitants of England, considers "that all those who eat wheaten bread, consume annually eight Winchester bushels of wheat; which includes puddings, pies, confectionery and every other application of wheat in the article of food. This quantity of wheat is about equivalent to the average net produce of half an acre of land; that is, after deducting seed, loss by vermin, accidents, etc., from the gross produce, the remaining net quantity is sixteen bushels per acre."

At that date the food of the people was not so varied, and bread formed a greater proportion of the diet of the people than later; nevertheless, the assumed estimate is considered too high even for that date.

In 1896, Rew, taking into account the home production, the amount used for seed, and the imports into the United Kingdom, concluded that the amount of wheat available for consumption per head of the population in the period 1852–96, varied irregularly from year to year between 4·52 and 6·81 bushels, the average being 5·67 bushels. A similar calculation, under the conditions prevailing now, indicates that the amount of wheat available for consumption in Great Britain at the present time is about 5½ bushels per annum per head of the population.

For all practical purposes, Great Britain may be considered one large town or industrial centre dependent for its existence upon food from outside sources. That the agricultural resources of the country are quite inadequate to supply the bread that is needed is readily understood when they are examined, for, in order to grow enough wheat to allow 6 bushels per head per annum to its 47 million inhabitants, an area of over 8 million acres yielding an average of 32 bushels per acre would be required, or, on a four-course rotation, over 34 million acres, which is more than the total land and water of England, and more than twice the annual average of arable land cultivated throughout the whole of Great Britain during the last eighty years.

The extraordinary growth of the population in this country during the last 100 years or so, when compared with the total increase between the Norman Conquest and the beginning of the nineteenth century, is of grave interest to all, and presents many unsolved problems of the greatest national importance.

During the 735 years from 1066 to 1801, the population of England and Wales rose from 1½ or 2 millions to 8,872,980, while in the space of 130 years, from 1801 to 1931, the alarming increase from 8,872,980 to 39,947,931 occurred.

As matters exist at present it is to the toil of the farmer that we must look for protection against famine and its dire distress; may the millions who rarely consider the difficulties with which he is constantly faced in the production of the essential necessaries of life be led to ensure that he shall receive just recompense for his efforts.

Below are given some statistics of the arable land, the area under wheat, and the yield per acre in Great Britain at different periods, together with some figures of the imports and exports of wheat into the country; a table of the population of the United Kingdom is also added.

It was not until 1866 that reliable returns concerning the

cultivation of the various farm crops were obtained by the Board of Agriculture. The figures given for the periods before that date are estimates, the best that could be secured under the circumstances, for landlords and farmers were little inclined to furnish details of the land and its produce; both feared taxation, and in addition the farmer was reluctant to divulge yields of his crops which might lead to a rise in rent.

I. TOTAL AREA OF LAND AND WATER (ACRES)

England	*Wales*	*Scotland*	*Great Britain*
32,597,398	4,721,823	19,406,978	56,786,199

II. ARABLE LAND (ACRES)

	England	*Wales*	*Scotland*	*Great Britain*
1601 . .	6,750,000–9,000,000 (Maxey)[1]	—	—	—
1696 . .	11,000,000 (Gregory King)[2]		—	—
1808 . .	11,489,000 (Comber)[3]		—	—
1827 . .	10,252,800 (Couling)[4]	890,570	—	—
1868[5] . .	13,335,000	1,088,000	3,396,000	17,819,000
1869 . .	13,274,000	1,003,000	3,326,000	17,603,000
1870 . .	13,729,000	1,120,000	3,486,000	18,335,000
1880 . .	13,134,410	961,766	3,578,774	17,674,950
1890 . .	12,171,947	907,949	3,670,947	16,750,843
1900 . .	11,321,913	895,295	3,491,143	15,708,351
1910 . .	10,592,055	728,389	3,348,446	14,668,890
1918 . .	11,463,679	934,961	3,453,195	15,852,135
1920 . .	11,180,322	839,423	3,380,237	15,399,982
1930 . .	9,176,035	656,914	3,071,815	12,904,764

[1] E. Maxey, *New Instruction of plowing and setting of Corne*. 1601.

[2] Gregory King, *Natural and Political Observations and Conclusions upon the State and Condition of England*. 1696.

[3] W. T. Comber, *An Inquiry into the State of National Subsistence*. 1808.

[4] W. Couling, *Select Committee on Emigration*. Sessional Papers, 1827. V, 361.

[5] The figures of 1868–1932 are from *Agricultural Statistics*, issued by the Ministry of Agriculture and Fisheries.

III. WHEAT AREA (ACRES) IN GREAT BRITAIN AND YIELD PER ACRE

	England	*Wales*	*Scotland*	*Great Britain*	*Yield per acre (bushels)*
1771	2,795,808 (A. Young)[1]	—	—	—	24
1798	3,000,000 (Billingsley)[2]	—	—	—	20
1801	2,000,000 (Capper)[3]	—	—	—	24
1808	3,160,000 (Comber)[4]	—	—	—	—
1846	3,800,000 (McCulloch)[5]	—	—	—	30
1852[6]	—	—	—	3,705,165	22·5
1853	—	—	—	3,687,067	20·2
1854	—	—	—	3,625,685	35·5
1855	—	—	—	3,630,672	27·4
1856	—	—	—	3,648,601	27·2
1857	—	—	—	3,626,328	34·5
1858	—	—	—	3,584,858	32·5
1859	—	—	—	3,555,500	26·2
1860	—	—	—	3,526,242	22·2
1861	—	—	—	3,496,934	26·1
1862	—	—	—	3,467,626	30·6
1863	—	—	—	3,438,318	39·8
1864	—	—	—	3,409,010	36·0
1865	—	—	—	3,379,702	31·1
1866[7]	3,161,431	113,862	110,101	3,385,394	25·1
1867	3,140,025	116,733	111,118	3,367,876	21·0
1868	3,396,890	130,552	124,683	3,652,125	34·6
1869	3,417,054	135,562	135,741	3,688,357	27·5
1870	3,247,978	126,928	125,642	3,500,543	30·5
1871	3,312,550	126,334	133,010	3,571,894	24·4
1872	3,336,888	126,367	135,702	3,589,957	24·4

[1] Arthur Young.

[2] J. Billingsley, *General View of the Agriculture of Somerset*, Second Ed. 1798. 154.

[3] B. P. Capper, *Statistical Account of the Population, Cultivation, Produce and Consumption of England and Wales*. 1801.

[4] W. T. Comber, *An Inquiry into the State of National Subsistence*.

[5] J. R. McCulloch, *A Descriptive and Statistical Account of the British Empire*. 1854. Vol. I, 549.

[6] Lawes and Gilbert (1852–65), "Home Produce, Imports and Consumption of Wheat," *J. of Agric. Soc.* 1868.

[7] Returns from 1866–1933 from *Agricultural Statistics* of the Ministry of Agriculture.

	England	*Wales*	*Scotland*	*Great Britain*	*Yield per acre (bushels)*
1873	3,252,802	116,852	120,726	3,490,380	22·9
1874	3,391,440	117,869	120,991	3,630,300	29·7
1875	3,128,547	111,797	102,137	3,342,481	23·5
1876	2,822,342	94,423	78,892	2,994,957	25·4
1877	2,987,129	100,226	81,185	3,068,540	27·0
1878	3,041,241	101,813	75,363	3,218,417	30·5
1879	3,718,992	94,639	76,613	2,890,244	25·7
1880	2,745,733	89,729	73,976	2,909,438	24·9
1881	2,641,045	90,026	74,738	2,805,809	24·4
1882	2,829,491	95,387	79,082	3,003,960	26·0
1883	2,466,596	78,394	68,872	2,613,162	28·5
1884	2,530,711	77,611	68,716	2,677,138	29·9
1885	2,349,305	73,858	55,155	2,478,318	31·3
1886	2,161,126	68,653	56,126	2,285,905	26·9
1887	2,197,580	69,407	50,337	2,317,324	32·0
1888	2,418,674	76,828	68,735	2,564,237	28·0
1889	2,321,504	68,464	59,386	2,449,354	30·0
1890	2,255,694	68,669	61,973	2,386,336	30·7
1891	2,192,393	61,590	53,294	2,307,277	31·2
1892	2,102,969	55,278	61,592	2,219,839	26·4
1893	1,798,869	54,562	44,093	1,897,524	25·9
1894	1,826,626	56,470	44,866	1,927,962	30·7
1895	1,339,806	44,036	33,641	1,417,483	26·2
1896	1,609,255	46,973	37,729	1,693,957	33·6
1897	1,785,562	53,810	49,789	1,889,161	29·0
1898	1,987,385	58,960	55,861	2,102,206	34·7
1899	1,899,827	53,898	47,256	2,000,981	32·7
1900	1,744,556	51,654	48,832	1,845,042	28·5
1901	1,617,721	47,019	36,225	1,700,965	30·8
1902	1,630,892	48,323	47,258	1,726,473	32·8
1903	1,497,254	43,197	41,136	1,581,587	30·1
1904	1,302,404	35,144	37,736	1,375,284	26·8
1905	1,704,281	44,073	48,641	1,796,995	32·6
1906	1,661,147	44,403	50,059	1,755,609	33·6
1907	1,537,208	39,921	48,307	1,625,436	33·9
1908	1,548,732	34,573	43,428	1,626,733	32·2
1909	1,734,236	39,575	49,679	1,823,490	33·6
1910	1,716,629	39,428	52,797	1,808,854	30·3
1911	1,804,045	38,487	63,506	1,906,038	32·8
1912	1,821,931	41,383	62,373	1,925,687	29·0
1913	1,663,453	38,135	54,784	1,756,372	31·5
1914	1,770,470	37,028	60,521	1,868,019	32·6
1915	2,121,519	48,651	76,654	2,246,824	31·4
1916	1,862,211	49,997	63,083	1,975,291	28·8
1917	1,854,870	63,615	60,931	1,979,416	30·1

	England	Wales	Scotland	Great Britain	Yield per acre (bushels)
1918 . .	2,460,695	95,966	79,062	2,635,723	33·2
1919 . .	2,150,281	70,914	79,509	2,300,704	29·1
1920 . .	1,824,037	50,548	54,359	1,928,944	28·7
1921 . .	1,937,229	38,750	65,191	2,041,195	35·4
1922 . .	1,924,476	42,390	65,251	2,032,117	31·4
1923 . .	1,703,706	36,500	58,789	1,798,995	31·8
1924 . .	1,518,148	26,616	49,449	1,594,213	32·4
1925 . .	1,476,160	23,336	48,617	1,548,113	32·9
1926 . .	1,610,152	25,777	66,577	1,702,506	32·0
1927 . .	1,610,152	25,777	66,577	1,702,506	32·0
1928 . .	1,374,928	20,601	58,227	1,453,756	32·7
1929 . .	1,310,094	20,094	50,730	1,380,918	34·3
1930 . .	1,325,702	20,433	53,927	1,400,062	29·6
1931 . .	1,180,903	15,794	50,024	1,246,721	29·8
1932 . .	1,270,478	17,430	52,072	1,339,980	31·5
1933 . .	1,639,077	21,283	78,386	1,738,746	34·2
1934 . .	1,734,824	24,586	97,627	1,857,037	35·9
1935 . .	1,747,302	24,982	100,744	1,873,028	33·5
1936 . .	1,684,397	20,072	93,742	1,798,211	30·1
1937 . .	1,713,376	18,457	100,266	1,832,099	29·7

	England	Wales	Scotland	Great Britain	Yield per acre (cwt.)
1938 . .	1,811,157	19,104	92,497	1,922,758	20·4
1939 . .	1,669,724	12,892	80,071	1,762,687	18·6
1940 . .	1,665,411	31,465	100,352	1,797,228	18·1
1941 . .	2,077,255	63,671	105,997	2,246,923	17·8
1942 . .	2,308,084	82,522	113,345	2,503,951	20·4
1943 . .	3,147,103	132,802	170,623	3,450,528	19·9
1944 . .	2,949,714	112,950	152,423	3,215,087	19·5
1945 . .	2,122,159	59,021	91,091	2,272,171	19·1
1946 . .	1,939,696	42,505	77,606	2,059,807	19·1

IV. WHEAT AREAS IN THE AGRICULTURAL DIVISIONS OF GREAT BRITAIN IN 1870 AND 1930

	1870 (*acres*)	*1930* (*acres*)	*Decrease per cent.*
England			
Eastern Counties . .	621,621	360,869	42
North-east . . .	623,528	332,749	47
South-east . . .	425,245	133,373	68
East Midlands . .	406,779	170,607	58
West Midlands . .	403,588	110,883	72

	1870 (*acres*)	*1930* (*acres*)	*Decrease per cent.*
England			
South-west . . .	296,155	63,922	78
North.	257,768	99,313	60
North-west . . .	184,925	54,001	70
Wales			
North.	62,529	8,295	86
South	85,763	10,138	88
Isle of Man . . .	8,256	281	96
Scotland			
South	6,503	110	98
South-east . . .	29,622	14,881	50
South-west . . .	17,576	3,950	77
West Midlands . . .	4,283	1,149	73
East Midlands . .	37,422	19,456	48
North-east . . .	21,671	13,592	37
North-west . . .	8,591	789	98

COUNTIES OF THE AGRICULTURAL DIVISIONS OF GREAT BRITAIN

England

Eastern Counties: Bedford, Huntingdon, Cambridge, Suffolk, Essex, Hertford, Middlesex.

North-east: Norfolk, Lincoln, Yorks (East Riding).

South-east: Kent, Surrey, Sussex, Berkshire, Hampshire.

East Midlands: Nottingham, Leicester, Rutland, Northampton, Buckingham, Oxford, Warwick.

West Midlands: Shropshire, Worcester, Gloucester, Wiltshire, Hereford.

South-west: Somerset, Dorset, Devon, Cornwall.

North: Northumberland, Durham, Yorks (North and West Ridings).

North-west: Cumberland, Westmorland, Lancashire, Chester, Derby, Stafford.

Wales

North: Anglesey, Carnarvon, Merioneth, Montgomery, Denbigh, Flint.

South: Cardigan, Radnor, Brecon, Monmouth, Glamorgan, Carmarthen, Pembroke.

Scotland

South: Wigtown, Kirkcudbright, Dumfries.

South-east: Roxburgh, Selkirk, Peebles, Berwick, Haddington (East Lothian), Edinburgh (Midlothian), Linlithgow (West Lothian).

South-west: Lanark, Ayr, Renfrew, Dumbarton.

West Midlands: Stirling, Bute, Argyll.

East Midlands: Clackmannan, Kinross, Fife, Perth.

North-east: Forfar (Angus), Kincardine, Aberdeen, Banff, Moray (Elgin), Nairn.
North-west: Inverness, Ross and Cromarty, Sutherland, Caithness, Orkney, Shetland.

V. ARABLE LAND, WHEAT AREA AND BARE FALLOW IN GREAT BRITAIN, 1868–1930

	Arable land (*acres*)	*Wheat* (*acres*)	*Bare fallow* (*acres*)	*Percentage of arable land in Wheat*	*Percentage of arable land in bare fallow*
1868	17,819,000	3,652,125	958,221	20·5	5·3
1870	18,335,000	3,500,543	610,517	19·0	3·3
1880	17,674,950	2,909,438	812,566	16·4	4·6
1890	16,750,843	2,386,336	508,119	14·2	3·0
1900	15,708,351	1,845,042	308,108	11·7	1·9
1910	14,668,890	1,808,854	354,010	12·3	2·4
1918	15,852,135	2,635,723	413,547	16·7	2·6
1920	15,399,982	1,928,944	573,267	12·5	3·7
1930	12,904,764	1,400,062	299,610	10·8	2·3
1935	12,380,775	1,873,076	301,618	—	—
1937	12,015,828	1,832,121	550,372	—	—
1939	11,870,085	1,762,697	373,745	—	—
1941	14,990,994	2,246,923	219,339	—	—
1943	17,386,899	3,450,528	239,616	—	—
1945	17,865,757	2,272,274	347,069	—	—
1946	17,674,906	2,059,812	293,513	—	—

VI. AVERAGE ANNUAL IMPORTS AND EXPORTS OF WHEAT AND FLOUR FOR EACH OF THE FIVE-YEARLY PERIODS INDICATED

	IMPORTS *England* *Annual average* *Wheat and flour* (*qrs.*) (480 *lb.*)	EXPORTS *England* *Annual average* *Wheat and flour* (*qrs.*) (480 *lb.*)
1697	400	14,699
1698	845	6,857
1699	486	557
1700	5	49,056
1701–5	11	96,334
1706–10 . . .	423	105,900
1711–15 . . .	3	147,936
1716–20 . . .	4	76,105
1721–5	32	173,702
1726–30 . . .	24,993	57,856
1731–5	5	282,164
1736–40 . . .	2,608	298,860

	IMPORTS *England* *Annual average* *Wheat and flour* (*qrs.*) 480 *lb.*)	EXPORTS *England* *Annual average* *Wheat and flour* (*qrs.*) (480 *lb.*)
1741–5	10	253,386
1746–50 . . .	209	503,518
1751–5	41	396,808
1756–60 . . .	30,417	148,951
1761–5	20,935	346,772
1766–70 . . .	172,520	60,557
1771–5	186,986	26,330
1776–80 . . .	73,850	177,148
1781–5	230,511	104,418
1786–90 . . .	118,945	115,976
1791–5	324,713	124,212
1796–1800 . . .	693,079	40,072
1801–5	765,626	79,064
1806–10 . . .	554,349	47,712
1811–15 . . .	484,576	—
1816–20 . . .	947,745	—
1821–5	574,228	—
1826–30 . . .	1,484,125	—
1831–5	—	—

	IMPORTS		EXPORTS	
	United Kingdom			
	Grain (*cwt.*)	*Meal and flour* (*cwt.*)	*Grain* (*cwt.*)	*Meal and flour* (*cwt.*)
1836–40 . .	5,558,791	691,540	—	—
1841–5 . .	6,889,812	951,273	—	—
1846–50 . .	12,220,895	3,688,643	214,727	70,860
1851–5 . .	15,331,402	3,870,364	226,670	88,581
1856–60 . .	18,543,805	3,683,784	153,719	44,021
1861–5 . .	27,902,576	5,399,218	247,466	83,704
1866–70 . .	31,807,745	4,372,747	345,409	86,275
1871–5 . .	43,756,956	5,390,536	554,287	113,717
1876–80 . .	52,696,932	8,490,355	1,360,910	106,140
1881–5 . .	58,866,466	14,334,450	1,049,855	209,690
1886–90 . .	55,905,163	16,021,741	656,443	350,293
1891–5 . .	69,710,587	19,347,919	582,642	455,055
1896–1900 .	66,859,931	21,102,363	468,573	852,639
1901–5 . .	86,849,408	17,848,375	295,814	890,929
1906–10 . .	96,868,680	12,294,110	732,503	1,422,195
1911–15[1] .	101,222,614	10,555,031	732,490	1,866,155
1916–20 . .	86,044,852	16,068,109	141,721	531,158
1921–5 . .	98,320,010	12,238,529	909,787	4,812,979
1926–30 . .	105,362,290	10,396,115	841,952	4,306,152

[1] After 1923 the figures relate to Great Britain and Northern Ireland only.

WHEAT

Great Britain and Northern Ireland

	Imports		Exports	
	Grain (cwt.)	Meal and flour (cwt.)	Grain (cwt.)	Meal and flour (cwt.)
1916–20 . .	86,044,852	16,068,109	141,721	531,158
1921–5 . .	98,320,980	12,238,529	909,787	4,812,979
1926–30 .	105,362,290	10,396,115	841,952	4,306,162
1931–5 . .	108,256,352	9,309,715	797,549	3,587,274
1936–40 .	104,082,559	8,692,690	961,102	1,604,957
1941–5 . .	74,041,915	12,536,968	662,831	552,706
1946 . . (January–October)	57,561,536	10,466,775	305,435	980,872

VII. AVERAGE ANNUAL HOME PRODUCTION OF WHEAT IN GREAT BRITAIN

	Qrs. (480 lb.)	Cwt.
1886–90	8,857,189	37,959,381
1891–5	6,907,164	29,602,131
1896–1900 . .	7,575,787	32,467,660
1901–5	6,213,999	26,631,424
1906–10 . . .	7,078,887	30,338,087
1911–15 . . .	7,639,800	32,742,000
1916–20 . . .	8,161,600	34,978,300
1921–5	7,399,000	31,710,000
1926–30 . . .	5,999,400	25,711,714
1931–5	—	37,315,000
1936–40 . . .	—	41,035,000
1941–5	—	66,495,000

VIII. POPULATION OF THE UNITED KINGDOM

	England	England and Wales
Roman times[1] . . .	500,000	—
A.D.		
700[1]	750,000	—
1066[1]	1,500,000	
	2,000,000 (G.K.)[2]	—
1200–1500[3] . . .	2,300,000	—
1400	3,300,000 (G.K.)[2]	—
	2,921,204	

[1] R. G. Collingwood, "Town and Country in Roman Times," *Antiquity*, III, 262.
[2] (G.K.): Estimates given by Gregory King in his *Natural and Political Observations and Conclusions upon the State and Conditions of England*. 1696.
[3] The figures for 1200–1697 are from N. S. B. Gras, *The Evolution of the English Corn Market*, p. 75.

	England	England and Wales
1534	3,000,000	—
1600	4,620,000 (G.K.)[1]	—
	4,885,696	—
1605	4,000,000	—
1634	4,500,000	—
1661	5,000,000	—
1697	5,400,000 (G.K.)[1]	—
1700[2]	—	5,475,000
1710	—	5,240,000
1720	—	5,565,000
1730	—	5,796,000
1740	—	6,064,000
1750	—	6,467,000
1760	—	6,736,000
1770	—	7,428,000
1780	—	7,953,000
1790	—	8,675,000

	England	Wales	Scotland	Great Britain	Ireland	Population per square mile. Eng. & Wales	Scotland	Ireland
1801[3]	8,331,434	541,546	1,599,068	10,472,048	5,395,456	152	54	166
1811	9,538,827	611,788	1,805,688	11,956,303	5,937,856	174	60	186
1821	11,261,437	717,438	2,093,456	14,072,331	6,801,827	206	70	209
1831	13,091,005	806,182	2,365,114	16,262,301	7,767,401	238	79	239
1841	14,995,138	911,603	2,620,184	18,526,925	8,175,124	273	88	251
1851	16,921,888	1,005,721	2,888,742	20,816,351	6,552,385	307	97	201
1861	18,954,444	1,111,780	3,062,294	23,128,518	5,798,564	344	100	178
1871	21,495,131	1,217,135	3,360,018	26,072,284	5,412,377	389	113	167
1881	24,613,926	1,360,513	3,735,573	29,710,012	5,174,836	445	125	159
1891	27,483,490	1,513,297	4,025,647	33,022,434	4,704,750	497	135	144
1901	30,813,043	1,714,800	4,472,103	36,999,946	4,458,775	558	150	137
1911	34,045,290	2,025,202	4,760,904	40,831,396	4,390,219	618	160	135
1921	35,681,019	2,205,680	4,882,497	42,769,196	—	648	164	—
1931	37,354,917	2,593,014	4,842,554	44,790,485	—	—	—	—

[1] (G.K.): Estimates given by Gregory King in his *Natural and Political Observation and Conclusions upon the State and Conditions of England*. 1696.
[2] The figures for 1700–90 are from the *Abstract of Population and Parish Registry Returns for* 1821. Ordered to be printed by the House of Commons, July 2, 1822.
[3] The first official Census for the whole United Kingdom was taken in 1801 and continued decennially.

CHAPTER V

CLASSIFICATION; QUALITY OF WHEAT

MANY hundreds of kinds of wheat are grown in different parts of the world. They are classified into eleven or twelve groups or races which are sometimes ranked as species. The wheats cultivated in Great Britain belong to two races only, namely, (1) Rivet or Cone Wheat (*Triticum turgidum* L.) and (2) Bread Wheat (*Triticum vulgare* Host).

Very great variation is found among the numerous representatives of the different races, and the classification and description of the vast number of wheats met with in cultivation is a matter of great complexity. The separation into small groups or botanical varieties is, however, comparatively simple, and is based upon certain easily recognisable characters of the ripe ears, which are hereditary or constant from one generation to another. The chief of these upon which the botanical varieties are founded, are: (1) The presence or absence of awns or beards, (2) the colour of the glumes or chaff, (3) the presence or absence of hairs on the glumes, (4) the colour of the awns, and (5) the colour of the grain.

Many ears of wheat are bearded, the flowering glumes bearing long awns often as long or longer than the grain-bearing part of the ear; in a few rare sorts the ears are quite beardless, but in the majority of the so-called beardless wheats, which belong chiefly to the Bread Wheat Race, short awns usually less than 2 or 3 cm. long are found at the tip of the ear. In colour the chaff may be white or yellowish, red, or black, of varying shades, and the surface may be quite smooth (glabrous) or clothed with hairs.

The awns of the ear are not unfrequently of the same colour as the chaff, but sometimes they are black and independent of the chaff tint. The grain also varies in colour; in some varieties it is white or a pale creamy tint, in others some shade of red or brown; a few Abyssinian wheats have purple grains.

All the above-mentioned characters are readily dis-

tinguished, and there is usually little or no difficulty in assigning any wheat to its particular botanical variety.

It is in regard to the further classification and identification of the many forms, selected strains, or commercial sorts which together constitute the botanical variety that much perplexity arises, and it is in the Bread Wheats, which vary far more than other races, that the difficulties are greatest. For example, all the beardless Bread Wheats with white, smooth chaff and white grain make up the botanical variety *T. vulgare*, var. *albidum*, but included in it are a large number of cultivated forms or strains sold by seedsmen and farmers under many names, such as Victor, A1, Wilhelmina and Starling, and it is in the clear and unequivocal differentiation of these that the botanist meets with difficulty. While all the wheats named agree in the characters which distinguish the botanical variety, they differ from each other in habit of growth, time of ripening, height of straw, density of the ear, and many other peculiarities. How far the classification and identification of the different forms of any botanical variety can be carried depends on the hereditary constancy of the characters mentioned and on the certainty with which they can be recognised.

Among the features utilised in the differentiation of wheats of the same variety are the following: (1) Habit of growth of the young plants, (2) colour, height and structure of the straw, (3) time of appearance and ripening of the ear, (4) length and density of the ear, (5) shape and other characters of the empty glumes, (6) shape and size of the grain, and nature of the endosperm, and (7) the phenol reaction of the grain; as investigation proceeds other peculiarities, morphological, histological, and physiological, will doubtless be added to the list.

Some of the characters mentioned are subject to fluctuation, and further research is necessary to determine the influence of the enviroment upon them before their definition and estimation can be made with precision; sufficient, however, is known concerning them for use in the classification and identification of most of the wheats in cultivation.

HABIT

In the slow-growing autumn or winter wheats, the shoots of the young plants in winter and early spring usually lie close to the ground, those of the true spring wheats standing erect; an intermediate group, having young shoots which grow up from the ground at an angle of 45–60 degrees, behave as winter wheats and are best sown in autumn in this country, although some of them succeed if sown as late as the middle of February.

STRAW

The straw of some forms such as Rivet Wheats are solid or completely filled with pith, while that of most of the Bread Wheats is hollow; the hairiness or smoothness of the nodes, the colour of the upper internode, which is sometimes pink, and the height of the straw are useful characters, although the latter is subject to considerable variation.

APPEARANCE AND RIPENING OF THE EAR

The time of emergence of the ear from the upper leaf-sheath exhibits a very remarkable degree of constancy for any particular locality, varying but a few days from one season to another.

At Reading the following dates are recorded for various wheats:

Very early	before	May 24
Early	from	May 24–31
Mid-season . . .	from	June 1–7
Late	from	June 6–15
Very late	after	June 15

The length of time occupied in ripening is also fairly constant, but more subject to climatic conditions which prevail after the ear appears; it is usually eight to nine weeks after emergence of the ear.

LENGTH AND DENSITY OF THE EAR

The average length and the density or closeness of arrangement of the spikelets of the ear are characters of much

importance in distinguishing wheats of the same botanical variety. They fluctuate somewhat with variations of climate, season and soil, and in some cases more than others, yet they are remarkably constant when comparisons are made over a series of years.

The density (D) is defined as the number of spikelets per 10 cm. length of rachis or axis of the ear, and is determined from the following formula: $D = \frac{N \times 10}{L}$ where N is the total number of spikelets of the ears examined, and L the total length of the axes of the ears.

In the following example twelves ears were measured; D the ear-density of the variety $= 28$.

Ears	Length of rachis (cm.)	Number of spikelets
1	9	24
2	9	23
3	9	24
4	8	23
5	8	23
6	8	23
7	8	24
8	9	26
9	9	26
10	8	23
11	8	24
12	9	24
	102	287

$$D = \frac{287 \times 10}{102} = \frac{2870}{102} = 28$$

In the descriptions of the wheats in Part II, the terms of the following table of densities are adopted:

Lax	density below	22
Medium		22–8
Dense		28–34
Very dense . . .	above	34

EMPTY GLUME

Of special value in distinguishing closely allied wheats is the shape of the empty glume, the keel, the form and length of the keel tooth, all of which are remarkably constant within the same line or strain.

In Rivet and some other races of wheats there is a distinct keel from the apex to the base of the empty glume; some Bread Wheats also have completely keeled glumes, but in the majority of this race the keel is only present in the upper half of the glume. A fairly prominent secondary nerve is sometimes seen on the outer face of the glume, which terminates in a blunt projection on its upper edge.

The terminal tooth of the empty glume of Rivet and most beardless Bread Wheats is usually short, and may be acute or blunt, of variable width at the base, and straight or curved inwards; in bearded Bread Wheats the tooth is nearly always longer, and in some cases may be prolonged into an awn reaching a length of two centimetres or more.

The lower and upper empty glumes forming the pair belonging to each spikelet differ slightly from each other, and not infrequently vary in shape and in length of keel tooth according to their position on the ear, the tooth generally increasing in length from the base of the ear to the tip.

The width of the "shoulder" or upper edge of the glume, measured from the base of the tooth to the outer margin, and the slope of the shoulder, vary considerably, the shoulder being in some forms comparatively broad and square, in others narrow and sloping; in addition, the shoulder of the upper empty glume is often broader and less sloping than that of the lower.

Although the glumes from the base, middle, and upper parts of the same ear often differ, a pair taken from an ear of wheat are almost exactly like those of a spikelet occupying the same position on any other ear belonging to the same line of strain, a feature of great assistance when dealing with questions of synonymous forms of commercial varieties.

Harrington, who made an extensive study of the glumes of several strains of Marquis Wheat, concluded that the upper or secondary glume taken from a spikelet situated at a point approximately one-third of the distance between the base and tip of a normally developed ear is most constant and representative of the strain.

I have found it useful to pay attention to both lower

(primary) and upper (secondary) glumes taken from the third or fourth completely developed spikelet of a normal ear, counting from the base, and, as descriptions present difficulty, have given illustrations of both (Figs. 7, 8): the descriptions occurring in the text refer to the secondary glume only.

GRAIN

As previously mentioned (p. 64), wheat grains are of various shades of creamy white, red or brown. They also vary considerably in form and size, and in the appearance of the endosperm. There is little difficulty in placing wheats in groups according to grain colour, and measurements of the average size of normally developed samples can be made. Experts who are constantly handling wheat are able to distinguish the grains of nearly allied forms, but the fine shades of difference in shape, size and colour cannot be clearly described.

PHENOL REACTION

In 1927 Pfuhl showed that the grains of many different kinds of wheat become more or less deeply coloured when treated with a 1 per cent. solution of phenol. Various methods of carrying out the test have been tried; the following gives reliable results: Place fifty grains of the variety to be tested on filter paper in a petri dish 6 cm. in diameter, and pour over them 5 c.c. of the phenol solution; gently shake the grains until their surfaces are wetted, and observe the colour attained at the end of eight hours. The grains of many varieties remain almost unchanged in colour after this treatment, while those of other varieties are coloured varying shades of brown to an almost black tint.

Almost all wheats when left as long as twenty-four to forty-eight hours become equally dark-coloured. There is, however, great and constant difference in the speed and extent of the change of colour among different strains of wheat, when treated in the manner just mentioned, and after eight hours well-marked differences in colour are observed, even among closely allied strains of Bread Wheats. Although accurate estimation of the shade of colour attained presents difficulty, five fairly clear degrees of coloration may be recognised, namely: O, grains unchanged; I, grains very pale brown; II, pale brown; III, brown; IV, dark brown to black. Some English Bread Wheats belonging to the several groups are mentioned below:

Group O: Victor, Mansholt's Wilhelmina.
I: Dutch Imperial, Partridge.
II: Ambrose Standup, Benefactress.
III: Setter, Starling, Iron III.
IV: Yeoman, Million III, Squareheads.

The majority of the Wild and Cultivated Emmers, Macaroni, Polish, and Egyptian Cone Wheats fall in groups O or I.

The test is of great value in helping to distinguish various commercial wheats and in the problems of synonymy.

The characteristic tint of a particular strain of wheat was observed in grains which had been stored for a period of eight years.

The coloration is presumably dependent upon the presence

REFERENCES FOR FIG. 7

RIVET OR CONE WHEATS

(*T. turgidum*)

Var. *iodurum*
1. Blue Cone; Blue Ball

Var. *speciosum*
2. Red Smooth Rivet.

Var. *gentile.*
3. White Rivet.

BREAD WHEATS

(*T. vulgare*)

Var. *erythrospermum*
4. Spring White Chaff Bearded, Form I
5. Spring White Chaff Bearded, Form II.
6. Badger.

Var. *ferrugineum*
7. Welsh April Bearded Red.
8. April Bearded Red or Fern.
9. Webb's Bearded Red.
10. Devon Bearded Red.

Var. *barbarossa*
11. Welsh Bearded Red Rough Chaff.

Var. *albidum*
12. A 1.
13. Ambrose Standup.
14. Setter.
15. Wilhelmina, Form I.
16. Wilhelmina, Form II.
17. Million III.
18. Victor.
19. Starling II.
20. Dutch Imperial.
21. Benefactress.

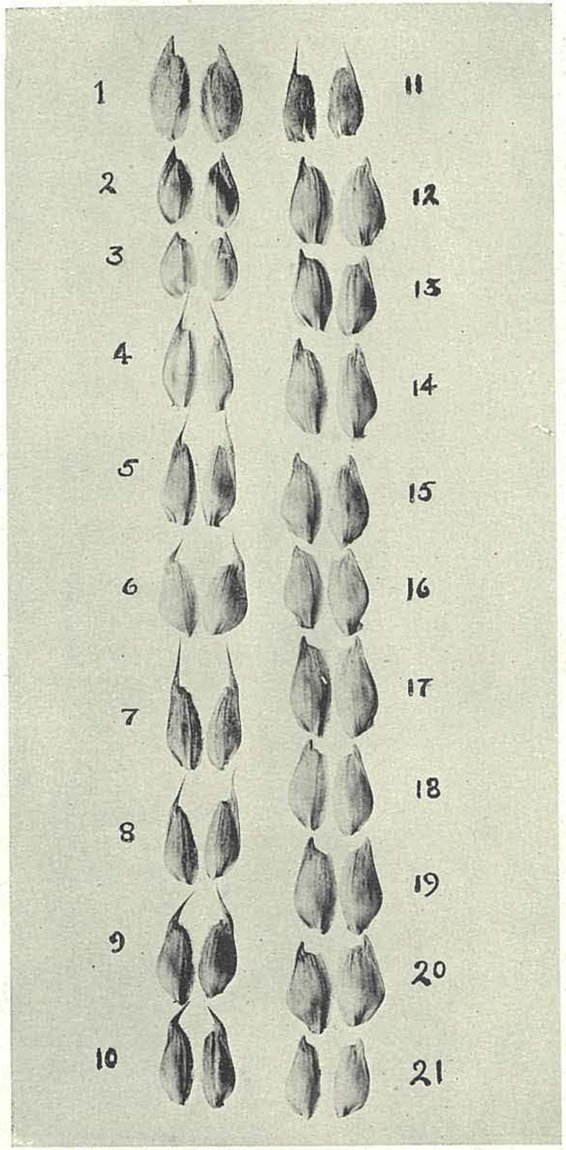

Fig. 7.

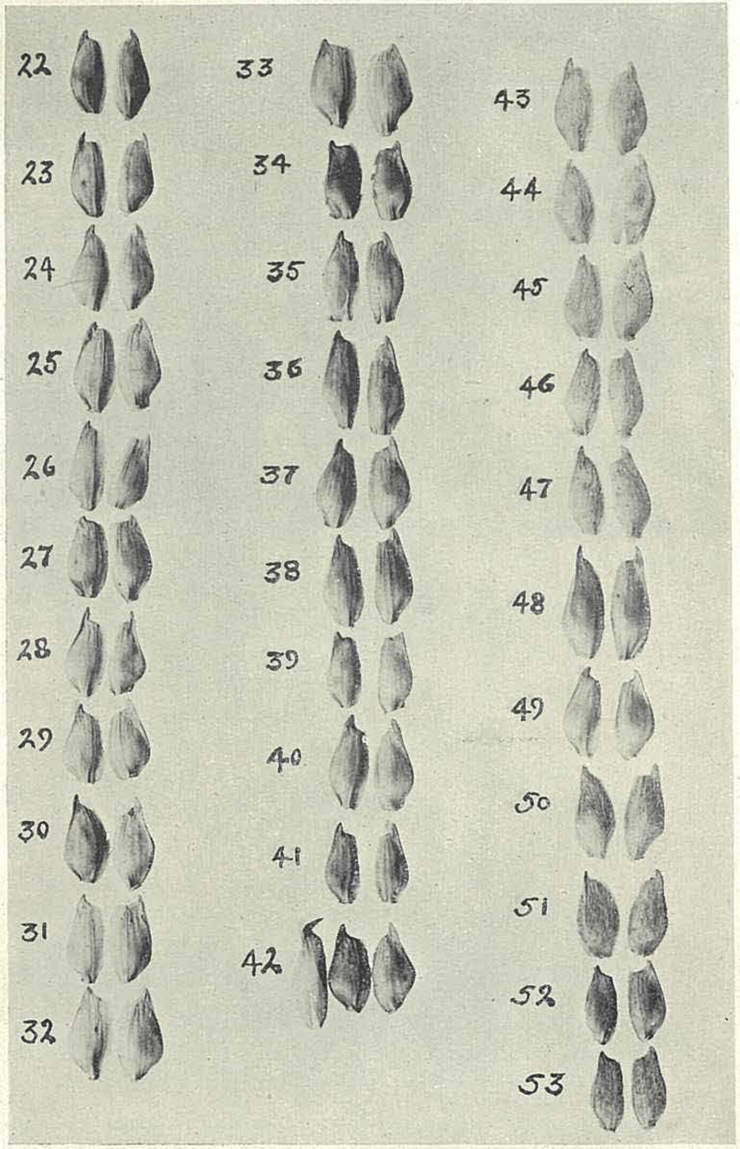

Fig. 8.

of free oxygen, for it does not appear in an atmosphere of carbon dioxide.

There are other characters which may be utilised sometimes as a means of distinguishing varieties of wheat. Among these are the colour of the leaves and immature ears, some being yellowish green, others glaucous or bluish green; the presence or absence of hairs on the leaf-sheaths and nodes of the straw; the erect, sloping or pendent habit of the ripe ears, and various minor features which require further investigation before their diagnostic value can be settled.

Apart from variations in the botanical characters, wheats differ in their suitability to the requirements of the farmer, the miller, and the baker.

THE FARMER

In all wheat-growing regions the primary object of the farmer is to obtain the greatest financial return from the land. In Great Britain, and indeed throughout Western Europe,

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REFERENCES FOR FIG. 8

BREAD WHEATS

(*T. vulgare*)

Var. *lutescens*

22. Hen Wenith Coch (Old Welsh Red).
23. Old Welsh White Chaff Red, 484 (Hen Gymro, 484).
24. Old Cumberland.
25. Red Marvel: Japhet.
26. Devon White Chaff Red.
27. Weibull's Standard.
28. Price's Prolific.
29. Partridge.
30. Iron III.
31. Yeoman II.
32. Squarehead, Form I.
33. Cambridge Browick.

Var. *milturum*

34. Old Welsh Red Chaff, 274 (Hen Gymro, 274).
35. Old Devon Red Chaff.
36. Old Irish Red Chaff.
37. Little Joss.
38. Irish Coney Island Red.
39. Old Welsh Red Chaff, 326 (Hen Gymro, 326).
40. Montgomery Red.
41. Orange Devon Red Squarehead.
42. Squareheads Master; Red Standard, Form 1.

Var. *leucospermum*

43. Rough Chaff White; Old Hoary.
44. Benefactor.

Var. *velutinum*

45. Orange Devon Hoary.
46. Old Welsh Hoary, Form I.
47. Old Welsh Hoary, Form II.

Var. *albo-rubrum*

48. Ideal.
49. Premier.

Var. *pyrothrix*

50. Fox.
51. Red Stettin; Irish Red Velvet Chaff.
52. Old Devon Red Rough Chaff.

Var. *cyanothrix*

53. Orange Devon Blue Rough Chaff

this is only secured by the growth of autumn-sown, winter wheats, varieties with a long growing-period which give the greatest yields of grain per acre.

Many of the wheats cultivated in Great Britain in the eighteenth and first half of the nineteenth centuries were of good bread-making quality. They were, however, discarded later, for the fall in price of wheat and the high cost of rents, rates, labour and other charges compelled the farmer to make yield per acre his chief aim. In consequence, from about 1870 onwards wheats of the heavy-cropping varieties have spread widely, and become the only forms which give an economic cash return to the farmer. Even nearly ninety years ago, it was recognised that yield of crop is of greater significance than quality, and Andrews in his *Modern Husbandry* (1858) wrote: "It should always be borne in mind that those wheats which are more prolific are generally of inferior quality, but as a rule the most prolific is the most profitable." It is important to realise that the price at which wheat sells per bushel, quarter or ton is no guide to its economic value to the farmer; the cash return is what the latter seeks, and this is governed by the combination of yield per acre and the price per quarter. The farmer may rest assured that, of two varieties of wheat, the one for which the miller offers the higher price per quarter will give the lower yield per acre, and calculation will readily demonstrate that the increase in price per quarter will rarely, if ever, make up for the loss in yield.

For example, the yield of a wheat sold to the miller at 50*s*. per quarter was 4 quarters per acre, giving the farmer a cash return of £10, while the yield per acre of another variety for which only 46*s*. per quarter was paid was 5 quarters per acre—that is, a return of £11 10*s*., a gain to the farmer of £1 10*s*. per acre.

At the present controlled price of 20*s*. 1*d*. per hundred weight for all millable wheat, whatever the variety, it is obvious that the one giving the highest yield per acre is the most profitable.

Wheats of the highest milling and bread-making quality, because of their invariably low yield have been abandoned as unprofitable in this country and Western Europe generally. This action is sometimes condemned, but, as N. A. Cobb, the Australian Cerealist, aptly said long ago, "Farmers do not grow wheat for philanthropic reasons; they grow it to make money, and it will be a long time before they grow it for any other reason. . . . Give the grower a new wheat that will bring him more money for his outlay, and he will grow it, whether the consumers starve on it or grow fat."

THE MILLER

Although some of the farmer's crop of wheat may be used for the feeding of his stock and poultry, the main part of it is sold to the miller who converts it into flour from which bread and biscuits are made.

For his purpose the miller requires certain qualities in the sample, and to these he pays special attention when he makes his purchases. The first requirement is that the wheat shall contain a high proportion of millable grain—that is, grain which can be used for the manufacture of flour. It should be clean, uniform, plump, undamaged grain, free from weed seeds, pieces of straw, chaff and other useless material. In some imported wheats the impurities may be considerable, but in wheat grown in Great Britain they rarely amount to more than 1 per cent.

These remarks refer to the general qualities of millable wheat, but it is the yield of flour that can be obtained from a given weight of grain that determines the financial return to the miller, and this is dependent on the bushel weight and the moisture content of the grain. There is a close and direct relationship between bushel weight and the yield of flour; the heavier the bushel weight the greater is the amount of flour that can be obtained from it. On the other hand, the yield of flour varies inversely with the water content of the grain; the damper the grain the less the amount of flour.

The water content of grain is greatly influenced by the climatic conditions at harvest, and the methods of stacking and storage. In Great Britain wheat as threshed not infrequently contains 16–20 per cent. of water, that from countries with hotter, drier climates averaging not more than half this amount. Since there is loss of water during milling, and water cannot be ground into flour, it is obvious that the weight of flour which can be made from a definite weight of damp grain will be less than that obtainable from an exactly equal weight of a drier sample. English wheats generally yield from 67–71 per cent. of flour, those of the highest bushel weight with the lowest moisture content usually giving the greatest proportion. Imported Manitoba wheat with a bushel weight of not less than 62 lb. and a moisture content of 10–15 per cent. usually yields from 70–73 per cent. of flour.

In normal times several grades or kinds of flour are made by millers from imported and home grown wheat, each containing a different percentage of the whole grain.

Kind of flour	*Percentage of the grain included in the flour*
Patents	30
Straight grade	70
Household	80
Old "Standard"	82
Brown	88
Brown	92
Wholemeal	100

At present, in these austere days, a compulsory extraction rate of 85 per cent. is imposed on millers which applies to bread-flours made from imported and home-grown wheat; this works out at 86 to 87 per cent. of the cleaned grain ready for grinding.

The restriction applies also to biscuit, cake and self-rising flours, which ususally contain from 80 to 100 per cent. of home-grown wheat.

The terms "milling quality" and "baking quality" are sometimes used erroneously as synonymous. The terms are, however, quite different. The milling quality refers especially to the amount of flour which can be obtained from a given weight or measure of the grain by the ordinary milling process. On the other hand, as explained later (p. 76), the bread-making quality is related to the number of loaves that can be made from a given weight of the flour, usually a sack of 280 lb.

The weight of flour derived from the grain depends also upon factors, among which may be mentioned the form of the grain and the thickness of its pericarp or coat, as well as

the efficiency of the milling process employed. As ordinarily milled, white-skinned wheats give a slightly higher proportion of flour than red wheats.

Up to about 1880, and even later, wheat was ground between millstones and the colour of the grain was of importance to the miller and baker, for under the best management some of the bran or coat of the grain was ground and the finest particles which could not be separated by sifting affected the colour of the flour. Flour from red-grained wheats was, therefore, never so white as that from white wheats; hence the latter commanded a higher price in the market, and farmers, therefore, preferred to grow white rather than red wheats.

Henry Best, in his Yorkshire farming book, states that in 1641 "white wheat sells for 35*s*. per quarter, 5*s*. per quarter more than red wheat," and the following quotation from the London Corn Exchange, June 13th, 1814, also illustrates the difference in price between red and white wheats at that date:

	Red (per qr.)		*White (per qr.)*
Cambridge and Lincoln wheats	40*s*.	45*s*.	60*s*.
Yorks, Norfolk and Suffolk	52*s*.	60*s*.	68*s*.
Essex and Kent	54*s*.	66*s*.	80*s*.
Scotch	46*s*.	58*s*.	60*s*.
Irish	46*s*.	52*s*.	56*s*.

Similar proportional differences prevailed up to about 1880, after which date colour of grain became of little moment, for in the roller system of milling then introduced, little or none of the bran undergoes fine grinding, and the flour obtained from red wheat may be as white as that from white wheat.

THE BAKER

In all countries the greatest amount of flour manufactured by the miller from the farmer's wheat is sold to the baker, by whom it is made into yeast-risen bread. Lesser amounts, unsuited for bread-making, are supplied to the makers of biscuits, confectioners and pastry cooks.

The chief quality of the flour to which the baker pays the greatest attention is the "strength" and its opposite "weakness," old terms which were in common use at the beginning of the nineteenth century and earlier.

The actual "strength" or bread-making quality of a wheat can only be exactly determined by grinding, followed by a baking test of the flour. It is found, however, that grains of "strong" wheats which are comparatively hard, with a flinty or horny, translucent appearance, easily seen when the grain is cut across, yield flour of good breadmaking quality; on the other hand grains which have a soft, opaque, snow-white interior, yield flour of the "weak" class.

The baker prefers flour of the "strong" class, because the number of loaves which can be made from a given weight of it is greater than from an equal weight of "weak" flour. This arises from the fact that "strong" flour imbibes more water and retains more after baking than "weak" flour, and the water sells as bread. For example, a 280-lb. sack of "strong" Canadian flour will absorb as much as 80 quarts of water, and from the dough 400–40 lb. of bread (100–10 4-lb. loaves) can be baked; a sack of the same weight of flour made from an average English wheat will not take up more than about 62–4 quarts in preparing a dough of the right consistency for baking, and the yield of bread will not exceed about 360 lb. (90 4-lb. loaves). Since the weight of flour is the same in both cases, it is clear that the larger amount of bread made from the "strong" Canadian flour is due to the water which it contains. The water content of bread made entirely from "strong" flour milled from foreign wheat may be as high as 40 per cent., that of bread from flour of all-English wheat rarely reaching 30 per cent.; thus a loaf from English wheat has more flour in it than a loaf of the same weight made from a "strong" foreign wheat. Nevertheless, in spite of these facts, the baker is unable to sell loaves made from average English wheats, for "strength" of flour not only influences the number of loaves which can be baked from a sack of it, but has a very decided influence on the size of the loaves obtained. The flour of a "strong" wheat gives large, upstanding, porous loaves, while the loaves made from "weaker" flour are small, flat, and comparatively dense in texture. The size of the loaf is of psychological value to the baker, for he is aware that it is difficult for the consumer to avoid taking the larger of two equally-priced loaves of the same weight, yet in making the choice the buyer may, indeed, be getting less food for his money.

It will be asked: Why does not the English farmer grow "strong" wheats like those of Canada and the United States, especially since the miller is prepared to pay a higher price per quarter for wheats of this class? The answer is that such wheats can, indeed, be readily grown in this country, but their yields are too low to be remunerative to the farmer under the economical conditions which prevail here.

As previously mentioned, most of the home-grown wheats yield flour of the "weak" class, admirably suited for the manufacture of biscuits, and much is used for this purpose. In addition considerable amounts are employed in the feeding of poultry; in some counties more than half of the quantity grown there may be absorbed in this manner.

The demand for these two purposes is soon satisfied, and the remainder when ground by itself yields flour of little or no use for breadmaking. The miller, however, is able to sell it to the baker, his best customer, for breadmaking by blending with it a variable proportion of "strong" imported Manitoba wheats or similar varieties from other countries, and it is the flour from such mixtures that we find in the loaves which come to our tables daily.

The practice of blending "weak" with "strong" wheats is adopted in all countries where both types are grown.

Attempts have been, and are being made in many countries, to secure varieties combining high yields with good bread-making quality by crossing individuals from the two classes, and a certain amount of success in this direction has been achieved, as in the Yeoman varieties introduced by Sir Rowland Biffen, which under certain conditions crop well and possess a "strength" considerably above that of ordinary English wheats.

CHAPTER VI

IMPROVEMENT OF WHEATS

In considering the kinds of wheats cultivated by succeeding generations, it is observed that old kinds are replaced by new ones better suited in one way or another to the needs of the farmer. The new sorts may be superior in quality or yield, they may be more resistant to diseases, or may possess some other useful character not found or present in lesser degree in the older kinds. Whence come these new varieties? To the ancients they were the "gifts of the gods," an expression which is indeed the very essence of truth, for in the majority of cases man has discovered them ready made and has had no part in their production.

The old Chidham wheat grown in this country from about 1800 to 1880 or later was derived from a single ear found growing in a hedge at Chidham in Sussex; the variety Fenton, also an excellent sort much cultivated last century, was discovered by Mr. Hope of Fenton Barns, Scotland, in a quarry in 1835, and the famous Fife wheat of Canada and the United States was started from a single plant grown from a sample of Dantzig wheat sent by a friend from Glasgow to David Fife in Ontario about 1842.

Patrick Shirreff, who introduced several new kinds of cereals during last century, used to examine fields of growing crops for individual plants superior to the rest, and his best introductions were thus discovered.

By far the greater number of the best kinds of wheats which have been grown by farmers during many generations have begun in the manner indicated. The exact mode of origin of these superior plants is quite unknown, and all that mankind can claim in regard to them is their recognition, isolation, and propagation, not their production.

As an example of the method and time taken to develop a useful stock of a new variety from a single plant, the following account given by Marshall in 1788 in his *Rural Economy of Yorkshire* (Vol. II, 6) is of interest: "A man

whose observation is ever on the wing in the field of husbandry, having perceived in a piece of wheat a plant of uncommon strength and luxuriance, diffusing its branches on every side, and setting its closely surrounding neighbours at defiance, marked it, and at harvest removed it separately.

"The produce was fifteen ears, yielding six hundred and four grains of a strong-bodied, liver-coloured wheat, different in general appearance from every other variety I have seen. The chaff smooth, awnless. . . . The straw stout and reedy.

"These six hundred grains were planted singly nine inches asunder, filling about forty square yards of ground; not in a garden or in a separate piece of ground, but upon a clover stubble; the remainder of which was at the time sown with other wheat in the common way; by which means *extraordinary trouble* and *destruction by birds* were equally avoided.

"The produce of these forty yards was two and a half gallons, weighing twenty pounds and a half, of prime grain fit for seed, besides some pounds of seconds. One grain produced thirty-five ears, yielding twelve hundred and thirty-five grains.

"The second year's produce being sufficient to plant an acre of ground, the variety was of course, sufficiently established."

Another example of the rapid propagation of a stock of wheat from a single ear may also be mentioned. In 1838 Mr. Jonas of Liverpool sowed fifty grains from a selected ear; thirty of these produced plants from which $14\frac{3}{4}$ oz. of grain were obtained. This grain was carefully sown and from it $1\frac{1}{2}$ bushels were produced in 1839, which returned 45 bushels in 1840; the latter crop was used as seed and gave 537 bushels in 1841, four years after the selection of the single ear.

"PURE LINE"; "SINGLE LINE"

Before discussing the attempts to secure improved wheats by selection of plants from a "pure" or "single" line, reference is necessary to the origin and meaning of the terms.

In 1901 Johanssen of Copenhagen carried out a series of investigations on the weight and size of the seeds of an old-established commercial variety of Dwarf Bean (*Phaseolus* *vulgaris*, form *nana*) known as the Brown Princess Bean. The bean is a self-fertilised species, and the particular variety used in Johanssen's researches had been grown for a long time on the Danish island of Fühnen.

Johanssen raised progeny from single beans, selected from a sample of the commercial stock, and discovered that the average seed-weight of the progeny from several of the selected beans was different, the descendants of some of the beans having a high, others a comparatively low, average seed-weight.

Although the crop from which the seeds were derived was a so-called "pure stock," Johanssen concluded from his researches that it was in reality a "population" or mixture of several distinct "lines," each line characterised by a different average seed-weight, which was hereditary, remaining pretty constant during the period of two years in which the experiments were carried out. In the account of his work first published in 1903, two years after the commencement of the researches, Johanssen introduced the term "pure line," defining it as the "individuals which have sprung from a single self-fertilised individual." Later, in 1906 (Intern. Conf. on Genetics, 3rd Report, p. 103), he introduced into the definition the conception of homozygosity, saying that "pure lines" are "the individuals descending from one single homozygotic individual. Pure lines are only to be had in organisms with self-fertilisation—or parthenogenesis."

" 'Pure line' is a mere geneological term; different authors have unfortunately misconceived this meaning, and confounded 'pure lines' with 'types,' 'small species,' and other such things. I must energetically protest against this misinterpretation of my term 'pure line.' It indicates nothing more than the warranted purity of descent. By mutation or segregation new types of gametes can be formed within pure lines as well as in geneological hybrids, the line remains nothwithstanding as pure as before in the geneological sense."

From this it is seen that the term "pure" is intended only to convey the meaning that the line or collection of descendants constituting it has arisen from a single self-fertilised individual, and has nothing to do with the constancy or the variability of the individuals of the line, although it has

frequently been taken to imply some kind of invariability, a view which the introduction of homozygosity into the definition has fostered.

"Pure line" is an unfortunate term, and should be discarded in favour of the term "single line," which satisfies Johanssen's original definition, and avoids unjustifiable implications which the word "pure" seems to convey.

The variations occurring within single lines may be qualitative or quantitative. Examples of quantitative variations, or variations affecting characters which can be measured or weighed, are changes in the weight or size of seeds and the height of plants. As is well known, the many individual beans produced by a plant raised from a single seed are not all of the same weight or size, seeds of many different weights and sizes being found among the offspring. Moreover, the weight of any particular bean is not inherited, for among its many descendants are found beans both larger and smaller than the parent seed. Such non-hereditary variations are termed "fluctuations," and are in great measure dependent on the position of the seeds in the pod, variations in soil and climate in which the plants are grown, the time of sowing of the seed, and other conditions.

Johanssen's investigations were specially concerned with the quantitative variations in the weight and size of the seeds descended from single beans which he selected from the original stock of the Princess variety. The lines or progeny of nineteen selected seeds were kept separate and the average or mean seed-weight of the descendants in each line was determined during three seasons. As previously noted, these proved to be more or less different from each other. Line I with the highest, and Line XIX with the lowest mean seed-weight were investigated further. From each line a number of the largest and a number of the smallest beans were again selected and sown, and the mean seed-weight of their progeny determined during six successive generations. Johanssen discovered that the mean seed-weight of the descendants of a large bean differed very little from that of a small bean of the same line, and concluded that although there were wide fluctuations in the seed-weight of the descendants when compared with the weight of the individual seeds from which they came, the average seed-weight was a hereditary constant for each line.

Repeated selection of heavy seeds descended from a single ancestor did not lead to the establishment of a line in which the mean seed-weight was higher than that of the original parent line, nor was a small-seeded line with a lower mean than that of the original parent secured by the isolation and propagation of small seeds in succeeding generations.

From these results it has been concluded that selection, within single lines, of individual plants showing differences in quantitative characters, in order to obtain lines with higher or lower means than those of the parent line, is without avail and useless; it is time that this view was revised, for it can only be true if mutation in respect of quantitative characters does not occur in single or "pure lines," which is not correct. Selection carried on for six seasons, and that only upon two of the selected lines, is not sufficient on which to base such far-reaching deductions as have been made in some quarters. This comment is amply justified, for Johanssen himself selected and isolated in 1905–6 from one of his "pure lines" two new hereditary lines, one with shorter and wider, the other with longer and narrower seeds than those of the parent line; quantitative mutation had occurred, since accidental crossing was ruled out as an explanation, for the flowers both of the parent line and those of the two new lines were all white.

In addition to the discovery of hereditary quantitative variations within his "homozygous pure lines," Johanssen observed the appearance of a plant showing a qualitative difference from the parent line, having leaves of a pale green, instead of the normal green tint, the character proving constant for several generations. In this case selection within the pure line was effective and easy, since it involved none of the difficulties encountered in the laborious work of selecting and separating hereditary quantitative differences from fluctuations.

Both quantitative and qualitative hereditary variations are now found to be not uncommon in single lines, and their occurrence amply justifies the continuation of selection within such lines as a means of establishing new and improved strains.

Johanssen made no suggestion regarding the origin or cause of the multiplicity of the different "pure lines" in the stock of the old Princess variety from which he selected his nineteen lines. The variety had long been grown on the island of Fühnen, and there is nothing to show that the nineteen beans from which he began his nineteen lines were not descendants of one and the same original line. To state that they could not have come from the same pure line because their descendants had a different average seed-weight is a crude but not uncommon way of settling the question at issue. Only carefully conducted large-scale experiments over longer periods than hitherto attempted will furnish an adequate explanation of the existence of mixed populations in practically all old stocks of cultivated plants.

The progeny descended from a single ear of any of the commercial varieties of wheats which have been long in cultivation is always more uniform in its characters than the unselected stock from which the ear is chosen. Moreover, the progeny retains its striking uniformity in the field for a considerable time, which varies with the particular variety under trial, and this is true where every care is observed to avoid accidental mixing with varieties from thrashing machines and other sources of contamination. Ultimately, however, whatever precautions are taken, variation sets in and the uniformity is lost; in time the progeny becomes a population of lines with different hereditary character, such as the population of different lines found by Johanssen in the old commercial pure stock of the Princess bean on the island of Fühnen, and I venture to think that the progeny of any one of Johanssen's isolated "pure lines" would become a similar complex mixture of lines exhibiting hereditarily different characters if propagated long enough on a large scale.

How the diversity arises is at present beyond our knowledge, but it may be assumed that the causes, whatever they are, which lead to the variations in these cases, are always at work in our highly cultivated fields, and the study of the different forms to be found from year to year among crops of wheat and other plants raised originally from single seeds is worthy of more attentive study than has been devoted to it.

SINGLE LINES OF WHEAT

For more than thirty years, short rows of ten to twenty plants have been raised at Reading annually from single ears of about 1,200 distinct forms representing all races of wheat, small samples of each year's progeny being reserved for reference and comparison. Each generation was raised from an ear of the generation immediately preceding it.

Examination of the material shows that in any single line the ears of the plants raised in the last year of the period stated, resemble with great fidelity those of the ears of the first generation in length and density, colour of chaff, form of empty glume, length of awns and other characters.

It has been argued from this kind of evidence that single lines do not vary, or that hereditary variations within them are of rare occurrence; it must, however, be remembered that the total number of plants of any single line raised during the whole thirty years was not more than 500 or 600. Moreover, every endeavour was made to preserve the variety and only typical ears were chosen annually for propagation; it is to this careful selection that the similarity of the first and last ears is to be attributed, and not to the immutability of the line. Every year obvious deviations from the type arise in some ten or twenty of the lines of the 1,200 or more which are grown, and occur more frequently in the 42-chromosome Bread Wheats than in any other race; they are almost always single plants in the row, and, are, of course, not used for propagation of the line. Many of them have been studied and found to be natural hybrids exhibiting ordinary Mendelian segregation in the F_2 generation; a small number, doubtless mutations, differ from the type in a single character only, and retain the character for many generations.

In addition to the annual propagation and study of small plots of a very large number of different wheats, commercial stocks of five or six new varieties have been raised at Reading, commencing in each case with a single ear; it has been observed in all these varieties that when 5 or 10 acres of descendants have been produced, many obviously different variations are seen in the fields; this is the experience of workers in many countries who have practical aquaintance

with the raising of new varieties of Bread Wheats. Some of the variations observed are quite stable, and differ from the original ear in a number of characters; these are, doubtless, accidental contaminations which have been introduced through imperfectly cleaned thrashing machines or drills, or have been brought to the fields in unclean sacks or carried by birds from adjoining areas.

Other variations when grown exhibit Mendelian segregation, and are undoubtedly natural hybrids. In addition to these two classes of variations, a small number of plants are discovered which differ in single characters only from the type grown. For example, sooner or later in a bearded form named "Badger," there appeared a small number of plants exactly like "Badger" in length and density of ear, shape and colour of the glumes, but with beardless ears which proved constant in respect of beardlessness; such variations are "sports" or mutations, which, although more frequent in some varieties than others, can be found among the descendants of single lines of any Bread Wheat in greater or lesser numbers, provided that a large progeny is reared.

Accurate and extensive investigations have nowhere been undertaken to determine the relative numbers of the three classes of variations—accidental contaminations, hybrids, and mutations—which are found in fields of single line crops, but observations at Reading point to the conclusion that the first class is very rare among progeny of small rows grown and controlled in experimental cages; hybrids under these conditions have averaged about ten to fifteen per 10,000, while mutations have never amounted to more than about one or two per 10,000 plants.

Where only a few plants are grown annually under controlled conditions, the chances are great that many years would elapse before a single mutation would be observed, and the conclusion that hereditary variations do not occur in single lines might appear reasonable. A different conclusion, is, however, always reached when observations are made on single lines which have attained the stage of field culture—usually in four or five years—for by this time the descendants of the line amount to many millions of individuals and the number of mutants, in spite of their comparative rarity, are sufficiently numerous to be readily detected when large numbers like this are examined. The selection of such mutants and their cultivation are examples of the usefulness of selection within "pure" or single lines. The process is simple and certain in the case of mutations affecting morphological characters, since these are easily recognised, and although little or nothing is known concerning the number and extent of mutation affecting the quantitative characters of yielding-capacity and similar peculiarities of greater economic importance, there is nothing against the belief that mutations of this class are just as frequent as the other, in which case selection would be equally effective though more difficult, owing to the trouble of distinguishing hereditary mutations from non-hereditary fluctuating differences.

The variations of the cultivated Bread Wheat plant with its forty-two chromosomes are almost endless, and the "pure line" completely homozygous in all characters, if it exists at all, must be so rare that the likelihood of a plant breeder meeting with it must be very remote.

MASS SELECTION AND PEDIGREE SELECTION

The reservation of the best ears of a crop and the selection of the largest grains were recommended by the ancient Roman farmers; others in more recent times have advocated with success the method of "mass selection" for the improvement and preservation of their cereal crops. Instead of choosing a single ear or plant, a number of the best, ripe ears are selected from the field and their grains sown. From the progeny a further choice of a number of exceptional ears is made, and the process is repeated annually; an improved strain is established superior in yield to the unselected stock from which the original selections were made.

Another more circumscribed method of selection known as the "pedigree" system which was especially practised by Major F. F. Hallett during many years of last century, aims at the repeated selection and propagation from the best grain of the best ear of the best plant, increased yield being the chief object. Beginning with an ear of Red Nursery wheat, he sowed its grain and from the progeny selected the best ear of the most prolific plant; the produce was sown, and a similar choice made of the best ear of the best plant of the progeny, the process being repeated annually. While the annual selection was maintained, propagation of each year's improved stock was carried on, and the seed corn which he supplied proved of exceptional merit, both in regard to yielding capacity and purity of strain. The process has the merit of maintaining the purity of the variety, and should either large or small mutations in respect of superior yielding capacity arise, the method will certainly find them.

HYBRIDISATION

In addition to the methods already discussed, crossing or hybridisation is also carried on with the object of securing improved wheats.

The first experiments in the crossing of wheat in this country appear to have been made about 1793 by T. A. Knight, who states that he obtained hybrids by natural crossing among varieties grown close together. Of these he remarks, "some . . . were excellent, others very bad, and none of them permanent."

Hybrid wheats were exhibited in 1846 by Mr. Maund of Bromsgrove at a meeting of the English Agricultural Society, and in the same year Hugh Raynbird produced the hybrid Piper's Thickset ♀ × Hopetoun ♂, the female parent a red-chaffed wheat with short, dense ears, the pollen parent a lax-eared form with white chaff. The descendants of Raynbird's cross were very variable, but one of them was awarded a gold medal by the Highland Society of Scotland in 1848.

The most assiduous worker in the field of cereal improvement in Great Britain during the last century was Patrick Shirreff of Haddington, in Scotland, who made numerous selections of "sports" appearing in field crops in different parts of the country, and between 1856 and 1870 produced a number of hybrids, none of which, however, proved superior to the varieties in common cultivation.

According to some records, crossing seems to have led to the immediate production of wheats of improved character which were apparently constant and only needed large-scale propagation before distribution to the farmer; however, in most instances in wheat, as in other plants, hybridisation results in the production of an unstable, variable progeny, out of which it is hoped that a selection can be made of forms possessing superior yielding power, grain of higher bread-making quality, or other desirable features.

Since the discovery of some of the laws of inheritance by Mendel and their application by more recent workers, some of the obscurities attending the hybridisation of plants have been cleared away, and the extent and manner in which many of the characters of the parents are distributed among their hybrid offspring are beginning to be understood.

Through the knowledge now attained it is possible to combine in one plant some of the characters found in two or more individuals. For example, on crossing a white-chaffed, bearded, with a red-chaffed, beardless wheat, in the second generation of the progeny will be found not only plants like the parents of the cross, but individuals with red-chaffed, bearded ears, and plants with white-chaffed, beardless ears, new combinations of the original parental characters. Similarly, by crossing a white-chaffed, white-grained wheat with a variety having red chaff and red grain, plants with red chaff and white grain, as well as individuals with white chaff and red grain can be secured.

Not only is it possible to obtain varieties with new combinations of the few simple parental characters indicated, but the number of them which will breed true to these characters can be predicted and selected with certainty.

Unfortunately, the mode of inheritance and the transmission of physiological characters such as frost and disease resistance, high yielding capacity, bread-making quality of the grain, and other features on which the economic value of the different wheats depend, are much more complex and much less understood than the inheritance of the colour of the chaff, awns, or grain and morphological characters generally.

Yield, which is of such vast importance, is so largely influenced by rainfall, temperature, soil and other conditions of the plant's environment, that intrinsic differences in the hereditary nature of two wheats in respect of this character may become completely obscured by the external conditions

of growth. Moreover, the combination of high yield with other desirable characters presents many difficulties; nevertheless, progress is being made, and as examples of the work already accomplished in this field may be mentioned the Yeoman and Little Joss wheats of Sir Rowland Biffen, which, in a certain degree, combine good yielding capacity with high bread-making quality.

THE NAMES OF WHEATS

In the earliest days of agriculture, doubtless, wheat was simply wheat, but more than two thousand years ago the Greek botanist Theophrastus refers to early and late varieties, varieties with short dense ears, others with large lax ears, and states that many kinds take their names from places where they grow, as, Libyan, Pontic, Thracian, Assyrian, Egyptian and Sicilian. In mediæval times in this country, many of the wheats were also named after the districts in which they originated or were first grown, such as red, yellow and downy Kent wheats, Hertfordshire White, Zealand White, Burwell Red, and Taunton White. Others, as Lammas, derived their names from the period at which they ripened, while some, as April Red, took their names from the time at which they were usually sown.

By the end of the eighteenth century the names of wheats had increased enormously, and Banister in 1799 states that the names of the beardless wheats "are endless," and remarks that "there is scarcely a market town but has a favourite species, which having been successfully cultivated by some farmer in the neighbourhood, is by him designated with a pompous title, and becomes the fashionable grain; whilst, in most instances the variation is so very trifling as not to entitle it to any superior regard."

In the middle of the last century, not far short of a hundred different names were being applied to the wheats in cultivation in England, but how far these represented really distinct kinds it is not now possible to determine. From the specimens and descriptions which exist, it is clear that there were many well-defined sorts; some, however, were strains of a single form to which different names had been given.

At the present time fewer really different kinds are grown, but the number of names has not diminished much; synonyms, or different names for the same wheat, and homonyms, or the same name for different wheats, are abundant. For example, many different names have been given to wheats which cannot be distinguished from the old Squareheads Master, and the name Browick has been applied to two or more varieties, some with red, others with white chaff: similarly the name Red Standard has been given both to a white and a red-chaffed variety.

In some instances farmers and seedsmen have raised stocks of well-known sorts from a single ear, or by the method of mass selection; they may also have given much attention and care to the cultivation of an old variety of wheat for a great many years, and feel justified in giving a new name to the forms so improved. How far this practice is to be defended or condemned is difficult to decide.

PART II

CHAPTER VII

WHEATS OF GREAT BRITAIN

THE wheats grown in Britain at the present time belong to two Races, namely: (1) Rivet or Cone Wheats (*Triticum turgidum* L.) and (2) Bread Wheats (*Triticum vulgare* Host), by far the greater number of varieties belonging to the latter.

I. RIVET OR CONE WHEATS

(*Triticum turgidum* L.)

The wheats of this Race have tall, reed-like straw, either solid and filled with pith or hollow with thick walls. The leaves of the young plant are narrow, and covered with soft velvet-like hairs; the ears are large, square in section, and the spikelets well-filled, many producing four grains each. The grains are generally plump, blunt at the tip, with a characteristic hump on the dorsal side just above the embryo, and the endosperm or floury portion of the grain is soft and white. The hairs of the "brush" or apex of the grain are shorter and finer than those of the Bread Wheats, *T. vulgare*. Flour produced from these wheats is not fitted for the manufacture of bread, as loaves made from it are dense and nonporous; it is, however, adapted for biscuit making, and is used also for mixing with the flour of Bread Wheats.

The majority of the Rivet Wheats are delicate kinds grown chiefly in countries bordering the Mediterranean. A few, however, are hardy enough to withstand winter in the southern half of England. As a class they are the most prolific of all wheats, giving large yields of grain when the conditions for growth are favourable. They are also highly resistant to rust, smut and bunt diseases, and the ears are not so readily attacked by sparrows on account of their coarse, scabrid beards. At the present time only two or three varieties are found in this country, but in the seventeenth and eighteenth centuries several sorts were cultivated here under the names Red and White Rivet; White Grey and Red Pollard; White, Grey and Blue Cone; Grey and Blue Poll; Duckbill, Dugdale and Dunover Wheats. In some varieties the ears hang downwards, on which account they were given the name of Pendule or Pendulum Wheats in Berkshire and Oxfordshire in the eighteenth century.

The origin of the name Rivet is unknown. Its first recorded occurrence is in Tusser's *Fiue Hundred Pointes of Good Husbandrie* (ed. 1580), where he says:

> "White wheat or else red, red riuet or whight,
> far passeth all other, for land that is light,
> White pollard or red, that so richly is set,
> for land that is heauie is best ye can get."

From Tusser's time to the middle of the eighteenth century the name is spelt Rivet, but towards the end of that period and in the early part of the nineteenth century the names revet and revit are frequent, together with revitt, Revits, Revitt's and Rivett's, under which last name it appears in most seedmen's catalogues to-day.

The term Cone applied to these wheats is not found in Tusser, but a seventeenth-century specimen labelled Cone wheat is in the Morisonian Herbarium at Oxford; writers on agriculture in the eighteenth century frequently mention Cone wheats, and some of them suggest that the name refers to the shape of the ear, which tapers slightly from the base upwards.

The following varieties of Rivet or Cone wheats are grown in England or have been cultivated here in recent times.

1. *T. turgidum*, var. *iodurum*

Ears bearded; chaff, hairy, bluish-grey, sometimes foxy; grain red

1. Blue Cone; Blue Ball; Blue Poll (Fig. 9).

Young shoots: prostrate; leaves narrow, pubescent.

Straw: tall, 115–30 cm. (45–51 in.) up to 60 in. high, striate, the upper internode solid or nearly so; strong and elastic, the crop rarely becomes laid.

Ear: 8–9 cm. long, dense, square, 12–14 mm. across the face and side, tapering slightly to the tip, pendulous when ripe; awns scabrid, 10–11 cm. long, dropping off when dead ripe; spikelets, 25, well-filled, frequently with four grains in each; D = 30–32.

Empty glume: hairy, ashy blue with a reddish tinge in some seasons, the particular tint being due to the presence of white hairs covering a black or brownish glume; 8 mm. long, oval, with an acute apical tooth, 1–1·5 mm. long.

Grain: ovoid, yellowish red, plump, apex blunt, dorsal ridge prominent, endosperm opaque, white and soft; flour very weak; 7 mm. long, 3·8–3·9 mm. broad; phenol reaction III.

A very late wheat.

Blue Cone is an old wheat cultivated often in the seventeenth century and the variety of the Rivet Race most commonly grown at the present time.

In the eighteenth century it was known in many districts as Blue Cone or Blue Poll wheat; in Essex it was called Grey Poll, in Hertfordshire, Duckbill and Dugdale wheat, while in Huntingdonshire it had the name Dunover wheat.

A selection raised from a single ear by the author is widely grown.

On account of its long growing period, sowing should not be delayed beyond the middle of October; according to an ancient rule it gives the best returns when sown a fortnight before Michaelmas or earlier.

Blue Cone tillers so freely that 2 or 2½ bushels are sufficient seed for an acre. During winter and early spring its shoots and leaves lie very close to the ground, and at these periods a field of it shows a very marked contrast to one of any variety of Bread Wheat sown at the same time, for it appears comparatively bare, and farmers unacquainted with this peculiarity are inclined to plough it up; its extraordinary vigour is, however, revealed later.

The ears of Blue Cone are heavy, and well-filled from base to tip, a single ear not infrequently yielding 90–100 grains or more. When ripe they bend downwards becoming almost parallel to the straw, and most of the awns drop off. As the grains are somewhat firmly enclosed by the chaff in unripe ears, it is important that cutting should not take place until the crop is almost dead ripe, for unless this practice is observed, clean thrashing of the grain from the chaff is difficult, a character well known to the old farmers who thrashed with the flail.

On the heavier, well-drained soils, in warm districts this variety gives a higher yield than almost any other wheat.

2. In some forms from Essex the black pigment of the glume is reduced in amount, and the ear has a whitish or pale mouse-coloured tint.

2. *T. turgidum*, var. *dinurum*

Ears bearded; chaff hairy, foxy red; grain red

1. Rivet (Fig. 10).

Almost all the wheats bearing this name collected from various parts of England proved to be forms of Blue Cone (var. *iodurum*). A few, however, possessed the somewhat smaller, reddish ears of the true Rivet.

In habit, straw, ear, and glume characters, as well as in form, size, and quality of grain, Rivet resembles Blue Cone, and commercial stocks usually contain both varieties.

A very late wheat.

2. Rampton Rivet.

A typical example of old Red Rivet mentioned by Tusser in 1580. It is a selection made by Sir Frank Engledow at the Cambridge University Plant-breeding Institute from over 1,000 single plants of Rivet collected during 1928 and 1929. By plot observation and yield trials the numbers were reduced to four and Rampton Rivet was the final choice, the ear from which the stock was developed having been selected from a field in the parish of Rampton.

It was first distributed by the National Institute of Agricultural Botany in 1939.

3. *T. turgidum*, var. *speciosum*.

Ears bearded; chaff smooth, red; awns red; grain red

Red Smooth Rivet (Fig. 11).

Young shoots: prostrate; leaves narrow, pubescent.
Straw: about 127 cm. (50 in.) in height, upper internode solid.
Ear: 7–9 cm. long, very dense, square, or oblong in section, 12–15 mm. across the face, 15 mm. across the side; awns red, 12–15 cm. long; spikelets 26; D = 34–7.

Empty glume: smooth, slightly glaucous, pale chestnut red, about 7–8 mm. long, 4 mm. broad, with short, acute, apical tooth, 1–1·5 mm. long.
Grain: ovoid, large, reddish orange, narrowed towards the apex, dorsal ridge prominent; endosperm soft, white, opaque; flour weak; 7·5 mm. long, 3·8–3·9 mm. broad; phenol reaction III.

A late wheat found in a field of Rivet at Hessett, Suffolk.

4. *T. turgidum*, var. *gentile*

Ears bearded; chaff smooth, white; awns white; grain red

White Rivet (Fig. 12).

Young shoots: prostrate; leaves narrow, pubescent.
Straw: tall, about 127 cm. (50 in.) high; upper internode solid.
Ear: 7–9 mm. long, dense, square in section, 13–15 mm. across the face and side; spikelets 26; awns 10 cm. long, white; D = 32–7.
Empty glume: creamy white, smooth, 7–8 mm. long, 4 mm. broad, with short, acute apical tooth, 1 mm. long.
Grain: ovoid, pale orange red, shorter and narrower than most varieties of English Rivet Wheats, pointed at the apex, dorsal hump prominent; endosperm white, opaque and soft, flour weak; 6·8 mm. long, 3·4 mm. broad; phenol reaction III.

A late wheat, grown in the sixteenth century and formerly common, but now chiefly found as an impurity among other Rivet wheats. In recent times I have only seen this variety in Suffolk.

5. *T. turgidum*, var. *buccale*

Ears bearded; chaff pubescent, white; awns white; grain red.

An example of this variety found growing in Essex, was sent to me by Messrs. Marriage, Corn Merchants, Colchester.

II. THE BREAD WHEATS

(*Triticum vulgare* Host)

Although it is possible to make bread from the flour of all kinds of wheat, practically all the bread used by mankind is manufactured from the flour of the wheats of this Race.

Loaves prepared from these wheats expand to a larger size, and are more uniformly porous and more digestible than loaves made from flour of the Rivet, Macaroni, or other Races of wheat. Moreover, in flavour, colour and texture of the crust, and other qualities, such loaves are more attractive to the consumer.

The Bread Wheats constitute by far the greatest and most important Race and have the greatest range of distribution, being grown in countries near the Arctic Circle, as well as at high elevations in the tropics. There is also a greater range of variation among the Bread Wheats than any other Race, and more than a thousand different forms are known. These vary much in their resistance to diseases, frost, and adverse conditions of soil and climate, and also in the length of their growing period. Some varieties are specially adapted for sowing in spring in countries and districts with a short summer, while others can be sown in autumn, withstanding a moderate amount of frost, and, in regions where a long growing-period is possible, give a correspondingly high yield of grain.

In the slow-growing autumn or winter wheats the shoots of the young plants usually lie close to the ground, those of the rapid-growing spring sorts standing erect, an intermediate group suitable for sowing in England in autumn or early spring (to the end of February) having young shoots which grow up from the ground at an angle of 45–60 degrees.

The straw of the Bread Wheats is generally hollow, and varies in height from about thirty inches to five feet or over.

Both bearded and beardless varieties are found, and the ears vary in length from $2\frac{1}{2}$ inches to 7 inches or more. The average number of spikelets in an ear of most English wheats of this Race is 22 or 23, each spikelet having from two to six grains in it according to the variety and character of soil and season.

(*a*) BEARDED VARIETIES

Among the bearded varieties of Bread Wheat are found many which possess excellent bread-making qualities, and are grown in various parts of the world, especially as spring sown crops in countries with cold winters and hot summers.

In Great Britain, bearded varieties have never been extensively cultivated, and are almost entirely discarded at the present time. This neglect is due to the fact that although the grain is of good quality the yield per acre of most varieties is too low to be remunerative, and the awns on the ears render the chaff—an important item to the farmer here—of little or no value as food for stock.

One or two bearded forms are grown on small areas in Wales and other districts as spring sown crops, and one or two winter forms are still cultivated on account of their good yield and partial resistance to the attacks of sparrows and other small birds.

1. *T. vulgare*, var. *erythrospermum*

Ears bearded; glumes white, smooth; grain red

1. Spring White chaff bearded (Fig. 13).

Young shoot: erect.

Straw: thin, of medium height, 100–10 cm. (40–43 in.), very glaucous; leaves narrow, upright.

Ear: lax, 9·5–10 cm. long, narrow, very glaucous, 9–10 mm. across the face, 8 mm. acrosss the side; awns 4–8 cm. long; spikelets 20–22, 3–6 at the base of the ear rudimentary or sterile, each of the rest usually bearing two grains; D = 20–22.

Empty glume: narrow, keeled from apex to base, shoulder very narrow, nerve on the face prominent, apical tooth about 3 mm. long.

Grain: ovoid, red, flinty, medium length, narrow and pointed at the apex, with prominent dorsal ridge, 6·75 mm. long, 3·1 mm. broad; phenol reaction III.

An old Welsh wheat, early.

A somewhat later form is sometimes found mixed with red-chaffed bearded wheats (var. *ferrugineum*) in Pembrokeshire, Wales, and grown at an elevation of 1,100 feet.

2. In addition to the above, several other forms of *erythrospermum* are met with among the wheats of South Wales; some of these (Fig. 14) have long lax ears, 12 cm. long, usually with 3–5 abortive spikelets at the base; D = 20; grain, long, ovoid, with narrowed apex, 7·6 mm. long, 3·6 mm. broad. All these are early wheats.

3. Badger (Fig. 15).

Young shoots: semi-prostrate.
Straw: stout, about 100 cm. (40 in.) high.
Ear: dense, 7·5–9 cm. long, oblong in section, 13–15 mm. across the face, 10–12 mm. across the side; usually tapered at the tip; awns 2–6 cm. long; spikelets 23–25; D = 30.
Empty glume: white, smooth, somewhat inflated, not keeled to the base, 3 mm. long, shoulder very narrow, sloping; apical tooth acute, curved.
Grain: red, large, ovoid or oval, semi-flinty; 7–7·3 mm. long, 3·6–3·8 mm. broad.

A bearded Squarehead sport introduced by the author; a winter wheat which gives a high yield of grain of average quality.

2. *T. vulgare*, var. *ferrugineum*

Ears bearded; glumes red, smooth; grain red

1. Welsh April Red Wheat (Fig. 16).

Young shoots: erect.
Straw: medium thickness, strong, 115–20 cm. (45–8 in.) high.
Ear: very lax, narrow, 12–14 cm. long, 10 mm. across the face, 8 mm. across the side: awns 5–7 cm. long; spikelets 24–6, 2–4 at the base rudimentary or sterile, each of the rest bearing 2–3 grains; D = 18–19.
Empty glume: brownish red, often with a glaucous bloom, and sometimes with a dark brown margin, keeled from tip to base, shoulder narrow; apical awn 4–5 mm. long, almost straight.
Grain: red, flinty, with prominent dorsal ridge, medium length, oblong or ovoid, narrow, 6·7 mm. long, 3·2 mm. broad; phenol reaction II.

An early wheat grown in various parts of Wales up to 900 feet above sea level, and frequently mixed with other closely similar varieties of *ferrugineum.*

2. A similar early wheat known as April Bearded or Fern (Fig. 17) is sometimes grown in England, where it may be sown up to the beginning of April or even later; the apical tooth or awn on the empty glume is 2–3 mm. long, and bent inwards a little; phenol reaction III.

3. Webb's Bearded Red (Fig. 18).

Young shoots: semi-prostrate.
Straw: stout, 100–20 cm. (40–8 in.) high.
Ear: dense, 8·5–9 cm. long, 12–15 mm. across the face, 10 mm. across the side; awns 4–5 cm. long; spikelets 23–5, often with 2–3 at the base rudimentary or sterile, each of the rest bearing three grains; D = 28–30.
Empty glume: narrow at apex, keel prominent, apical tooth or awn 4–6 mm. long, curved inwards.
Grain: oval, large, long and broad, orange red, opaque, plump and soft, dorsal side prominent, 6·9 mm. long, 3·65 mm. broad; phenol reaction I.

A winter wheat, suggestive of a red bearded Squarehead type. This variety has not infrequently been sent to me under the name "Rivet Wheat," with which it has nothing in common except the presence of awns.

A mid-season wheat.

4. Devon Bearded Red (Fig. 19).

Young shoots: erect.
Straw: thin, tall, about 125 cm. (48–50 in.) high.
Ear: lax, 10 cm. long, flat, 13–15 mm. across the face and 8 mm. across the side, yellow-green when unripe; awns 3–6 cm. long; spikelets about 22, with 2–3 grains in each, except 4–6 of the lowest which are generally sterile; D = 22.
Empty glume: reddish chestnut, sometimes a darker brown, keeled to the base; shoulder somewhat narrow; apical awn acute, about 2 mm. long and bent inwards at an angle of nearly 45 degrees.
Grain: ovoid, red, narrow, flinty, 6·6 mm. long, 3·4 mm. broad; phenol reaction I.

A spring form found in mixtures of "Orange Devon Wheat," and among Old Welsh Wheats; it is denser in ear than most of the April Bearded red wheats.

An early wheat.

3. *T. vulgare*, var. *barbarossa*

Ears bearded; glumes red, hairy; grain red

Welsh Bearded Red Rough Chaff (Fig. 20).

Young shoots: prostrate.
Straw: thin, tall, 110–25 cm. (43–9 in.) high.
Ear: lax to medium density, 8–10 cm. long, narrow, 10–11 mm. across the face, 10 mm. across the side; awns 5–7 cm.

long; spikelets 20–2, 5–6 at the base of the ear often abortive; D = 22–4.

Empty glume: short, 7 mm. long, 4 mm. broad, keeled to the base, apical awn or tooth slender, 3 mm. long, shoulder square, narrow.

Grain: ovoid or oval, small, red, flinty, 6·4 mm. long, 3·3 mm. broad; phenol reaction II.

An uncommon early variety, often found in samples of Old Welsh Wheats. The glumes, which are clothed with soft hairs, vary in colour from a dark red to a pale yellowish red in some seasons.

(*b*) BEARDLESS VARIETIES

In Great Britain, and indeed in Western Europe generally, the chief wheats in cultivation belong to this group.

In countries where the straw and chaff of the crop is of slight or no value, it matters little whether the ears are bearded or beardless, so long as the grain is satisfactory; in Great Britain, however, the chaff of beardless varieties is useful as food for farm animals, but that of bearded wheats is not satisfactory for this purpose, as the beards or awns are scabrid and greatly irritate the eyes, nostrils, and tongues of cattle and horses to which such chaff is fed.

4. *T. vulgare*, var. *albidum*

Ear beardless; chaff smooth, white; grain white

A widely distributed variety, most forms of which are best suited to dry, warm climates. Down to about 1870 lax-eared forms were extensively cultivated in Great Britain; these, however, have been almost entirely displaced by dense-eared forms of the variety.

1. Al (Fig. 21).

Young shoots: erect or semi-erect.

Straw: slender, very glaucous, solid or hollow with thick walls, 102–20 cm. (40–8 in.) high.

Ear: 9–10 cm. long, lax to medium density, very glaucous when unripe, 14 mm. across the face, 10 mm. across the side; apical awns 5–10 mm. long, those on the lower spikelets 5 mm. long, slender; spikelets 22–3; D = 22–4.

Empty glume: white, keeled in the upper half, somewhat inflated, 9 mm. long, 4 mm. broad, shoulder narrow, slightly sloping, the secondary nerve prominent at the shoulder, keel tooth short, blunt.

Grain: ellipsoid, white, mealy, large, broad, 7 mm. long, 4 mm. broad; phenol reaction IV.

An early to mid-season wheat, which can be sown in late autumn or early spring. It is a single line selection raised by Messrs. Marsters of King's Lynn, Norfolk, from Messrs. Vilmorin's Blé des Alliés; it was introduced in 1921.

2. Ambrose Standup (Fig. 22).

Young shoots: prostrate.

Straw: slender, 102–15 cm. (40–5 in.) high.

Ear: 9–10 cm. long, 12 mm. across the face, 8–9 mm. across the side, medium density; apical awns 10–15 mm. long, those on the lower spikelets slender and bent inwards: spikelet 21–2, 1–2 at the base of the ear generally abortive; D = 23–5.

Empty glume: white or pale yellow, keeled at the base, 8 mm. long, 4 mm. broad, shoulder narrow, square, tooth blunt, the strong secondary nerve on the face of the glume prominent at the shoulder.

Grain: ovoid or oval, white, flinty or semi-flinty, large, plump, 6·8–7 mm. long, 3·8 mm. broad; phenol reaction II.

A mid-season wheat which Mr. H. H. Dunn informs me was introduced by Mr. Cole Ambrose, of Studley Hall, Cambridge, about 1892; it soon became popular in Dorset, Wiltshire and Somerset, but has been largely superseded by the denser-eared forms of *albidum* described later.

Commercial samples of Ambrose Standup always contain a few red grains, which when sown give rise to plants exactly similar in straw, ear and glume characters to the white-grained type, but produce red grains.

3. Setter (Fig. 23).

Young shoots: semi-erect.

Straw: stout, 102–15 cm. (40–5 in.) high.

Ear: 10–11 cm. long, of medium density, 15 mm. across the face, 10 mm. across the side; apical awns short, 5–8 mm. long, those on the lower spikelets claw-like and curved inwards; spikelets 22–3; D = 23–5.

Empty glume: white, keeled in the upper half, 9 mm. long, 4 mm. broad, shoulder narrow, sloping, tooth short straight, blunt.

Grain: white, flinty or semi-flinty, long, ovoid, 7·1 mm. long, 3·5–3·7 mm. broad; phenol reaction III.

Raised by Mr. H. W. Packard, of Shotley, Suffolk, from a plant growing in a crop of Brooker's Double Standup White, with longer ears than the type; it was placed on the market by the Eastern Counties Farmers' Co-operative Association, Ipswich, Suffolk.

4. Wilhelmina.

Commercial samples of this variety at present grown in Great Britain vary considerably, and often contain several somewhat different forms, of which two can be sorted out; both are mid-season wheats. Brooker's White, White Standup and Viking closely resemble forms of Wilhelmina.

The original Wilhelmina wheat was the product of the cross Spyk wheat (Squarehead ♀ × Zealand White ♂) × Squarehead ♂, made in 1889 by Dr. L. Broekema of the Institute for Plant Breeding, Wageningen, Holland. The wheat was introduced to Dutch farmers in 1901, and has become the most widely cultivated wheat in Holland; it spread to this country about 1910, and from it many selections have been made.

Form I (Fig. 24).

Young shoots: semi-erect.

Straw: stiff, 102–15 cm. (40–5 in.) high; stem leaves erect.

Ear: 8–9 cm. long, of medium density to dense, 15 mm. across the face, 10–12 across the side, glaucous when unripe; apical awns, 5–12 mm. long, those on the lower spikelets curved slightly inwards; spikelets 21–3; D = 27–8.

Empty glume: white, keeled only in the upper half, 8–9 mm. long, 4 mm. broad shoulder narrow, sloping, tooth short, blunt, slightly curved.

Grain: white, semi-flinty, ovoid, 7 mm. long, 3·6 mm. broad; phenol reaction III–IV.

Form II (Fig. 25).

Young shoots: as in Form I.

Straw: stouter, similar in height.

Ear: 8–9 mm. long; apical awns few, 5–8 mm. long, those of the

lower spikelets strongly curved inwards; spikelets 21–3; D = 27–8.

Empty glume: white, keeled in the upper half, 8 mm. long, 4 mm. broad, shoulder broader than in Form I, tooth shorter.

Grain: semi-flinty or mealy, ellipsoid, 6·8–7 mm. long, 3·8–4 mm. broad; phenol reaction O–I.

5. Million III (Fig. 26).

Young shoots: semi-erect.

Straw: stout, 102–15 cm. (40–5 in.) high; leaves somewhat pendulous.

Ear: 8–9 cm. long, medium density to dense, almost square in cross section, 13–15 mm. across the side, glaucous when unripe; apical awns 6–12 mm. long, those on the lower spikelets straight or slightly bent inwards; spikelets 22–3; D = 27–8.

Enpty glume: white, keeled to near the base, 9–10 mm. long, 5 mm. broad, shoulder medium width, slightly sloping, tooth blunt, rather narrow, curved slightly.

Grain: white, large, semi-flinty, ovoid or oval, 7–7·2 mm. long, 3·7 mm. broad; phenol reaction IV.

A late wheat introduced by the Institute for Plant Breeding, Wageningen, Holland. It was the produce of the cross Willem I ♀ (Challenge ♀ × Squarehead ♂) × Wilhelmina ♂.

6. Victor (Fig. 27).

Young shoots: semi-erect.

Straw: fairly stout, of medium height, 102–15 cm. (40–5 in.).

Ear: short, dense, tapering slightly, glaucous when unripe, 6–7·5 cm. long, 15 mm. across the face, 10–12 mm. across the side; apical awns 5–10 mm. long; spikelets, 23; D = 33–5.

Empty glume: white, keeled in the upper half, 8–9 mm. long, 4 mm. broad, shoulder narrow, slightly sloping, tooth 1 mm. long, blunt.

Grain: white, flinty or semi-flinty, ovoid or oval, 6·8 mm. long, 3·9 mm. broad; phenol reaction O–I.

A mid-season wheat, giving good yields, raised by Messrs. Gartons, Warrington, from the cross.

Squarehead × Red King

× Talavera

Victor

It closely resembles some segregates of Wilhelmina.

7. Starling II (Fig. 28).

Young shoots: semi-erect.
Straw: stout, of medium length, 102–15 cm. (40–5 in.).
Ear: 7–9 cm. long, dense, 14–15 mm. across the face, 12 mm. across the side, tapered slightly, rarely clubbed; apical awns 5–10 mm. long; spikelets 23–5; D = 30–3.
Empty glume: white, 9–10 mm. long, 4 mm. broad, shoulder narrow, sloping, tooth blunt.
Grain: white, flinty or semi-flinty, large, ovoid, 7–7·2 mm. long, 3·8–4 mm. broad; phenol reaction III.

A mid-season wheat giving excellent yields of grain of high quality. Starling I was the best single line of a series of ten raised by the author from a mixed stock of Dutch Wilhelmina about 1907. The several lines were tested for a period of five years, and the best in point of yield was then multiplied. After the sixth generation of growth on a field scale, the stock suddenly exhibited great variation, and numerous segregates appeared differing much in height and density of ear. A new single line was again started from a single ear and this was ultimately introduced as Starling II.

8. Imperial (Fig. 29).

Young shoots: semi-erect.
Straw: stiff, short, 90–102 cm. (36–40 in.) high.
Ear: 6·5–7 mm. long, dense, almost square in cross section, 12–15 mm. acrosss the sides; apical awns 10–15 mm. long, those on the lower spikelets straight or slightly curved inwards; spikelets 22–3; D = 32–34.
Empty glume: white, keeled in the upper half, 8 mm. long, 4 mm. broad, shoulder medium width, square or slightly sloping, tooth rather narrow, curved slightly.
Grain: white, dull, semi-flinty or mealy, plump, broad, ovoid or oval, 6·8 mm. long, 4 mm. broad; phenol reaction I.

A mid-season wheat, slightly earlier than Wilhelmina, the product of the cross, Premier ♀ × Wilhelmina ♂, introduced by the Institute for Plant Breeding, Wageningen, Holland, in 1903 and 1917.

9. Benefactress.

Young shoots: semi-erect.
Straw: short, stiff, about 100 cm. (40 in.) high.
Ear: 8 cm. long, very dense, almost square in section, 13–15 mm. across the sides; spikelets crowded in the upper third; apical awns 5–10 mm. long; spikelets 24–5; D = 33–5.
Empty glume: white, 8 mm. long, 4 mm. broad, shoulder narrow, slightly sloping, tooth blunt, curved.
Grain: white, opaque, mealy, ovoid, broad, 6·8–7 mm. long, 3·8 mm. broad; phenol reaction II.

A mid-season wheat, similar in form of ear and other characters to the rough-chaffed Benefactor (var. *leucospermum*) (Fig. 56), but with smooth chaff.

It was raised by Messrs. Gartons, Warrington, from the cross, Squarehead × Red King

× Rough chaff white

Benefactress

10. Holdfast (Fig. 30).

Young shoots: erect.
Straw: strong, of medium height, 44–6 in.
Ear: 11–12 cm. long, medium density, slightly tapered, 14 mm. across the face, 10 mm. across the side, apical awns, 10–14 mm. long, spikelets 21–3; D = 23.
Empty glume: white, keeled from tip to base, 9 mm. long, 4 mm. broad, shoulder broad, tooth short, blunt.
Grain: white, ovoid, flinty, 6·9 mm. long, 3·7 mm. broad; phenol reaction III.

An early to mid-season wheat which gives excellent yields of grain. It is the product of the cross Yeoman × White Fife made by Professor Sir Frank Engledow at the Cambridge Plant-breeding Institute in 1920; seed was released for distribution in 1935.

11. Juliana (Fig. 31).

Young shoots: semi-erect.
Straw: stout, medium height (43–5 in.)
Ear: 9–9·5 cm. long, 15 mm. across the face, 10 mm. across the side; spikelets 25–7, 3–4 at the base, usually abortive; D = 27.
Empty glume: white, keeled from tip to base, 9 mm. long, 4 mm. broad, shoulder narrow, sloping tooth short, blunt.
Grain: white, oval to ovoid, mealy, 7·4 mm. long, 3·7 mm. broad; phenol reaction II.

A widely grown mid-season winter wheat, giving good yields of grain on a variety of soils. It is the product of the cross, Wilhelmina × Essex Smooth Chaff, made at the Institute for Plant-breeding, Wageningen, Holland, in 1903; seed released for distribution in 1921.

12. Warden (Fig. 32).

Young shoots: prostrate.
Straw: stiff, medium height, 45–8 in.
Ear: 8–8·5 cm. long, dense Squarehead type, 15 mm. across the face, 14 mm. across the side; spikelets 23–5; D = 34.
Empty glume: white, keeled from tip to base, 10 mm. long, 5 mm. broad, shoulder narrow, tooth short, blunt.
Grain: white, oval, flinty, 7·1 mm. long, 3·6 mm. broad; phenol reaction O.

An early to mid-season wheat introduced by Messrs. Gartons, Ltd., Warrington, in 1938. It is the product of the cross Benefactress × Yeoman, and on fertile soils gives high yields of grain.

5. *T. vulgare*, var. *lutescens*

Ear beardless; chaff smooth, white; grain red

One of the most widely distributed of all varieties of Bread Wheat; numerous forms of it are cultivated in all wheat-growing countries.

1. Hen Wenith Coch (Old Red Wheat) (Fig. 33).

Young shoots: semi-erect.
Straw: very slender, glaucous, 100–22 cm. (40–8 in.) high.
Ear: long, narrow, tapering, lax, very glaucous when unripe, 11–12 cm. long, 10–12 mm. across the face, 10 mm. across the side; apical awns short, 5–8 mm. long; spikelets 22–4; D = 18–20.
Empty glume: white, keeled to the base, 8 mm. long, 3–4 mm. broad, shoulder slightly sloping, narrow, tooth very short, blunt.
Grain: red, flinty, long, narrow, ovoid, 7–8 mm. long, 3–3·2 mm. broad; phenol reaction III.

An old early variety of wheat from Montgomeryshire, Wales; a form very similar to this occurs in Devon.

2. Old Welsh White Chaff Red (Hen Gymro 484) (Fig. 34).

Young shoots: prostrate.
Straw: slender, very glaucous, about 120 cm. (47–8 in.) high.
Ear: long, lax, flat, very glaucous when unripe, 11–13 cm. long, 15 mm. across the face, 8–10 mm. across the side; apical awns 1–2 cm. long, awns on the lower spikelets 2–3 mm. long, straight; spikelets 22–4; D = 18–20.
Empty glume: white, keeled to the base, 8 mm. long, 4 mm. broad, shoulder square, narrow, tooth blunt, curved slightly, secondary nerve prominent and ending in a blunt point.
Grain: red, flinty or semi-flinty, small, ovoid or oval, 6·5–6·7 mm. long, 3·5 mm. broad; phenol reaction II.

An early wheat adapted to lighter soils, and said by Jenkins to be the best yielding form among Old Welsh (Hen Gymro) wheats.

Hen Gymro 480 is a somewhat similar form, but later, with slightly laxer ears, longer awns on the apical spikelets (up to 2·5 cm.) and larger grains.

Hen Gymro, or Old Welsh wheats, as usually grown, are mixtures of many varieties differing in botanical as well as physiological characters; all have slender, tough straw, generally with lax ears. They are adapted to the damp climate of Wales, especially on the lighter soils of the country; many of them give good yields of grain superior in quality to the average English wheats. Most of the forms described were kindly sent to me by Mr. T. J. Jenkins, M.Sc., who isolated them from the ordinary mixtures met with in cultivation in Wales.

3. Old Cumberland (Fig. 35).

Young shoots: prostrate.
Straw: slender, about 120 cm. (47–8 in.) high.
Ear: lax, tapering, 10–12 cm. long. 12 mm. across the face, 8–9 mm. across the side; apical awns 1·5–2 mm. long; spikelets 21–3; D = 18–20.
Empty glume: white, keeled only in the upper half, 9 mm. long, 3–3·5 mm. broad shoulder, very narrow, sloping, tooth short, narrow, blunt.
Grain: red, semi-flinty, long, narrow, oblong, 6·8–9 mm. long, 3·4 mm. broad; phenol reaction IV.

An Old English mid-season wheat from Cumberland.

4. Red Marvel or Japhet (Fig. 36).

Young shoots: erect.
Straw: somewhat slender, about 120 cm. (47–8 in.) high.
Ear: 9–10 cm. long, lax, glaucous when unripe, 15 mm. across the face, 10 mm. across the side; apical awns about 11 mm. long, awns of the lower spikelets 3–5 mm. long, curved inwards; spikelets 18–20; D = 20–2.
Empty glume: white, keeled to the base, 10 mm. long, 4 mm. broad, shoulder square, broad, tooth short, blunt.
Grain: yellowish-red, semi-flinty or mealy, large, plump, ellipsoid, 6·5–7 mm. long, 4 mm. broad; phenol reaction IV.

An early wheat which gives good yields when sown in February. It is a selection made by Messrs. Vilmorin, Paris, about 1892, and introduced by that firm under the name Japhet. It was brought to this country about 1904, and sold under the name Red Marvel; Red Admiral and others closely resemble it.

5. Devon White Chaff Red (Fig. 37).

Young shoots: semi-erect.
Straw: slender, glaucous, about 120 cm. (47–8 in.) high.
Ear: long, narrow, lax, somewhat rigid, glaucous when unripe, 10–12 cm. long, 12 mm. across the face, 8–9 mm. across the side; apical awns about 10 mm. long; spikelets 21–3; D = 22.
Empty glume: white, keeled to near the base, 9 mm. long, 4 mm. broad, shoulder almost square and moderately broad, tooth very short, blunt.
Grain: red, flinty, long, ovoid or oblong, 7·2 mm. long, 3·5 mm. broad; phenol reaction III.

A late wheat isolated from a mixed sample of Orange Devon.

6. Weibull's Standard (Fig. 38).

Young shoots: semi-erect.
Straw: strong, glaucous, 100–15 cm. (40–5 in.) high.
Ear: long, medium density, glaucous when unripe, 10–11 cm. long, 15 mm. across the face, 10 mm. across the side; apical awns 1–2·5 mm. long, awns of the lower spikelets 2–3 mm. long, curved slightly inwards; spikelets 21–3; D = 22.
Empty glume: white, keeled to the base, 9 mm. long, 4 mm. broad, shoulder broad, square, tooth very short, blunt.
Grain: red, semi-flinty, large, plump, avoid or oval, 7 mm. long, 3·8 mm. broad; phenol reaction IV.

A late wheat. It is a cross, Weibull's Iduna × Danish Tystofte Small Wheat, introduced by W. Weibull, Landskrona, Sweden: it is sometimes named Red Standard or Standard Red, but should not be confused with the English Red Standard (p. 123).

7. Price's Prolific (Fig. 39).

Young Shoots: semi-erect.
Straw: slender, glaucous, 100–15 cm. (40–5 in.) high.
Ear: 10–11 cm. long, medium density, glaucous when unripe, 14 mm. across the face, 10 mm. across the side; apical awns 6–10 mm. long, awns on the lower spikelets slender, 3–5 mm. long, straight or slightly curved; spikelets 21–3; D = 22–5.
Empty glume: white, keeled to near the base, 9–10 mm. long, 4 mm. broad, shoulder narrow, almost square, tooth narrow, 1–1·5 mm. long, blunt.
Grain: red, flinty or semi-flinty, oval, 7 mm. long, 3·5 mm. broad; phenol reaction I.

A mid-season wheat of high quality and good yield, raised by Mr. C. H. Price, Pauntley, Newent, Gloucestershire, about 1886; formerly much grown in Gloucestershire, Herefordshire, and adjacent counties, as well as in West Wales.

8. Partridge (Fig. 40).

Young shoots: semi-erect.
Straw: stout, glaucous, 122 cm. (about 48 in.) high.
Ear: oblong in outline, medium density, glaucous when unripe, 9·5–10·5 cm. long, 15 mm. across the face, 12 mm. across the side; apical awns about 10 mm. long, awns of the lower spikelets 3–5 mm. long, curved inwards; spikelets 22–4; D = 24–7.
Empty glume: white, keeled to near the base, 8 mm. long, 5 mm. broad, shoulder of medium breadth, slightly sloping, tooth short, broad, blunt.
Grain: red, mealy, plump, ellipsoid, 6·5–6·8 mm. long, 3·8–4 mm. broad; phenol reaction I.

A mid-season wheat, raised by the author from a single ear of a plant found in a small crop grown from wheat obtained from France about 1907.

9. Iron III (Fig. 41).

Young shoots: semi-erect.
Straw: stout, medium height, very glaucous, 100 cm. (about 40 in.) high.

Ear: oblong in outline, slightly tapered, medium density to dense, very glaucous when unripe, 9–10 cm. long, 15 mm. across the face, 11–13 mm. across the side; apical awns 5–10 mm. long, awns of the lower spikelets 2–3 mm. long and strongly curved inwards; spikelets 23–4; D = 26–8.

Empty glume: white, keeled to near the base, 9 mm. long, 4–5 mm. broad, shoulder medium breadth, slightly sloping tooth 1 mm. long, blunt.

Grain: orange-red, mealy, large, plump, ellipsoid, 6·5–7 mm. long, 4 mm. broad; phenol reaction III.

A late wheat.

Iron is the English name of the Swedish wheat Panser, which was the product of a cross, Kotte × Grenadier; Kotte (= Cone) was an old Swedish Landwheat, and Grenadier a selection of the English Squarehead.

Resembling Iron III are John Bull, Millenium, Eclipse and Croxton Champion; the grain of the two latter, however, give only a very pale phenol reaction, namely I.

Some samples of Harvester and Double Standup also resemble Iron III, but the ears are slightly laxer, and the awns on the lower lateral spikelets less curved.

10. Yeoman II (Fig. 42).

Young shoots: semi-erect.

Straw: strong, about 102 cm. (40 in.) high.

Ear: 7·5–10 cm. long, medium density, 12–15 mm. across the face, 10 mm. across the side; apical awns 1·5–3 cm. long, awns of the lower spikelets slender, 2–4 mm. long, curved slightly inwards; spikelets 20–3; D = 26–8.

Empty glume: white, keeled to near the base, about 10 mm. long, 4 mm. broad, shoulder medium to broad, square, tooth short, blunt.

Grain: red, flinty, long and narrow, oblong, 7–7·3 mm. long, 3·5 mm. broad; phenol reaction IV.

A mid-season wheat, giving high yields of grain of fine milling quality on soils in good condition. Like its predecessor, Yeoman I, it is the product of the cross, White-chaffed Browick × Red Fife, made by Sir Rowland Biffen, Cambridge University.

11. Squarehead.

The name Squarehead is given to a group of wheats characterised by short, dense ears, almost square in cross section, stiff straw and a high-yielding capacity.

References to Square-headed wheats were made in the early part of the nineteenth century, and Hickling's Prolific, or Hickling, as well as Suffolk Thickset, were wheats of this class cultivated in the Eastern Counties about 1830. It is, however, recorded that Herr Breymann of Germany (*Landw. Jahrb.*, 786, 1878), was informed by Samuel D. Shirreff that Squarehead wheat was discovered by a Mr. Taylor in a field of Victoria wheat in 1868. In 1870 it was propagated and sold by C. Scholey, of Eastoft Grange, Goole, Yorkshire. Tested against commonly grown sorts, Squarehead proved superior, giving yields of 9–10 quarters per acre on the rich alluvial soils in the Goole district. Its cultivation soon extended to other parts of Britain, and in 1874 was carried to Denmark by a pupil of Samuel Shirreff, spreading later to Germany, Sweden, Holland, Belgium and France.

With a view to obtaining improved forms of Squarehead wheats, with stiffer straw and giving higher yields, numerous selections were made by farmers and seedsmen both here and abroad, particularly during the last thirty years of the nineteenth century. To some of these the name Squarehead is appended, in other instances totally new names are given to the selections, although they differ from the type in minor details only, if at all.

In the last twenty years or so, other forms of heavy-yielding wheats have been introduced and the cultivation of Squarehead has declined, but some selections of the latter are still met with in Britain.

Squarehead (Figs. 43 and 44).

Young shoots: semi-erect.

Straw: stout, 90–100 cm. (about 36–40 in.) high.

Ear: 7–8 cm. long, dense, tapered slightly, glaucous when unripe; almost square in cross section, 12–15 mm. across the sides; apical awns 1·5–3·5 cm. long; spikelets 22; D = 28–31.

Empty glume: white, keeled in the upper half, 8–9 mm. long, 4 mm. broad, shoulder broad, square or slightly sloping, tooth short, broad, straight, blunt.

Grain: red, flinty or semi-flinty, large, plump, ellipsoid, 6·7–7 mm. long, 3·8 mm. broad; phenol reaction IV.

The possession of long awns on the apical spikelets is a constant character of the original Squarehead (Fig. 43, Form I), but many selections of the wheat have been made in this and other countries, and some of these differ from the type in having shorter apical awns (5–10 mm. long) (Fig. 44, Form II), and denser ears often clubbed at the apex (D = 32–6 or over).

Closely resembling Squarehead and having the same phenol reaction are Rentpayer, Stormproof, White-chaffed and Grey-chaffed Browick, as well as many others.

The original Browick found in a field of Scotch Annat wheat in 1844 by R. Banham on his farm at Browick, near Wymondham, Norfolk, was a red-chaffed Squarehead, sold by seedsmen under the name Browick or Browick Red down to about 1882; specimens of this with other wheats were exhibited by Patrick Shirreff at the Agricultural Hall, Islington, in December, 1864 (*Gardener's Chronicle*, 369, 1865), and the wheat is still grown at The University Agricultural Botanic Garden, Reading.

About 1890 Banham introduced "Banham's White Chaff Red," a typical Squarehead, which soon became known and advertised as White Chaff Browick, the old red-chaffed form being discarded.

12. Cambridge Browick (Fig. 45).

Young shoots: semi-erect.
Straw: stout, glaucous, about 100 cm. (40 in.) high.
Ear: 9–10 cm. long, very glaucous when unripe, dense, 15 mm. across the face, 10–12 mm. across the side; apical awns usually 5–10 mm. long; spikelets 23–4; D = 28–30.
Empty glume: white, keeled to the base, 8 mm. long, 4–4·5 mm. broad, shoulder broad, square, tooth very short, blunt.
Grain: pale red, semi-flinty, large, oval or ellipsoid, 7–7·3 mm. long, 3·8–4 mm. broad; phenol reaction IV.

A late wheat, the product of the cross, Browick White Chaff × Yeoman, made by Sir Rowland Biffen.

13. Atle (Fig. 46).

Young shoots: semi-erect.
Straw: slender, medium height, 40–4 in.
Ear: 9–10 cm. long, medium density, 12 mm. across the face, 8 mm. across the side, apical awns 10–14 mm. long; spikelets 20–4: D = 24.
Empty glume: white, keeled from tip to near the base, 10 mm. long, 4 mm. broad, shoulder sloping, tooth broad, blunt.

Grain: red, small, ovoid to elliptical, with a dorsal ridge, flinty, 6–6·5 mm. long, 3·7 mm. broad; phenol reaction II.

An excellent spring wheat giving high yields of grain, produced at the Weibullsholm's Plant-breeding Station, Landskrona, Sweden. In mild climates it may be sown in autumn. It is the product of the cross Extra Kolben × Saxo. The original form was introduced into commerce in 1936, and a new elite form, Atle No. 9703, put on the Swedish market in 1943. Atle is an old Scandinavian personal name which is said to mean strong, robust and brave.

14. Bersée (Fig. 47).

Young shoots: semi-erect.
Straw: somewhat slender, upper internode solid or with thick walls, medium height, about 40 in.
Ear: lax, tapering, 12 cm. long, 13–15 mm. across the face, 10 mm. across the side; spikelets 20–1; D = 20–1.
Empty glume: white, keeled from tip to base, 9 mm. long, 4 mm. broad, shoulder broad, slightly awned, tooth, short, blunt.
Grain: red, ovoid, flinty, 7·9 mm. long, 3·5 mm. broad; phenol reaction II.

A very early-ripening winter wheat which may be sown in January and early February, giving high yields of grain. It was introduced by M. Blondeau of Bersée (Nord) France, in 1937, and is the product of the cross Vilmorin 27 × Allies.

15. Crown (Fig. 48).

Young shoots: prostrate.
Straw: stout, medium height, 48 in.
Ear: 10·5 cm. long, 15 mm. across the face, 10 mm. across the side; spikelets 25–7. D = 26.
Empty glume: white, keeled from tip to base, 9 mm. long, 5 mm. broad, shoulder narrow, sloping, tooth straight, short, blunt.
Grain: red, large, ellipsoid, semi-flinty, 7 mm. long, 4 mm. broad; phenol reaction IV.

A winter wheat giving high yields of grain, first introduced in 1925, but since 1935 original seed has not been available. It is a cross, the product of Sun II × Panser, raised by the Svalöf Plant-breeding Station, Sweden. In botanical characters it closely resembles the variety Scandia.

16. Extra Kolben II (Fig. 49).

Young shoots: semi-erect.
Straw: stiff, slender, short to medium height, 46–8 in.
Ear: lax, 11–12 cm. long, tapering, 12 mm. across the face, 9 mm. across the side; spikelets 20–3; D = 22.
Empty glume: white, keeled from tip to base, 9 mm. long, 3 mm. broad, shoulder broad, slightly curved, tooth short, blunt.
Grain: red, ovoid to ellipsoid, flinty, 6·8 mm. long, 3·5 mm. broad; phenol reaction II.

A spring wheat which may be sown to the middle of March, it was introduced in 1919 by the Plant-breeding Institute, Svalöf, Sweden, and is a selection from the old Extra Kolben, the product of the cross Sv. Kolben × a selected line of the German wheat Emma.

17. Garton's Sixty (Fig. 50).

Young shoots: semi-erect.
Straw: strong, medium height, about 48 in.
Ear: 10 cm. long, 15 mm. across the face, 10 mm. across the side; spikelets 24–6; D = 26.
Empty glume: white, keeled from tip to base, 9 mm. long, 4·5 mm. broad, shoulder narrow, sloping, tooth curved, blunt.
Grain: red, large, oval, mealy, 7·2 mm. long, 4 mm. broad; phenol reaction II.

A winter wheat introduced by Messrs. Garton Ltd., Warrington; the product of the cross Victor × Squareheads Master. It gives heavy yields of grain even on the lighter class of soils, and is claimed to have produced the world's highest record of 100 bushels per acre.

18. Jubilégem (Fig. 51).

Young shoots: semi-erect.
Straw: stiff, with thick walls, medium height, about 40 in.
Ear: lax, 9–10 cm. long, 15 mm. across the face, 10 mm. across the side; spikelets 20–3; D = 21.
Empty glume: white, keeled from tip to base, 9 mm. long, 4 mm. broad, shoulder broad, slightly curved, tooth 8 mm. long, blunt.
Grain: red, ovoid, semi-flinty, 7 mm. long, 4 mm. broad; phenol reaction III.

A very early-ripening winter wheat which may be sown to the end of February. It was introduced by the Research Station for Plant-breeding at Gembloux, Belgium, and is the product of the cross Vilmorin 23 × Panser III. Adapted for combine-harvesting, and suitable for growth on rich soils where it gives high yields of grain. Originally named L'Hybride du Jubilé (The Jubilee Hybrid).

19. Quota (Fig. 52).

Young shoots: semi-erect.
Straw: stout, medium height, about 48 in.
Ear: 10 cm. long, 15 mm. across the face, 10 mm. across the side; spikelets 23–5; D = 23–5.
Empty glume: white, keeled from tip to base, 9 mm. long, 5 mm. broad, shoulder narrow, sloping, tooth short, straight, blunt.
Grain: red, large, ovoid, semi-flinty, 7·2 mm. long, 4 mm. broad; phenol reaction III.

A late wheat giving good yields of grain. It is the product of a single-plant selection, A No. 435, made in 1932 from a stock of Yeoman, by Messrs. James Carter and Co., Regent's Park, London.

20. Scandia (Fig. 53).

Young shoots: prostrate.
Straw: medium height, about 48 in.
Ear: 10–11·5 cm. long, 15 mm. across the face, 10 mm. across the side; spikelets 25–7; D = 26.
Empty glume: white, keeled from tip to base, 9 mm. long, 4 mm. broad, shoulder sloping, tooth short, blunt.
Grain: red, large, ovoid to ellipsoid, mealy, 7·2 mm. long, 4 mm. broad; phenol reaction III.

A mid-season to late wheat which gives good yields of mealy grain. It is the product of the cross Crown × a winter-hardy line of Fylgia, distinct from the spring wheat Fylgia described on p. 126. The original seed was distributed in 1935–41. New pure-line, forms Scandia II and III, are now on the market.

21. Vilmorin 27 (Fig. 54).

Young shoots: prostrate.
Straw: stout, with thick walls, medium height, 40–2 in.
Ear: lax, not tapered, 10 cm. long, 14 mm. across the face, 11 mm. across the side; spikelets; 20: D = 20.
Empty glume: white, keeled from tip to base, 8–8·5 mm. long, 5 mm. broad, shoulder broad, curved, tooth short, blunt.
Grain: red, long, narrow, ovoid, semi-flinty, 7 mm. long, 4 mm. broad; phenol reaction IV.

*

An early to mid-season winter wheat, with stout straw, specially adapted for combine-harvesting. May be sown up to the middle of February, and gives good yields of grain. It is the product of the cross Dattel (Japhet × Parsel) × (Hatif inversable × Bon Fermier), raised and distributed by Vilmorin-Andrieux, Verrier-Buisson, France.

6. *T. vulgare*, var. *leucospermum*

Ear beardless; chaff hairy, white; grain white

Wheats belonging to this variety are found in many parts of the world, but few of them are of importance. Last century some forms were widely grown in the southern half of Great Britain on account of their fine grain quality; they have, however, almost entirely disappeared, for, like all forms with hairy chaff, they are not adapted for cultivation in regions of high rainfall; the hairy chaff readily absorbs moisture which often delays harvesting of the crop and, in white-grained varieties especially, leads to sprouting of the grain in the ear.

1. Rough Chaff White (Fig. 55).

Young shoots: erect to semi-erect.
Straw: stout, 92–105 cm. (about 36–42 in.) high.
Ear: medium length and density, 8–9 cm. long, 12–14 mm. across the face, 10 mm. across the side; apical awns 1–3·5 cm. long; spikelets 18–20; D = 23–4.
Empty glume: white, hairy, keeled to the base, 8–9 mm. long, 4 mm. broad, shoulder medium width to narrow, tooth oblong, blunt, 1 mm. long.
Grain: ovoid, white, flinty, apex narrow, of medium length, narrow, 6–6·5 mm. long, 3·1 mm. broad; phenol reaction IV.

A mid-season wheat of fine quality, now rarely cultivated. Last century, down to about 1880, this and other forms closely resembling it were grown extensively in Essex, Kent, Sussex and other southern and south-midland counties under the names Velvet Chaff, Hedge Wheat, Old Hoary, and Tunstall.

2. Benefactor (Fig. 56).

Young shoots: erect or semi-erect.
Straw: short, stout, 90–100 cm. (about 36–40 in.) high.
Ear: short and very dense, with the spikelets usually crowded above the middle and near the apex, 6–8 cm. long, almost square in cross section, 12–14 mm. across the sides; apical awns 5–8 mm. long; spikelets 24–6; D = 35–7.
Empty glume: white, hairy, 8 mm. long, 4 mm. broad, shoulder narrow, sloping, tooth very short, blunt.
Grain: oval, white, semi-flinty, somewhat large and plump, 6·9 mm. long, 3·5 mm. broad; phenol reaction I.

A mid-season to late wheat introduced by Messrs. Garton; now little grown owing to the liability of the grain to sprout in the ear in wet seasons.

7. *T. vulgare*, var. *velutinum*

Ear beardless; chaff hairy, white; grain red

Forms of this variety are widely distributed. A few are found in cultivation in Finland, the United States and elsewhere, but in this country they are chiefly met with in samples of Old Welsh and Orange Devon Wheats; the remarks made in regard to the preceding rough-chaffed variety apply equally to this.

1. Orange Devon Hoary (Fig. 57).

Young shoots: semi-erect.
Straw: slender, of medium height, 95–102 cm. (about 38–40 in.); stem leaves broad.
Ear: lax, tapering, medium length, 8–10 cm. long, 10–12 mm. across the face, 9 mm. across the side; apical awns 5–10 mm. long; spikelets 23–6; D = 22–3.
Empty glume: white, hairy, 8 mm. long, 3–4 mm. broad, shoulder of medium width, tooth very short, blunt.
Grain: ovoid, orange red, mealy, of medium length and breadth, apex narrow, 6·3 mm. long, 3·4 mm. broad; phenol reaction IV.

A late wheat.

2. Old Welsh Hoary. Form I. (Hen Gymro 274) (Fig. 58).

Young shoots: prostrate.
Straw: tall, very glaucous, 115–25 cm. (about 45–50 in.) high; stem leaves narrow.
Ear: long, narrow, lax and tapering, very glaucous when unripe, 11–13 cm. long, 14 mm. across the face, 10 mm. across the side; apical awns 5–10 mm. long; spikelets 23–4; D = 20–2.
Empty glume: white, hairy, 8–9 mm. long, 3–4 mm. broad, often inclined to a rosy tint, shoulder medium width, slightly sloping, tooth short, blunt.
Grain: oblong, large, orange red, flinty or semi-flinty, apex narrow, 7·6 mm. long, 3·6 mm. broad; phenol reaction II.

A mid-season wheat.

3. Old Welsh Hoary. Form II. (Hen Gymro 789) (Fig. 59).

Young shoots: semi-erect.
Straw: slender, glaucous, 115–18 cm. (about 45–50 in.) high; stem leaves broad.
Ear: lax, 9–10 cm. long, 12–14 mm. across the face, 10 mm. across the side; apical awns 5–10 mm. long, awns of the lower spikelets claw-like, and turned inwards; spikelets 22–3; D = 20–2.
Empty glume: white, hairy, 8–9 mm. long, 4 mm. broad, shoulder narrow, sloping, tooth slightly curved, blunt.
Grain: oval or oblong, red, flinty, long, medium breadth, apex narrow, 7·3 mm. long, 3·5–3·7 mm. broad; phenol reaction IV.

A late wheat.

8. *T. vulgare*, var. *albo-rubrum*

Ears beardless; chaff smooth, red; grain white

An uncommon variety adapted chiefly to warm climates; the old Scotch Blood Red wheat was a form of this variety, but at no period have forms of *albo-rubrum* been widely cultivated in Great Britain. The wheats described below are both recent introductions.

1. Ideal (Fig. 60).

Young shoots: semi-erect.
Straw: slender, of medium height, 100–20 cm. (about 40–8 in.); stem leaves narrow.

Ear: 9–10 cm. long, 12–14 mm. across the face, 8 mm. across the side, yellow-green when unripe, lax or medium density; apical awns 5–10 mm. long; spikelets 20–1, one or two at the base abortive; D = 22–3.
Empty glume: foxy red, long and narrow, 10 mm. long, 4 mm. broad, shoulder narrow, sloping, tooth 1 mm. long, blunt and slighty curved inwards.
Grain: oblong, white, flinty, long and narrow, 7·45 mm. long, 3 mm. broad; phenol reaction IV.

A mid-season wheat, introduced in 1927 by Messrs. C. W. Marsters, King's Lynn, Norfolk; the pedigree given is

$$\underbrace{\underbrace{\text{Little Joss} \times \text{Victor}}_{\text{Hybrid } F_3} \times \text{Yeoman}}_{\text{Ideal}}$$

2. Steadfast (Fig. 61).

Young shoots: prostrate.
Straw: medium height, about 45 in.
Ear: 9–10 cm. long, 13 mm. across the face, 10 mm. across the side; spikelets 22–4, apical awns 6–10 mm. long; D = 22–4.
Empty glume: red, keeled in the upper half, 10 mm. long, 4 mm. broad, shoulder narrow, sloping, tooth narrow.
Grain: white, oval; semi-flinty to mealy, long, narrow, 7–7·8 mm. long, 3·8–4 mm. broad; phenol reaction III.

A mid-season wheat with stout straw, giving good yields of grain. It is the product of the cross Little Joss × Victor made by Professor Sir Frank Engledow at the Cambridge University Plant-breeding Institute in 1928; seed was released for distribution in 1941.

3. Premier (Fig. 62).

Young shoots: erect to semi-erect.
Straw: stout, medium height, 100–15 cm. (about 40–5 in.).
Ear: short, very dense, 7–8 cm. long, almost square in cross section, 12–13 mm. across the sides, yellow-green when unripe, spikelets often crowded in the upper half with a tapered apex; apical awns 5–10 mm. long; spikelets 24–6; D = 33–5.
Empty glume: pale-red with a dark margin, 8 mm. long, 4 mm.

broad, shoulder medium width, square or slightly sloping, tooth short, blunt.
Grain: oval, white, semi-flinty or mealy of medium length, plump, 6·8 mm. long, 3·6 mm. broad; phenol reaction IV.

An early to mid-season wheat; an extremely uncommon form of *albo-rubrum* with a Squarehead type of ear, introduced in 1924 by Messrs. Masters, King's Lynn, Norfolk; the result of the cross, Benefactor × Little Joss.

9. *T. vulgare*, var. *milturum*

Ear beardless; chaff smooth, red; grain red

Like the beardless, white-chaffed, red-grained variety *lutescens*, this is one of the most widely distributed and commonly-grown varieties of Bread Wheat; included in it are some of the wheats most extensively grown in Great Britain at the present day.

1. Old Welsh Red Chaff 460. (Hen Gymro 460) (Fig. 63).

Young shoots: prostrate.
Straw: slender, 115–25 cm. (about 45–50 in.) high, upper internodes pink.
Ear: long, narrow, lax, 11–13 cm. long, 8–10 mm. across the face, 7–8 mm. across the side; apical awns 10–15 mm. long; spikelets 19–21; D = 20.
Empty glume: dark purplish red, keeled to the base, 9 mm. long, 4 mm. broad, shoulder square, broad, tooth short, blunt.
Grain: red, flinty, large, ellipsoid, 7·2 mm. long, 3·6 mm. broad; phenol reaction II.

A mid-season wheat.

Associated with this wheat, forms of *milturum* are often found with broader ears, similar in outline to those of Old Devon Red Chaff described below, and with small semi-flinty grains giving the dark phenol reaction IV.

2. Old Devon Red Chaff (Fig. 64).

Young shoots: semi-erect.
Straw: tall, slender, 122 cm. (about 48 in.) high.
Ear: long, lax, 11–12 cm. long, 13–14 mm. across the face, 10 mm. across the side; apical awns up to 3 cm. long; spikelets 21–3; D = 20–1.

Empty glume: foxy-red, margins usually darker, keeled to the base, 8 mm. long, 4 mm. broad, shoulder medium to broad, square, tooth broad, blunt.
Grain: orange-red, mealy, small ovoid, 6·5 mm. long, 3·5 mm. broad; phenol reaction IV.

A mid-season wheat.

3. Old Irish Red Chaff (Fig. 65).

Young shoots: erect.
Straw: tall, 115–22 cm. (about 45–8 in.) high; upper internode pink.
Ear: 9–10 cm. long, 13–14 mm. across the face, 8 mm. across the side, usually tapered, lax, yellow-green when unripe; apical awns 5–8 mm. long; spikelets 20–1; D = 20–2.
Empty glume: dark red, keeled only in the upper half, long, narrow, 9–10 mm. long, 4 mm. broad, shoulder narrow to medium breadth, slightly sloping, tooth short, straight, blunt.
Grain: red, flinty, long, narrow, oblong, apex blunt, 7 mm. long, 3·3 mm. broad; phenol reaction IV.

A mid-season wheat of good quality, formerly common in the central parts of Ireland.

4. Little Joss (Fig. 66).

Young shoots: prostrate or semi-erect.
Straw: rather weak, 115 cm. (about 45 in.) high.
Ear: lax, 9–11 cm. long, 15 mm. across the face, 10 mm. across the side; apical awns 5–10 mm. long, awns of the lower spikelets claw-like, and curved inwards; spikelets 20–3; D = 20–3.
Empty glume: red, variable from a foxy-red to a pale red, keeled to near the base, 9 mm. long, 4 mm. broad, shoulder narrow, tooth short, blunt, curved.
Grain: red, large, flinty or semi-flinty, oval or ellipsoid, 7 mm. long, 3·6–3·9 mm. broad; phenol reaction II.

An early to mid-season wheat, which gives a good yield even on moderately light soils; can be sown in autumn or spring up to the end of February. It was raised by Sir Rowland Biffen from the cross Squareheads Master × Ghirka, the latter a Russian spring wheat.

As grown by the farmer, varieties under this name often contain white-chaffed wheats, some of them obviously accidental impurities totally different from the true stock;

some of the white ears, however, very closely resemble the true red-chaffed type in size, density of ear, and shape of the empty glumes, and crops in which these occur generally exhibit much variability in the red tint of the glumes, such as might be expected among segregates of a cross between a red-chaffed and a white-chaffed wheat.

5. Irish Coney Island Red (Fig. 67).

Young shoots: semi-erect.
Straw: slender, of medium height, 100–10 cm. (about 40–4 in.), stem leaves upright, broad.
Ear: medium length and density, 9–10 cm. long, 14 mm. across the face, 10 mm. across the side, yellow-green when unripe; apical awns 5–7 mm. long, awns on the lower spikelets very short, slightly curved; spikelets 22–4; D = 22–4.
Empty glume: dark red with darker margin, and glaucous bloom, keeled to the base, 8 mm. long, 4·4–5 mm. broad, shoulder broad, square or slightly sloping, tooth blunt.
Grain: red, semi-flinty, large, ellipsoid, apex blunt, 6·8–7 mm. long, 3·8 mm. broad; phenol reaction IV.

An old wheat of good quality from Coney Island off the coast of Sligo, Ireland.

6. Old Welsh Red Chaff 326. (Hen Gymro 326) (Fig. 68).

Young shoots: semi-erect.
Straw: slender, somewhat short, 90–100 cm. (about 35–40 in.) high; stem leaves narrow.
Ear: medium length and density, narrow, 8·5–9·5 cm. long, 10–11 mm. across the face, 8 mm. across the side; apical awns 10–12 mm. long; spikelets 18–20; D = 22–4.
Empty glume: red with a darker margin, keeled to the base, 8–9 mm. long, 4 mm. broad, shoulder medium to broad, square or slightly sloping, tooth short, blunt.
Grain: red, flinty, ovoid or ellipsoid, 7·1 mm. long, 3·5 mm. broad; phenol reaction I.

A mid-season wheat, adapted to poor light soils.

7. Montgomery Red (Fig. 69).

Young shoots: semi-erect.
Straw: tall, about 122 cm. (48 in.) high.
Ear: 10 cm. long, 14 mm. across the face, 9 mm. across the side lax, tapered slightly, yellow-green when unripe; apical awns 5 mm. long, awns on the lower spikelets claw-like and curved inwards; spikelets 22–3, 2–3 at the base often abortive; D = 22.
Empty glume: foxy red, keeled to the base, 8 mm. long, 4 mm. broad shoulder, medium width, square or slightly sloping, tooth blunt, curved.
Grain: pale red, semi-flinty, short, oval, plump, 6·3 mm. long, 3·5 mm. broad; phenol reaction III.

A mid-season wheat received from Mr. J. L. John, B.Sc., grown at an elevation of 400 feet in Montgomeryshire, Wales; it resembles the old English Teverson, but has slightly laxer ears.

8. Orange Devon Red Squarehead (Fig. 70).

Young shoots: semi-erect.
Straw: 115 cm. (about 45 in.) high.
Ear: a dense typical Squarehead in form and size, but with pale red chaff, apex tapered, 7–8 cm. long, 12–14 mm. across the face, 10–11 mm. across the side; apical awns 1–1·5 cm. long; spikelets 22–3; D = 28–30.
Empty glume: pale red often with darker margin, 8–10 mm. long, 4 mm. broad, shoulder medium width, square or slightly sloping, tooth blunt, slightly curved.
Grain: yellowish-red, semi-flinty or mealy, short, plump, ovoid, 6·5 mm. long, 3·9 mm. broad; phenol reaction II.

A mid-season wheat isolated from a sample of Orange Devon.

9. Squareheads Master; Red Standard.

The most widely cultivated wheats in Great Britain at the present day are included under the names Squareheads Master and Red Standard or Standard Red. Most farmers and seedsmen assume that these are all alike and do not hesitate to sell the same wheat under either name.

A comprehensive study of crops and samples from a great many parts of the country has revealed certain differences in the wheats in regard to the shape and density of the ears, colour and form of the empty glumes, as well as the length and curvature of the awns of the flowering glumes on the lateral spikelets.

Although the constancy of some of the differences is not yet quite clear, the different forms appear to fall into the following groups:

Group I (Fig. 71).

Young shoots: semi-erect.
Straw: stout, medium height, about 100–5 cm. (about 40 in.), not glaucous.
Ear: yellow-green when unripe, 8–9 cm. long, dense, oblong in outline, 15 mm. across the face, 10–11 mm. across the side; apical awns about 1 cm. long, awns on the lower spikelets, claw-like and bent inwards almost at a right angle; spikelets 20–5; D = 30.
Empty glume: red, 9–10 mm. long, 4 mm. broad, keeled to little more than half way to the base, shoulder of medium width, square or slightly sloping, tooth short, blunt.
Grain: brownish red, semi-flinty or mealy, large, plump, ovoid or oval, 7 mm. long, 3·7–3·8 mm. broad; phenol reaction II.

Most commercial stocks of Squareheads Master belong to this Group.

Group II (Fig. 72).

The young shoots, straw and grain are similar to those of Group I.

Ear: slightly longer, 9–10 cm. long, and less dense, D = 27–8; apical awns up to 1·5 cm. long, awns of the lower spikelets almost straight or only slightly bent inwards.

Squareheads Master is a mid-season wheat, which gives good yields on most soils and is less affected by seasonal changes than the majority of English wheats.

Wheats with the names of Success, Banker, Standard Red, Red Standup, Emperor and Renown, I am not able to distinguish from the type of Squareheads Master Group I.

The origin of Squareheads Master wheat is obscure. Mr. H. H. Dunn (in Seed Wheats list) states that the wheat was selected by Mr. Teverson and supposed to have been a cross of Scholey's Square Head and Golden Drop naturally pollinated.

Raynbird & Co., of Basingstoke, Hampshire, in 1888, advertised Red Chaff Squarehead, or "Square Head's Master," apparently as a new kind, which they say is "excellent for rich soils and high farming" (*Agric. Gazette*, 388, October, 1888) and "Squareheads Master, or Red Chaff Square Head" was also advertised in 1889, by S. Stanley, Ebrington Hall Farm, Compton, Gloucestershire (*Agric. Gazette*, 361, October, 1889).

Squareheads Master 13/4.

A very welcome and valuable addition to the forms of this most widely-grown variety of English winter wheats. It is a single plant selection made by Professor Sir Frank Engledow at the Cambridge University Plant-breeding Institute from a collection of commercial Squareheads Master stocks. The range of selections were reduced by plot and field trials, and the final selection 23/4 was first distributed by the National Institute of Agricultural Botany, Cambridge, in 1940.

In 1888 a "Standard Red" wheat was sold by C. Sharpe & Co., of Sleaford, Lincolnshire, but whether this was a synonym of Squareheads Master and the modern Red Standard or a different wheat, I have not been able to discover.

It is sometimes stated that Squareheads Master is the same as a variety known as Teverson, formerly grown in Kent, samples of which I obtained in Kent in 1895, and have grown ever since; Teverson resembles Squareheads Master in some characters, but the ears are longer and laxer than this, and more susceptible to yellow rust.

10. Diamond II (Fig. 73).

Young shoots: erect.
Straw: slender, short to medium height, about 42 in.
Ear: lax, 10–12 cm. long, tapering, 10 mm. across the face, 8 mm. across the side, apical awns, straight, 15–30 mm. long, those on the lower spikelets 3–5 mm. long and curved inwards; spikelets 22–4; D = 20.
Empty glume: red, keeled from tip to base, 9 mm. long, 4 mm. broad, shoulder, narrow, sloping; tooth straight, blunt.
Grain: red, oblong, narrow, flinty, 7–7·2 mm. long, 3·5 mm. broad; phenol reaction II.

An early spring wheat which may be sown to the end of March. It is the product of the cross Diamond I × Extra Kolben II, raised by the Plant-breeding Institute, Svalöf, Sweden, and is the variety of spring wheat, very widely grown in Sweden.

11. Fylgia (Fig. 74).

Young shoots: erect.
Straw: slender, pink or purplish in tint, medium height, 47–8 in.
Ear: lax, 9–10 cm. long, 12 mm. across the face, 8 mm. across the side; spikelets 18–20; D = 20–2.
Empty glume: brown, keeled from tip to base, 8 mm. long, 4 mm. broad, shoulder broad, tooth very short.
Grain: red, ovoid, long and narrow, with dorsal ridge, flinty, 7·2 mm. long, 3·2–3·5 mm. broad; phenol reaction II.

A spring wheat which may be sown to the end of March or early April. It gives good yields of grain, and is a selection from the cross Australian Aurora × Svalöf Extra Kolben, raised at the Plant-breeding Institute, Svalöf, Sweden.

12. Progress (Fig. 75).

Young shoots: erect.
Straw: slender, strong, medium height, about 40 in.
Ear: lax, 10–11·5 cm. long, tapering, 14 mm. across the face, 10 mm. across the side, apical awns 8–10 mm. long; spikelets 17–19; D = 18.
Empty glume: red, keeled from tip to base, 8 mm. long, 4 mm. broad, shoulder, narrow, sloping; tooth, short, blunt.
Grain: red, oblong or ellipsoid, blunt, flinty, 6·2 mm. long, 3·5 mm. broad; phenol reaction III.

An early spring wheat giving good yields of grain. It is the product of the cross Extra Kolben × Ä 23/8 (Svalöf Kolben × Brown Schlanstedt, a German selection from Bordeaux wheat) raised by the Plant-breeding Institute, Svalöf, Sweden. Seed was released for distribution in 1942.

13. Redman (Fig. 76).

Young shoots: prostrate.
Straw: stiff, medium height, about 46 in.
Ear: 9–10 cm. long, 13 across the face, 10 mm. across the side; spikelets 22–4; D = 24.
Empty glume: red, keeled from tip to base, 8 mm. long, 4 mm. broad, shoulder broad, slightly sloping, tooth short, blunt.
Grain: red, oval, flinty, 7·3 mm. long, 3·7 mm. broad; phenol reaction; D = IV.

An early to mid-season wheat with stiff straw suited to combine-harvesting, introduced by Messrs. Gartons Ltd.,

Warrington, in 1934. It is the product of the cross, Yeoman × Squareheads Master, and gives grain the flour from which is of fine quality.

10. *T. vulgare*, var. *pyrothrix*

Ears beardless; chaff hairy, red; grain red

A rare variety; very few of its forms are now in cultivation in any country.

1. Fox (Fig. 77).

Young shoots: prostrate.
Straw: short, slender, 80–92 cm. (about 30–6 in.) high.
Ear: 8–9 cm. long, of medium density, tapering, 12 mm. across the face, 9 mm. across the side; apical awns about 5 mm. long, awns on the lower spikelets curved inwards; spikelets 20–3; D = 25–7.
Empty glume: hairy, foxy-red, 8–9 mm. long, shoulder narrow and sloping, tooth blunt, 1 mm. long, nearly straight.
Grain: red, flinty or semi-flinty, oval, somewhat long and broad, 6·9 mm. long, 3·6 mm. broad; phenol reaction IV.

A sport selected by the author from Blé à duvet, a French wheat with white, velvety chaff, and white grain.

A mid-season wheat which tillers well; especially suited to well-drained soils, where it often gives good yields of grain of superior quality.

2. Red Stettin; Irish Red Velvet Chaff (Fig. 78).

Young shoots: erect.
Straw: tall, 115–25 cm. (about 45–50 in.) high.
Ear: tapering, of medium density, 9–10 cm. long, 12 mm. across the face, 9 mm. across the side; apical awns up to 8 mm. long; spikelets 20–3; D = 22–5.
Empty glume: hairy, foxy-red, about 9 mm. long, 3–4 mm. broad, shoulder narrow, sloping, tooth blunt, slightly incurved.
Grain: red, flinty or semi-flinty, of medium length, oblong, narrow, 6·7 mm. long, 3–3·3 mm. broad; phenol reaction IV.

An early wheat of high quality, somewhat resembling Fox, but with slightly longer and laxer ears, apical awns longer and grain smaller and narrower. Cultivated for more than one hundred years in central Ireland, and doubtless originally imported from the Baltic port of Stettin, from which considerable amounts of wheat were exported to this country 120–150 years ago.

3. Old Devon Red Rough Chaff (Fig. 79).

Young shoots: prostrate to semi-erect.

Straw: tall, slender, 122 cm. (about 48 in.) high.

Ear: narrow, tapered, curved when ripe, lax, 10–12 cm. long, 10–12 mm. across the face, 8 mm. across the side, very glaucous when unripe; apical awns long, up to 4 cm., awns on the lower spikelets slender and curved inwards; spikelets 22–4; D = 22.

Empty glume: red to pale red, hairy, the hairs few and closely adpressed to the glume, keeled to the base, 8 mm. long, 4 mm. broad, shoulder broad, square, tooth short, blunt, straight.

Grain: pale red, flinty, oblong, apex narrow, 6·5–7 mm. long, 3·1 mm. broad; phenol reaction I.

A mid-season wheat found among Old Devon.

Another form also met with in Old Devon resembles it, but has much shorter apical awns, slightly shorter and denser ears, and narrower empty glumes.

11. *T. vulgare*, var. *cyanothrix*

Ear beardless; chaff hairy, bluish or brownish grey; grain red

A very rare variety; the few forms which are known generally occur as mixtures among the primitive wheats grown in out-of-the-way parts of the world.

Orange Devon Blue Rough Chaff (Fig. 80).

Young shoot: semi-erect.

Straw: tall, 115 cm. (about 45 in.) high, the upper internode pink; stem leaves narrow.

Ear: long lax, 12–14 cm. long, 12–13 mm. across the face, 7–8 mm. across the side; apical awns 1·5–3 cm. long; spikelets 24–6; D = 20.

Empty glume: hairy, bluish or brownish grey, in some seasons dark red, 7–8 mm. long, 4 mm. broad, shoulder broad, square or slightly sloping, tooth broad, straight, blunt.

Grain: red, flinty, apex blunt, medium length and breadth, oblong or ellipsoid, 6·6 mm. long, 3·35 mm. broad; phenol reaction IV.

An early to mid-season wheat found among Old Devon.

Similar wheats sometimes appear among ancient Welsh wheats.

INDEX

Fig. 9. BLUE CONE.
(*T. turgidum*, var. *iodurum*.)

Fig. 10. RIVET.
(*T. turgidum*, var. *dinurum*.)

Fig. 11. RED SMOOTH RIVET.
(*T. turgidum*, var. *speciosum*.)

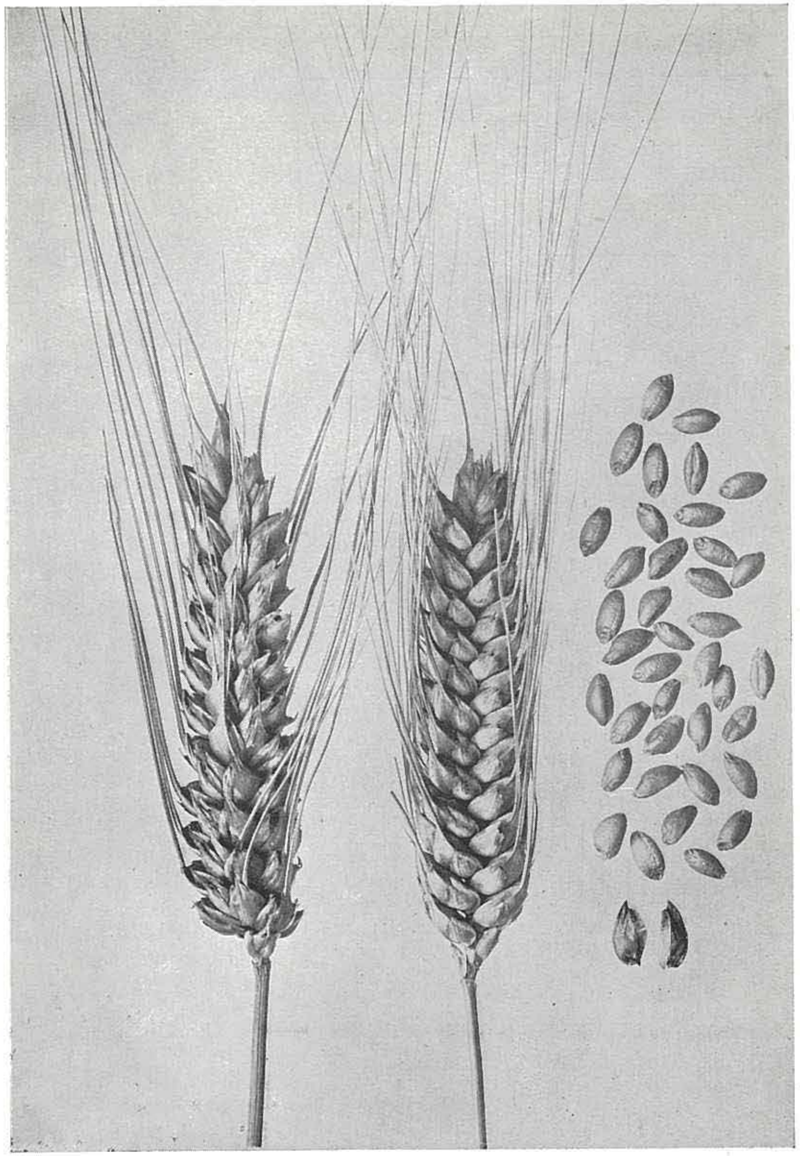

Fig. 12. WHITE RIVET.
(*T. turgidum*, var. *gentile.*)

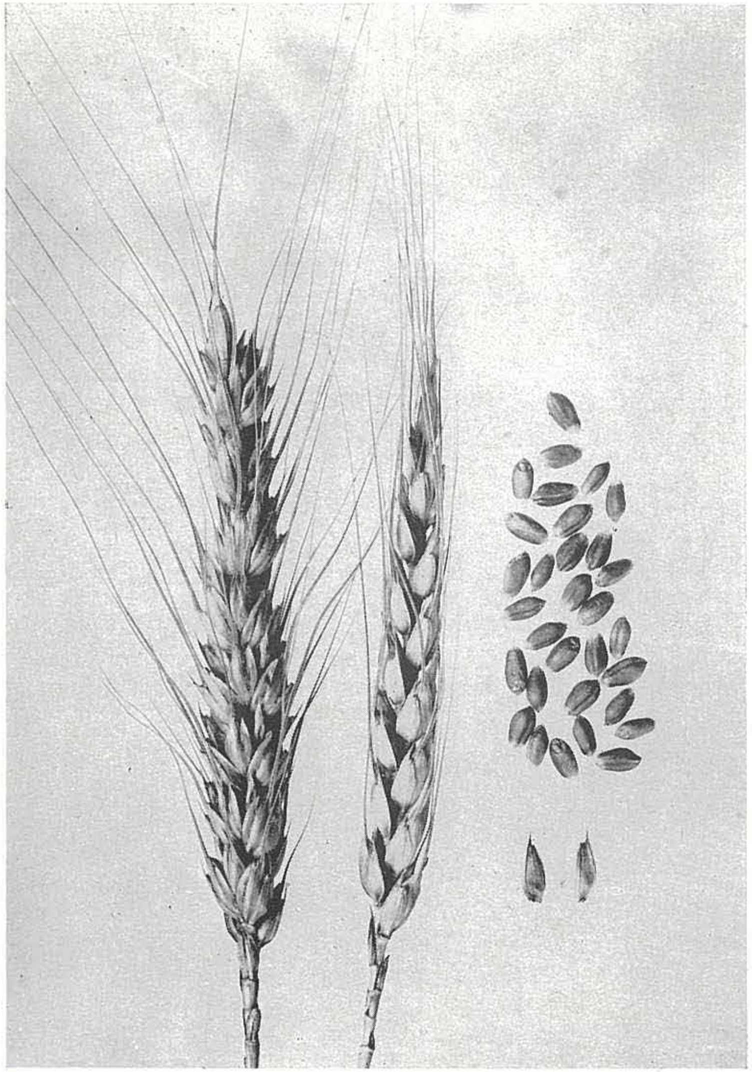

Fig. 13. SPRING WHITE CHAFF BEARDED, Form I.
(*T. vulgare*, var. *erythrospermum.*)

Fig. 14. SPRING WHITE CHAFF BEARDED, Form II.
(*T. vulgare*, var. *erythrospermum*.)

Fig. 15. BADGER.
(*T. vulgare*, var. *erythrospermum*.)

Fig. 16. WELSH APRIL RED.
(*T. vulgare*, var. *ferrugineum.*)

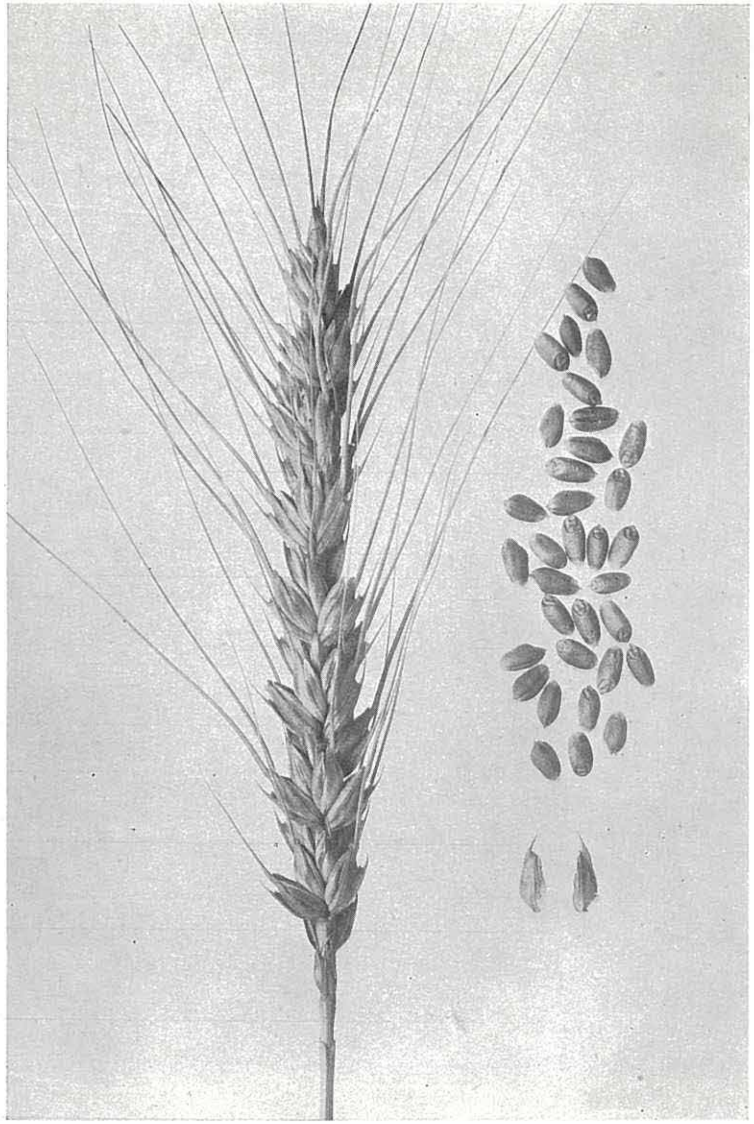

Fig. 17. APRIL BEARDED OR FERN.
(*T. vulgare*, var. *ferrugineum.*)

Fig. 18. WEBB'S BEARDED RED.
(*T. vulgare*, var. *ferrugineum*.)

Fig. 19. DEVON BEARDED RED.
(*T. vulgare*, var. *ferrugineum*.)

Fig. 20. WELSH BEARDED RED ROUGH CHAFF.
(*T. vulgare*, var. *barbarossa*.)

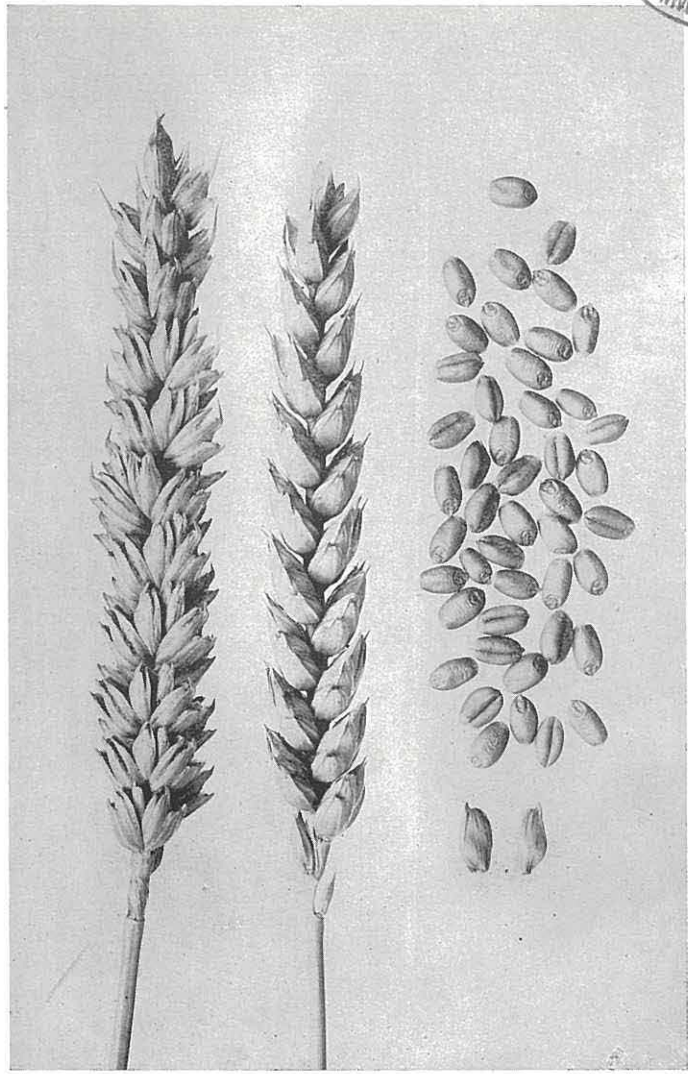

Fig. 21. A1.
(*T. vulgare*, var. *albidum*.)

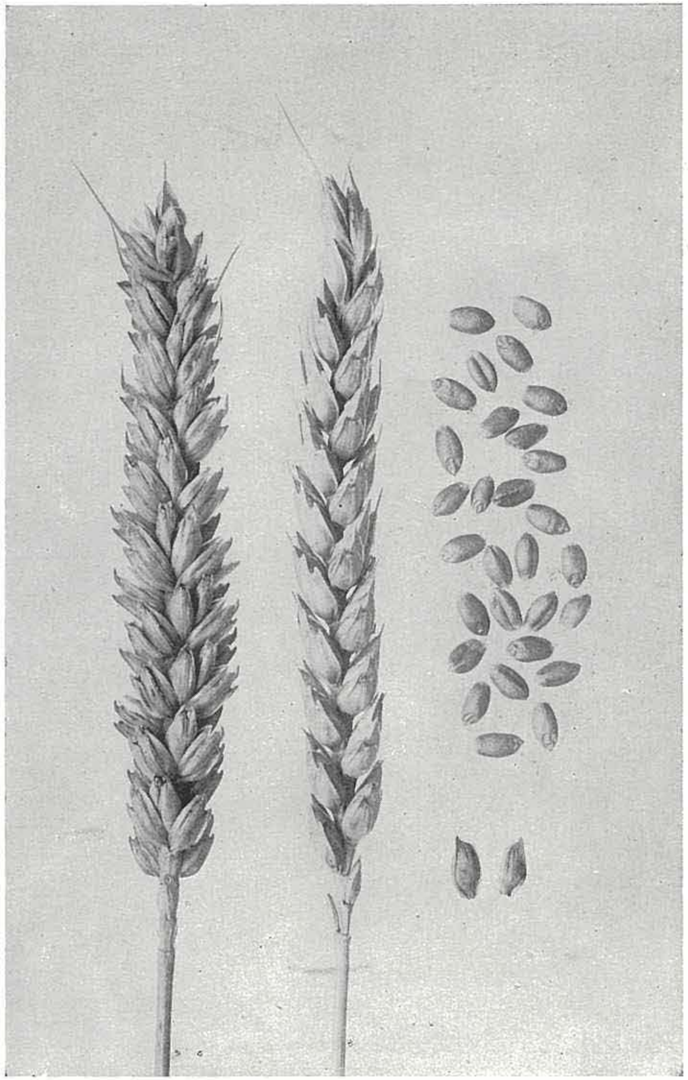

Fig. 22. AMBROSE STANDUP.
(*T. vulgare*, var. *albidum*.)

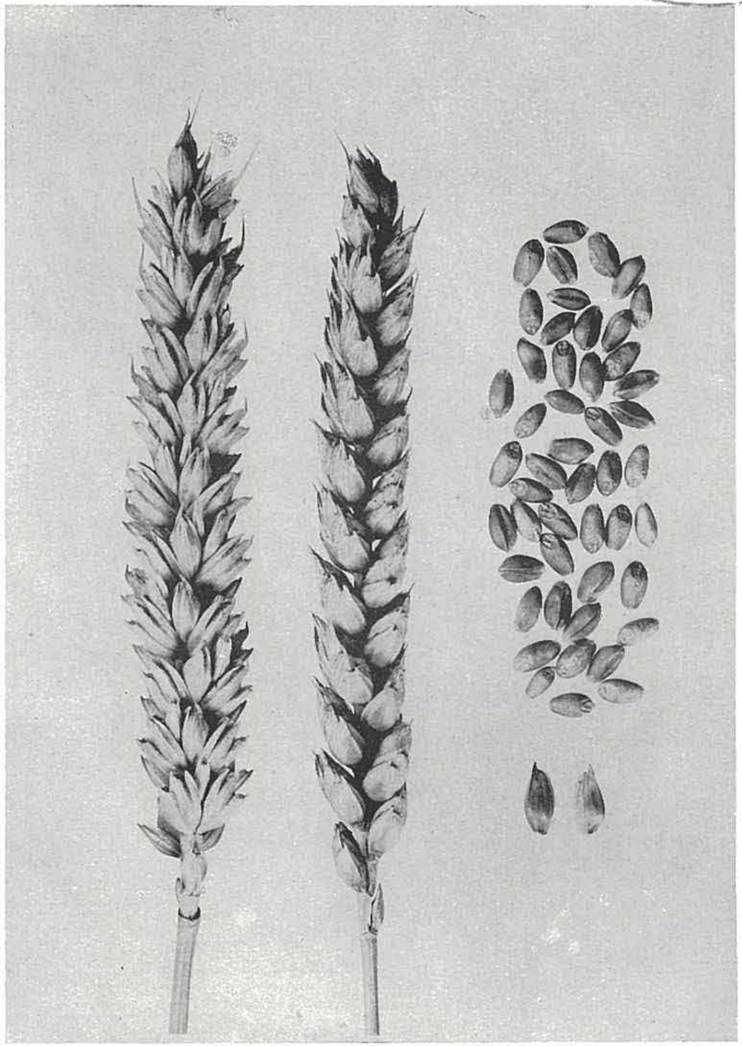

Fig. 23. SETTER.
(*T. vulgare*, var. *albidum*.)

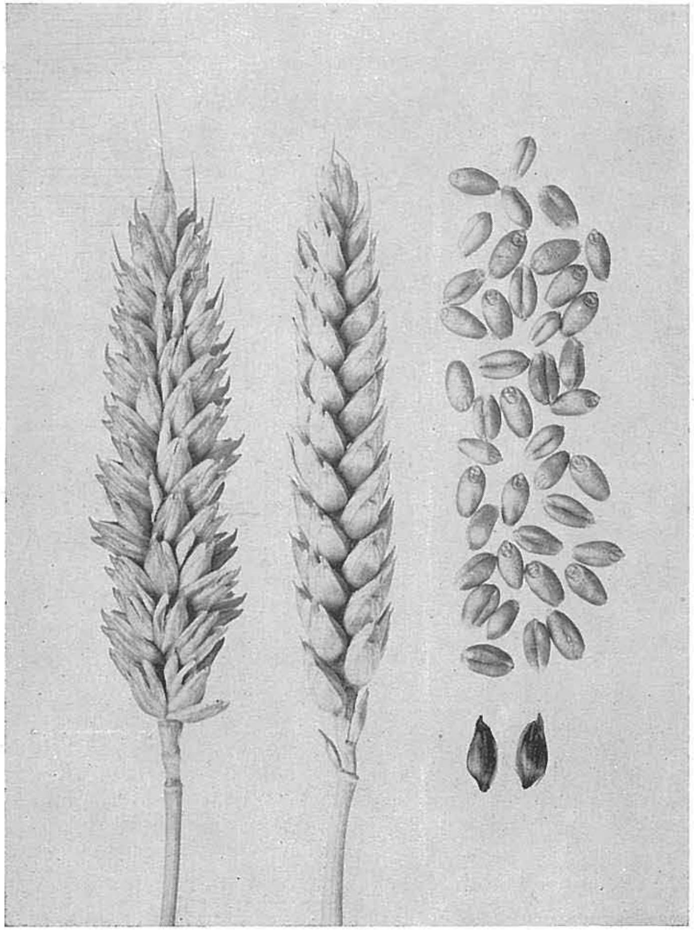

Fig. 24. WILHELMINA, Form I.
(*T. vulgare*, var. *albidum*.)

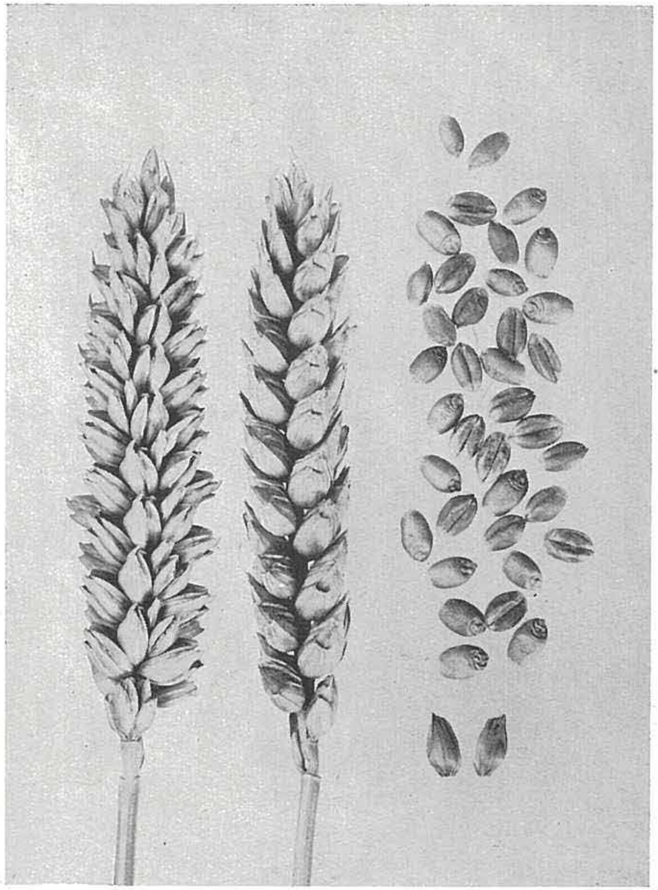

Fig. 25. WILHELMINA, Form II.
(*T. vulgare*, var. *albidum*.)

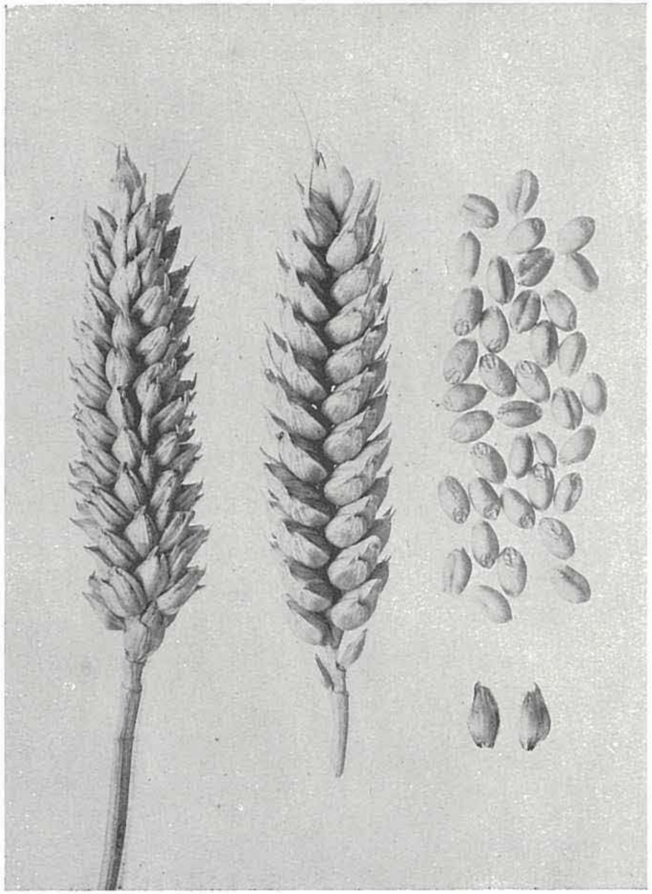

Fig. 26. MILLION III.
(*T. vulgare*, var. *albidum*.)

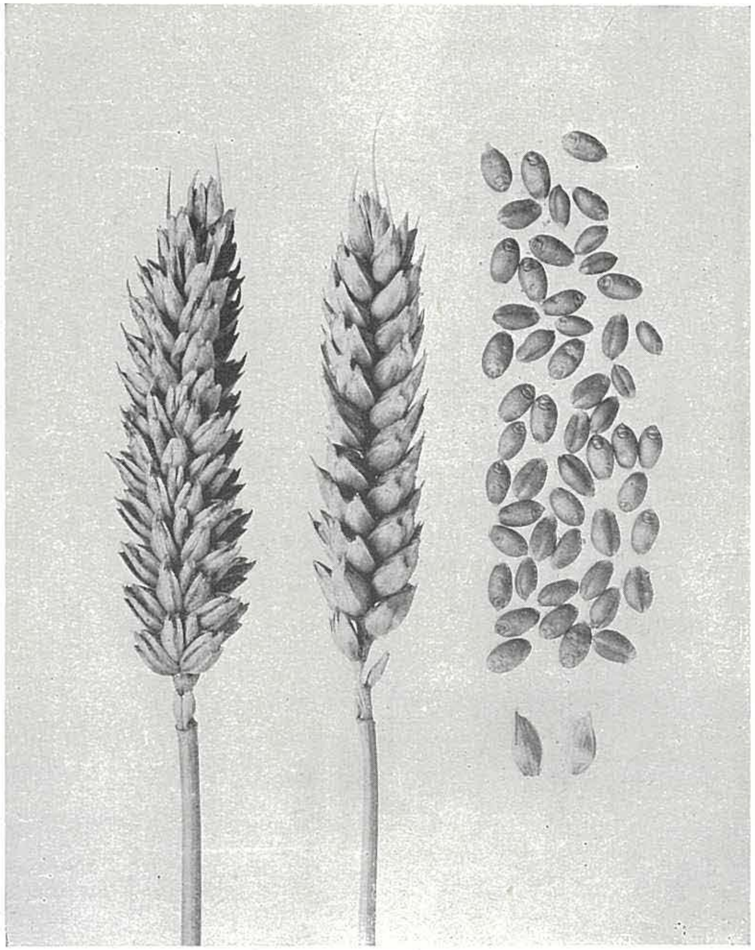

Fig. 27. VICTOR.
(*T. vulgare*, var. *albidum*.)

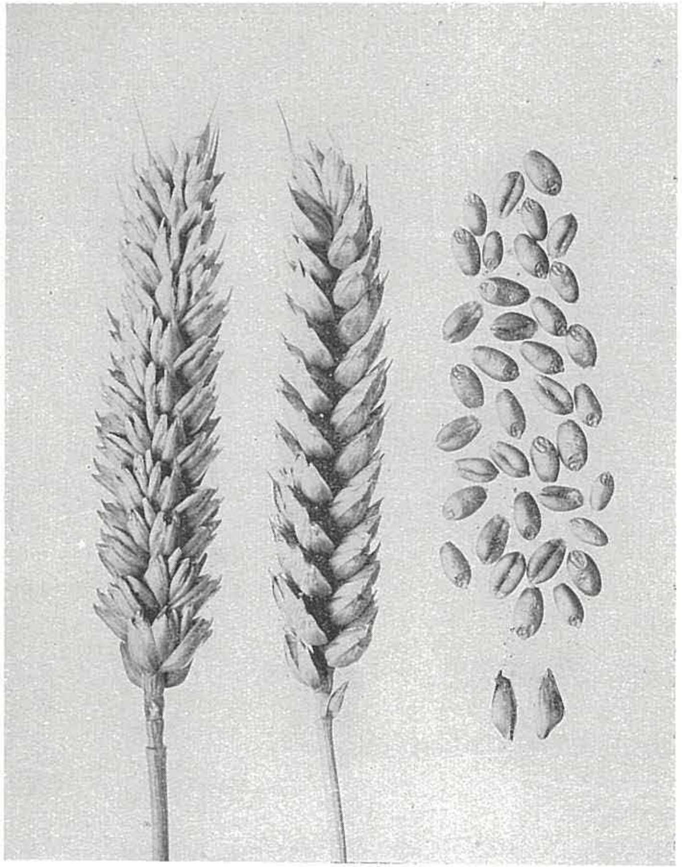

Fig. 28. STARLING II.
(*T. vulgare*, var. *albidum.*)

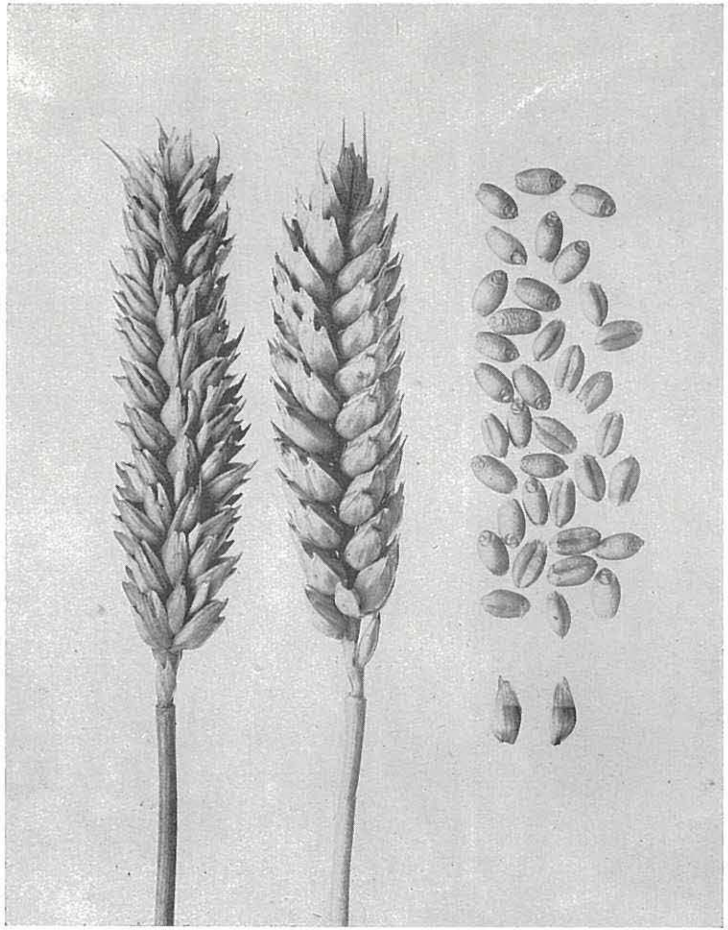

Fig. 29. DUTCH IMPERIAL.
(*T. vulgare*, var. *albidum.*)

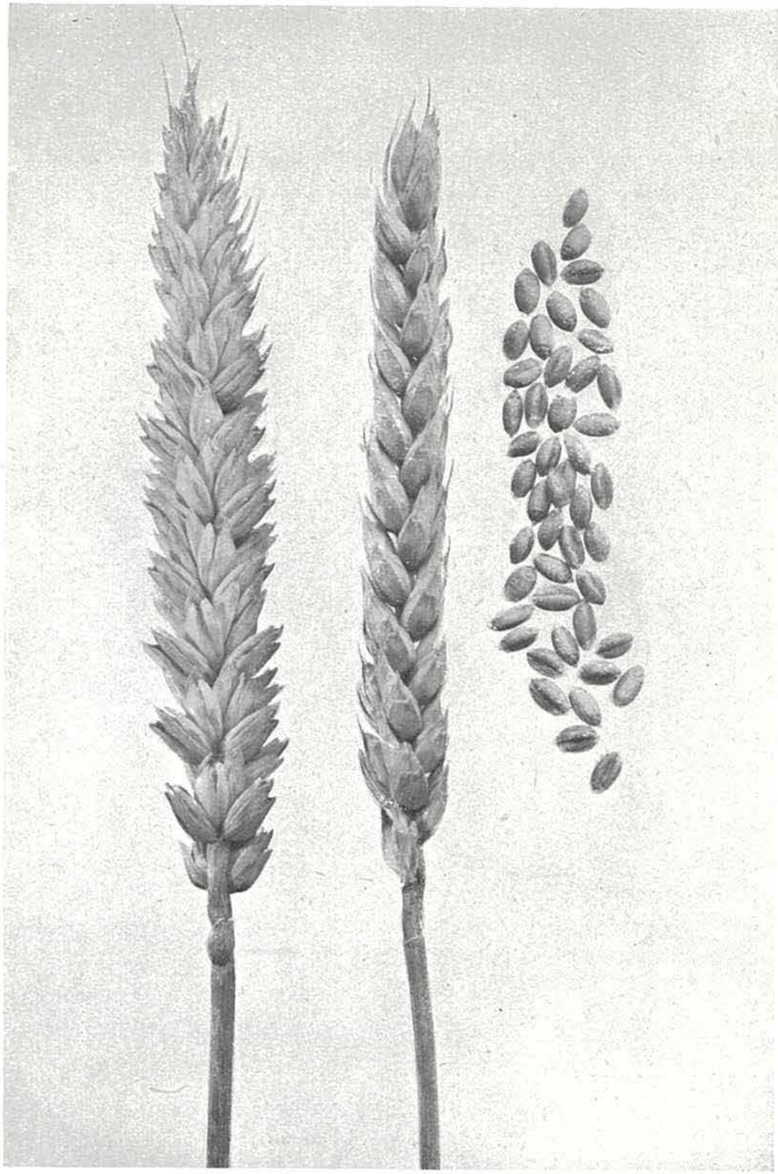

Fig. 30. HOLDFAST.
(*T. vulgare*, var. *albidum*.)

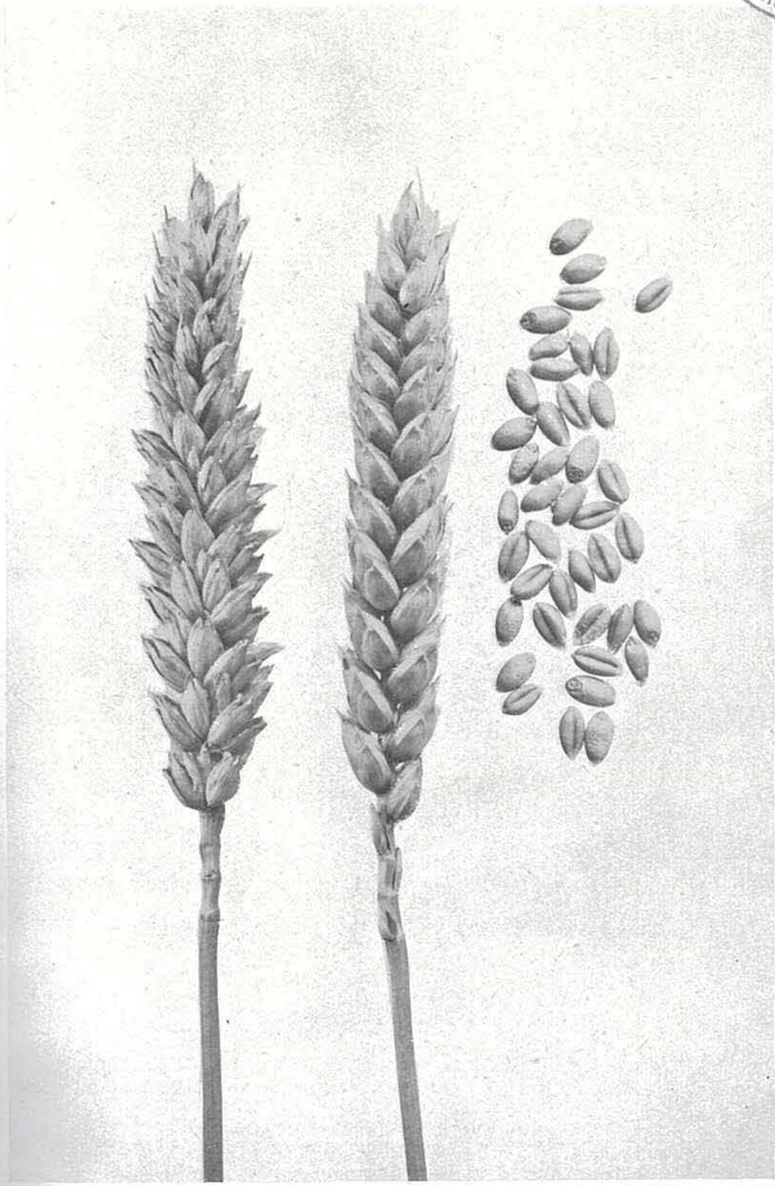

Fig. 31. JULIANA.
(*T. vulgare*, var. *albidum*.)

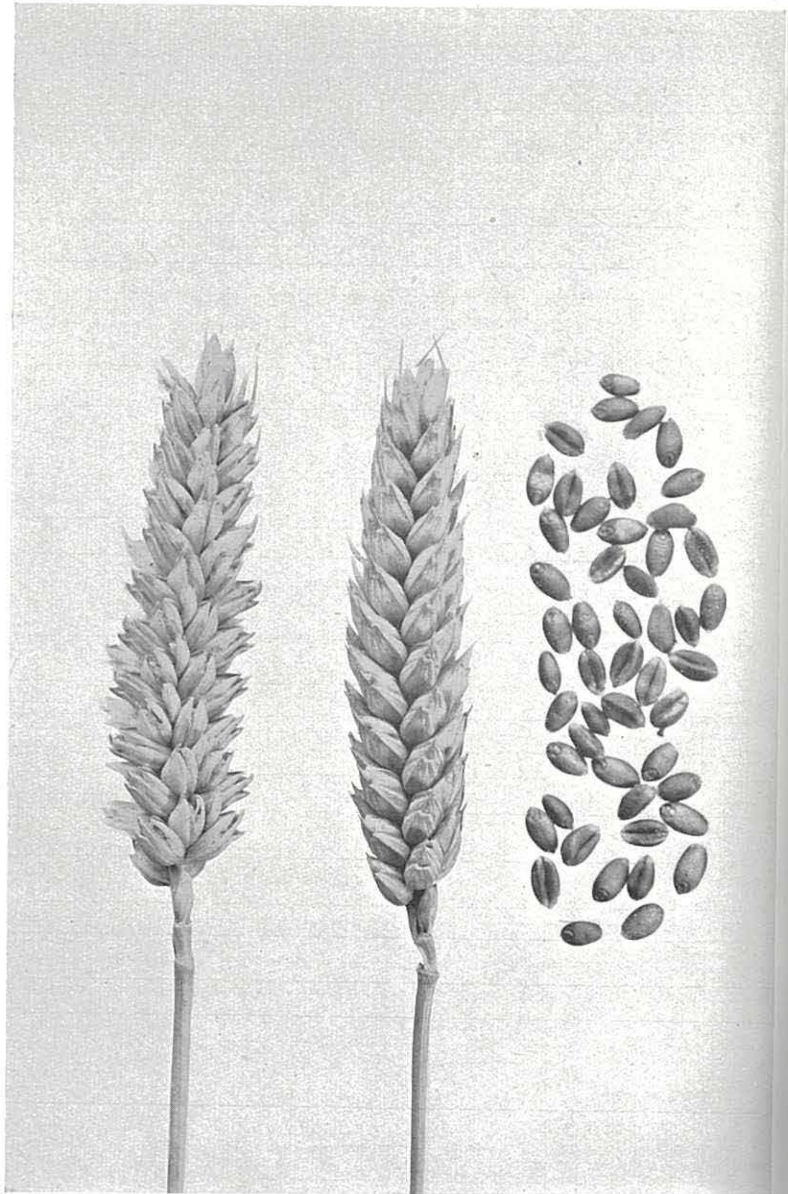

Fig. 32. WARDEN.
(*T. vulgare*, var. *albidum*.)

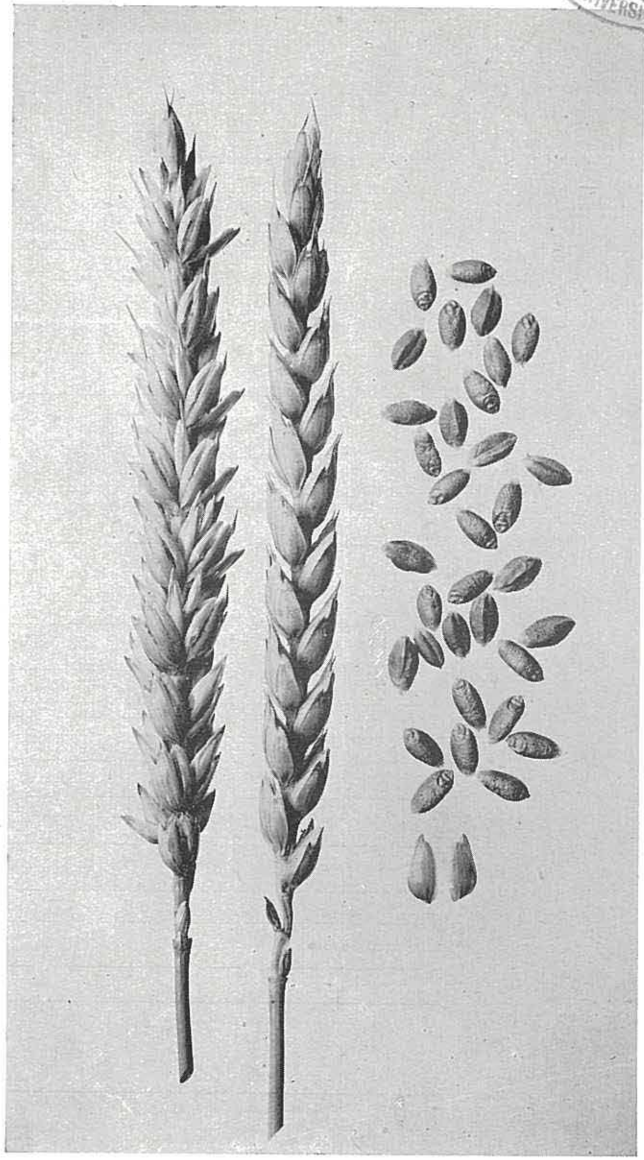

Fig. 33. HEN WENITH COCH (OLD WELSH RED).
(*T. vulgare*, var, *lutescens*.)

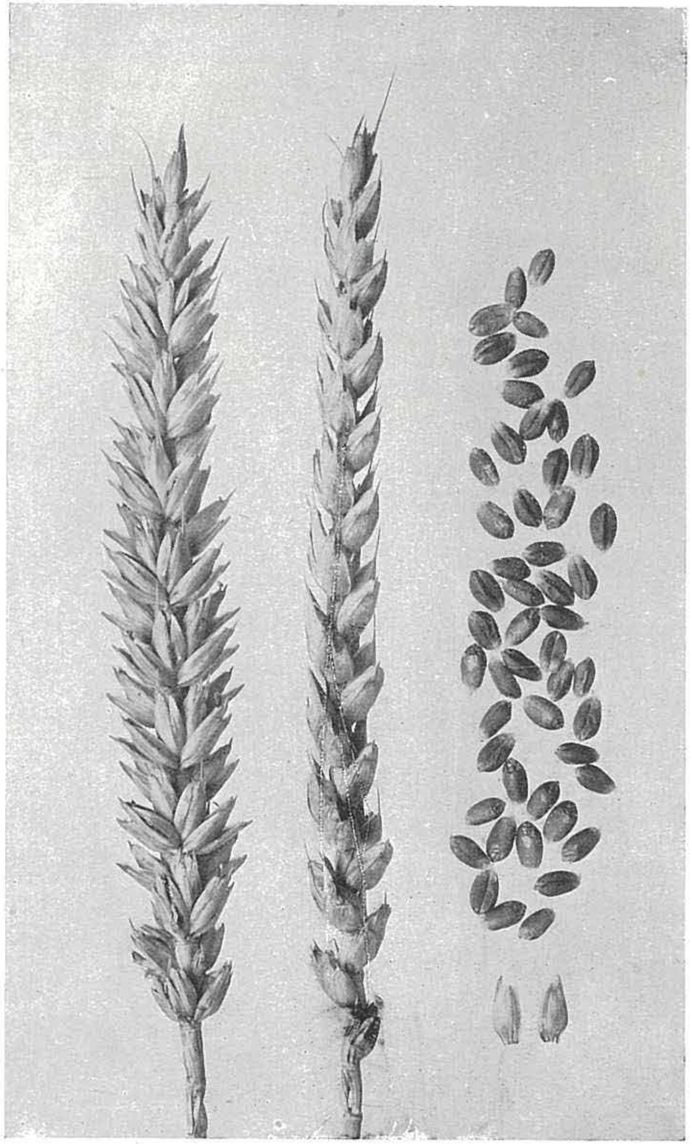

Fig. 34. OLD WELSH WHITE CHAFF RED (Hen Gymro 484).
(*T. vulgare*, var. *lutescens*.)

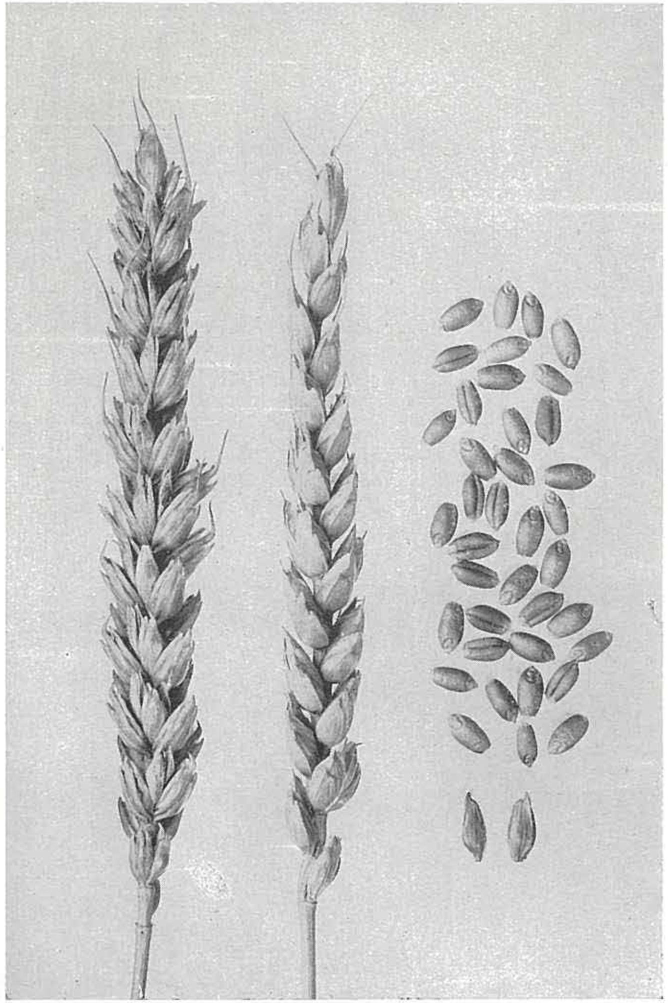

Fig. 35. OLD CUMBERLAND.
(*T. vulgare*, var. *lutescens*.)

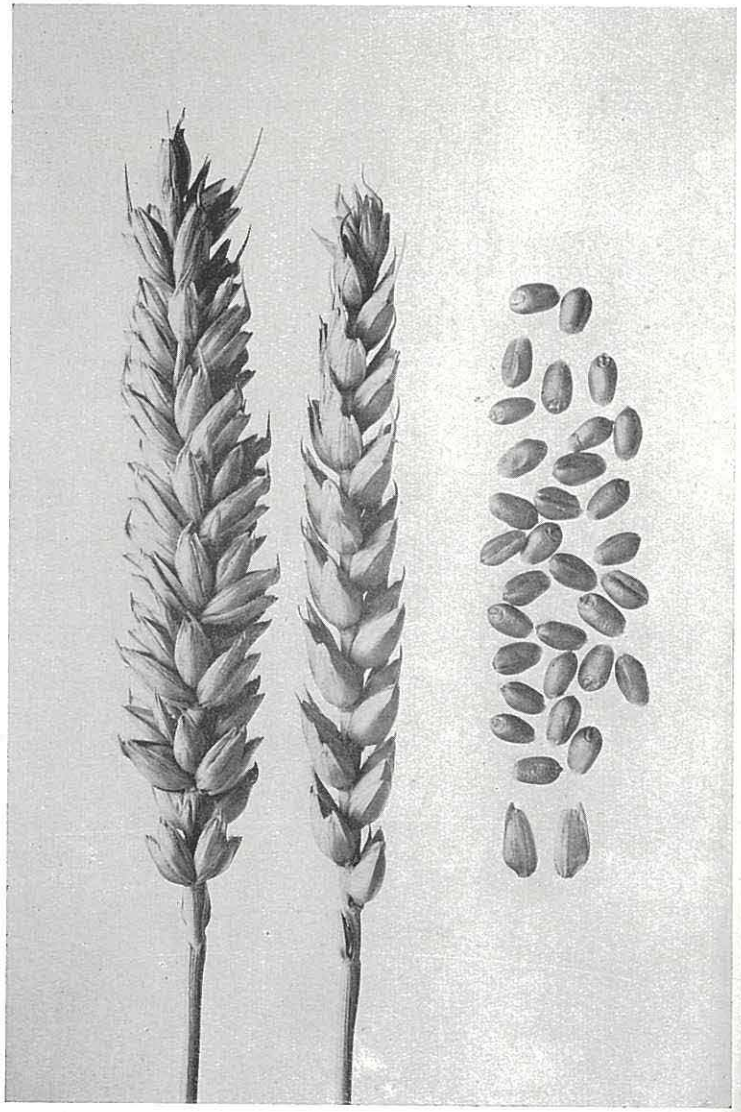

Fig. 36. RED MARVEL OR JAPHET.
(*T. vulgare*, var. *lutescens.*)

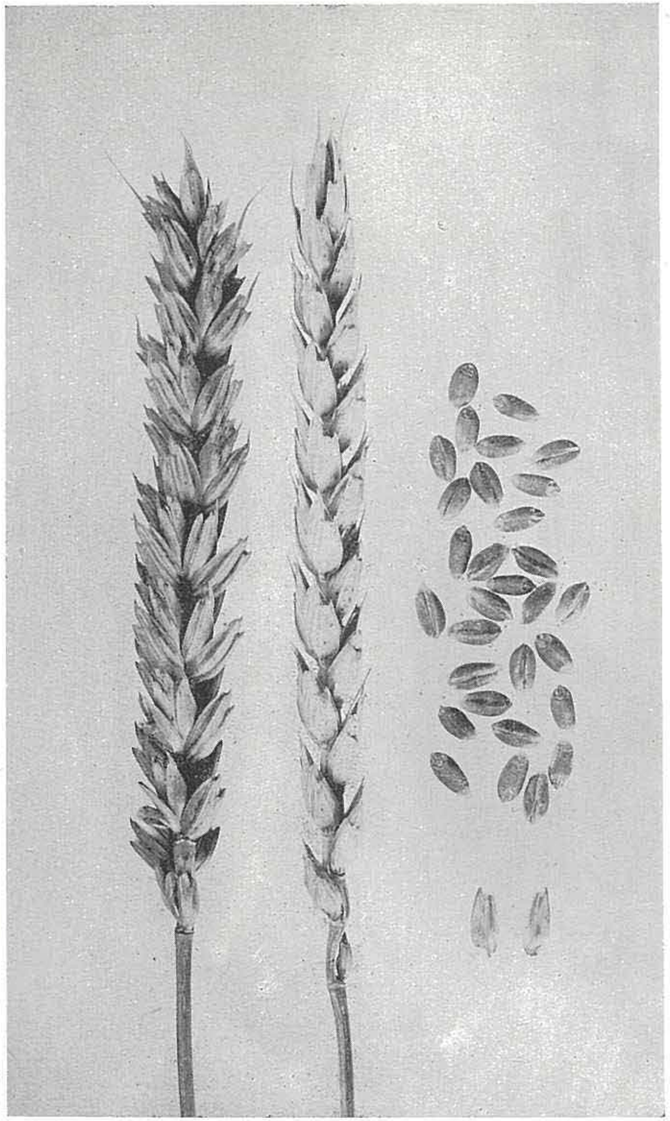

Fig. 37. DEVON WHITE CHAFF RED.
(*T. vulgare*, var. *lutescens.*)

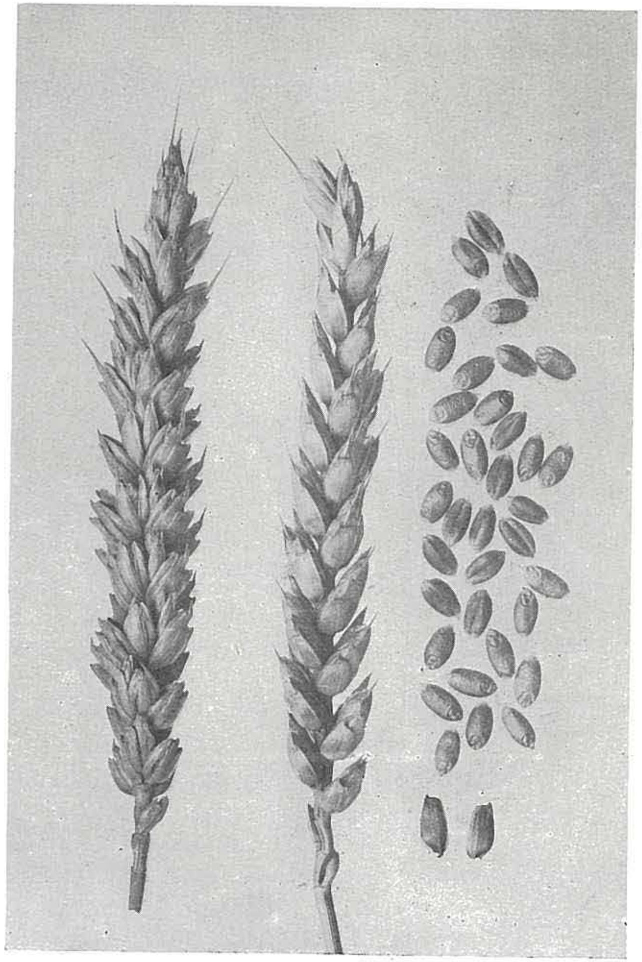

Fig. 38. WEIBULL'S STANDARD.
(*T. vulgare*, var. *lutescens.*)

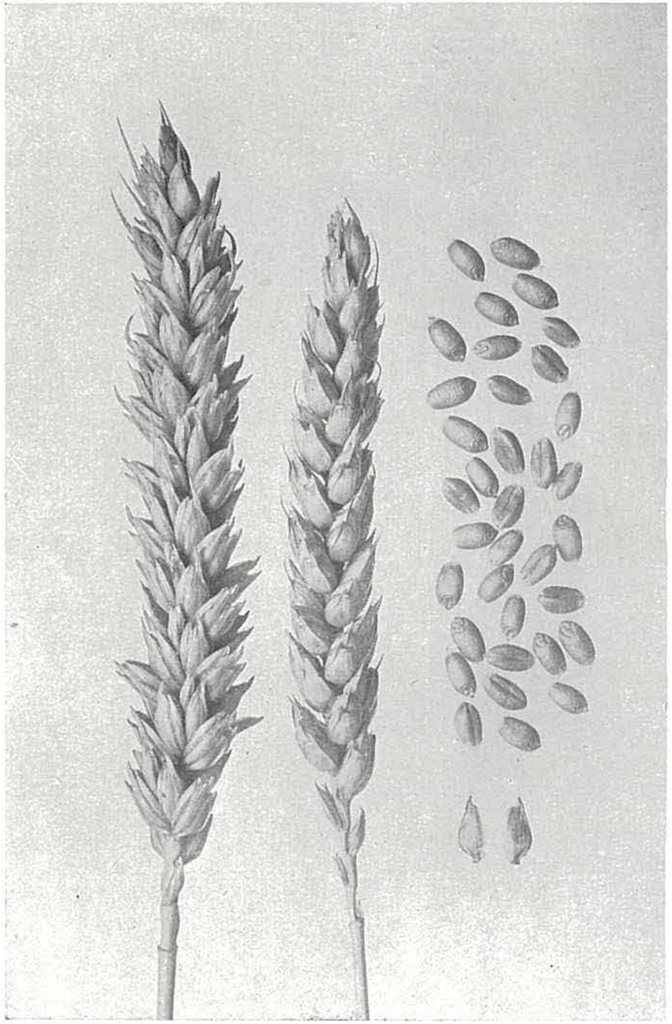

Fig. 39. PRICE'S PROLIFIC.
(*T. vulgare*, var. *lutescens.*)

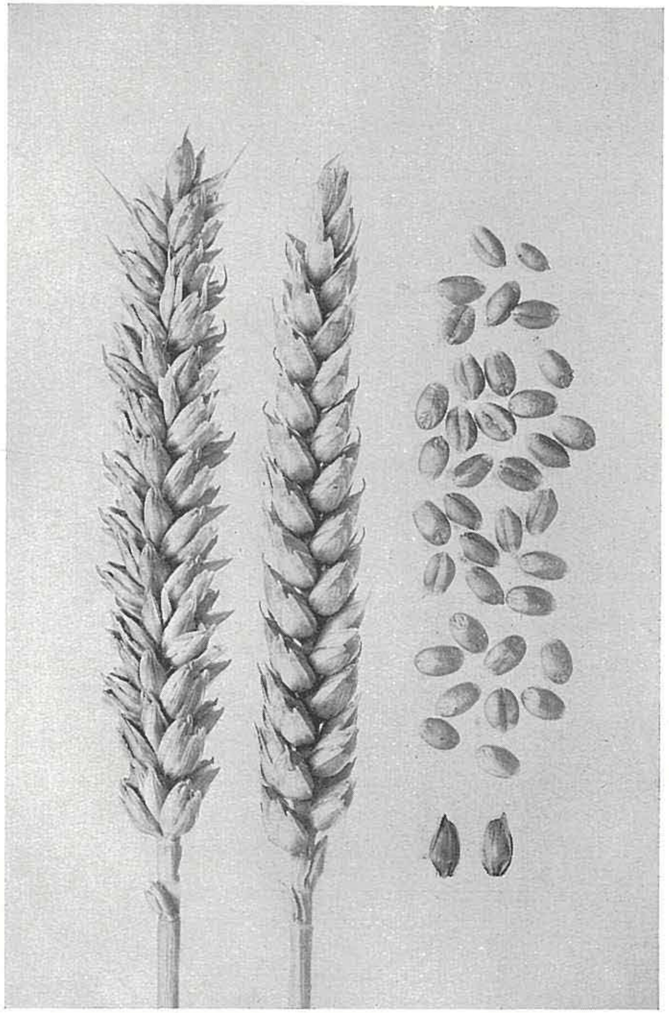

Fig. 40. PARTRIDGE.
(*T. vulgare*, var. *lutescens.*)

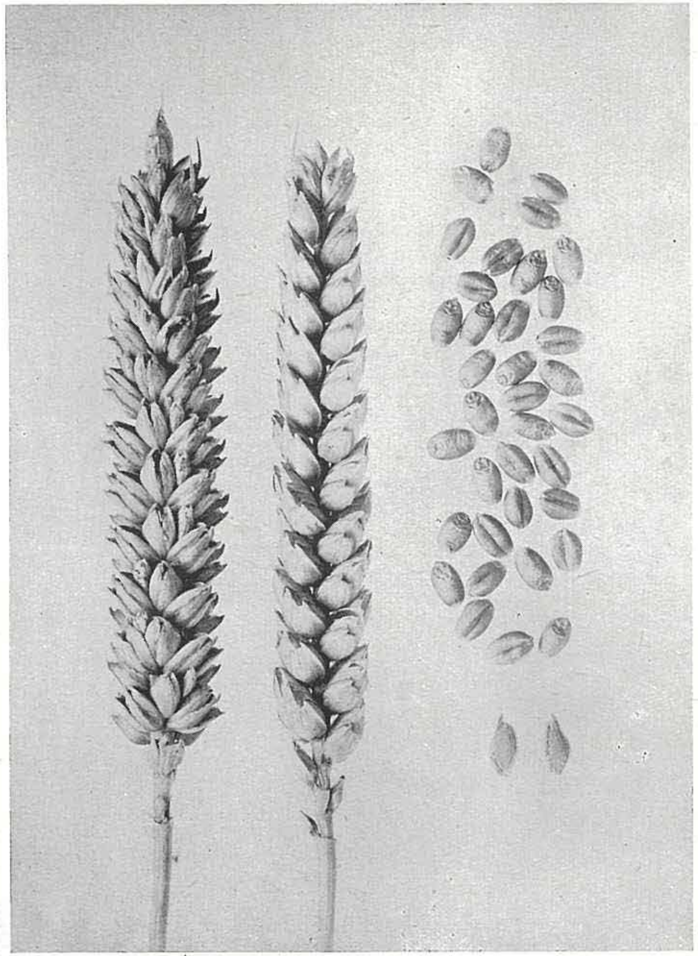

Fig. 41. IRON III.
(*T. vulgare*, var. *lutescens.*)

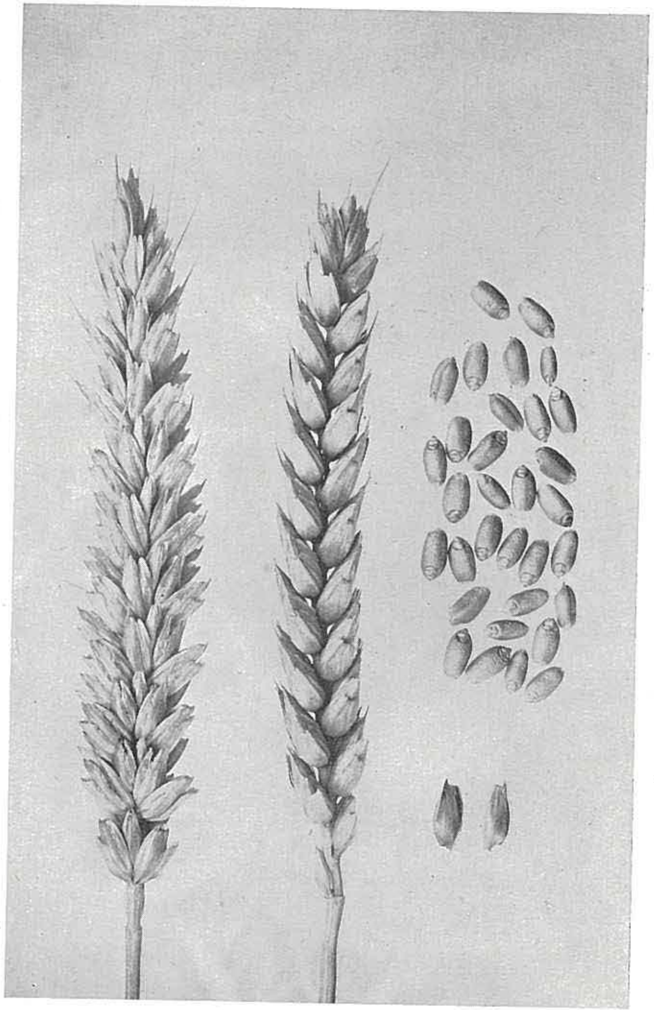

Fig. 42. YEOMAN II.
(*T. vulgare*, var. *lutescens.*)

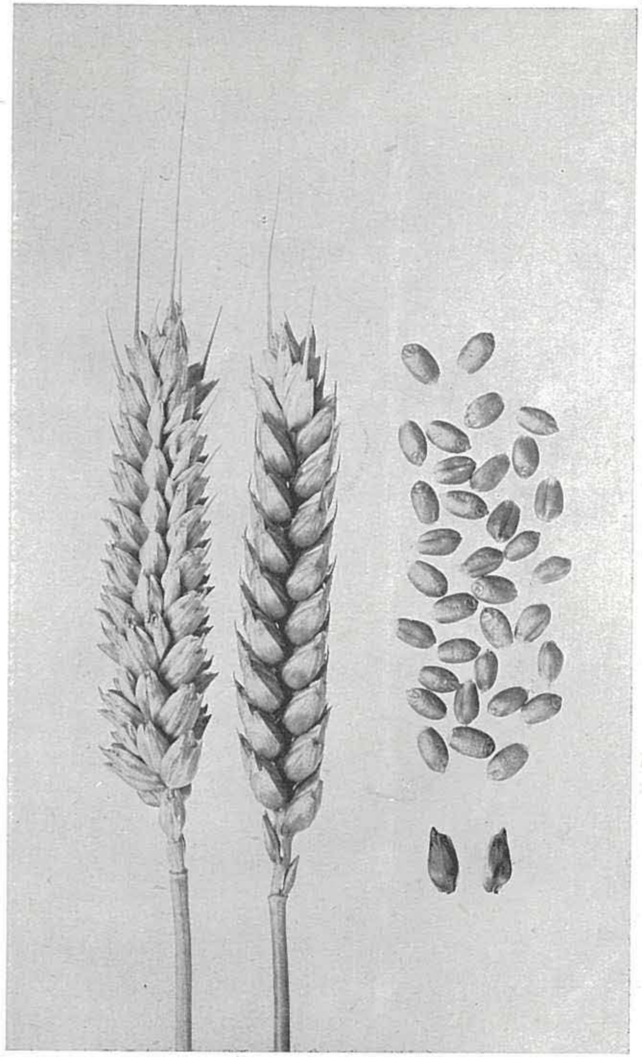

Fig. 43. SQUAREHEAD, Form I.
(*T. vulgare*, var. *lutescens.*)

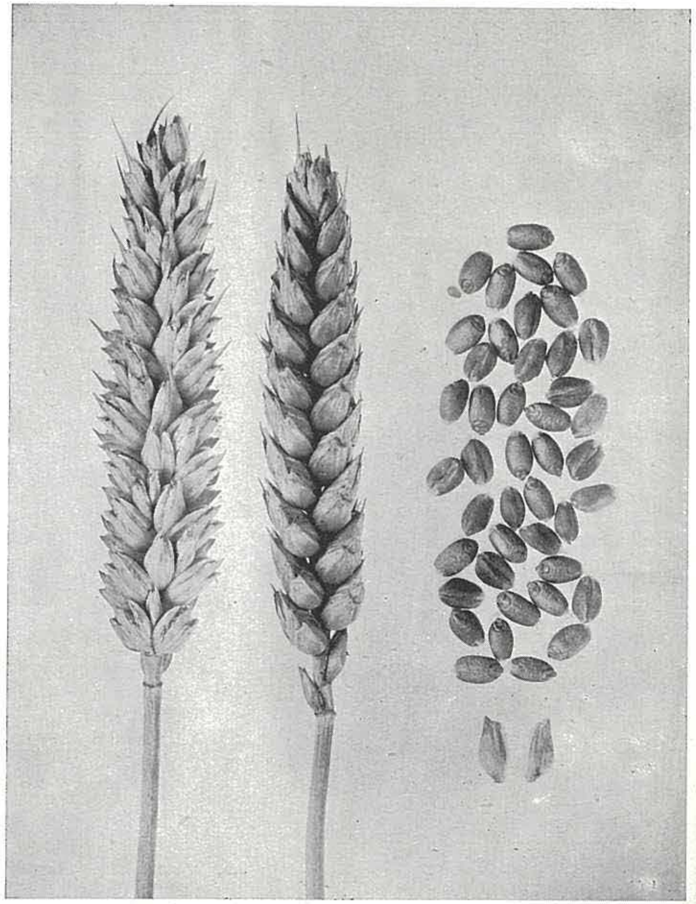

Fig. 44. SQUAREHEAD, Form II.
(*T. vulgare*, var. *lutescens.*)

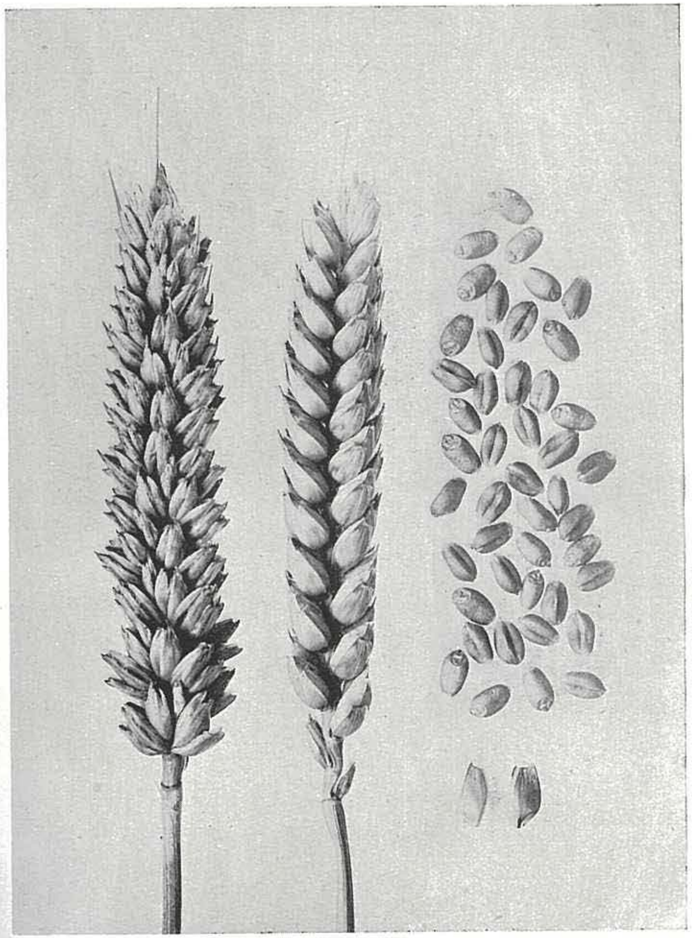

Fig. 45. CAMBRIDGE BROWICK.
(*T. vulgare*, var. *lutescens.*)

Fig. 46. ATLE.
(*T. vulgare*, var. *lutescens.*)

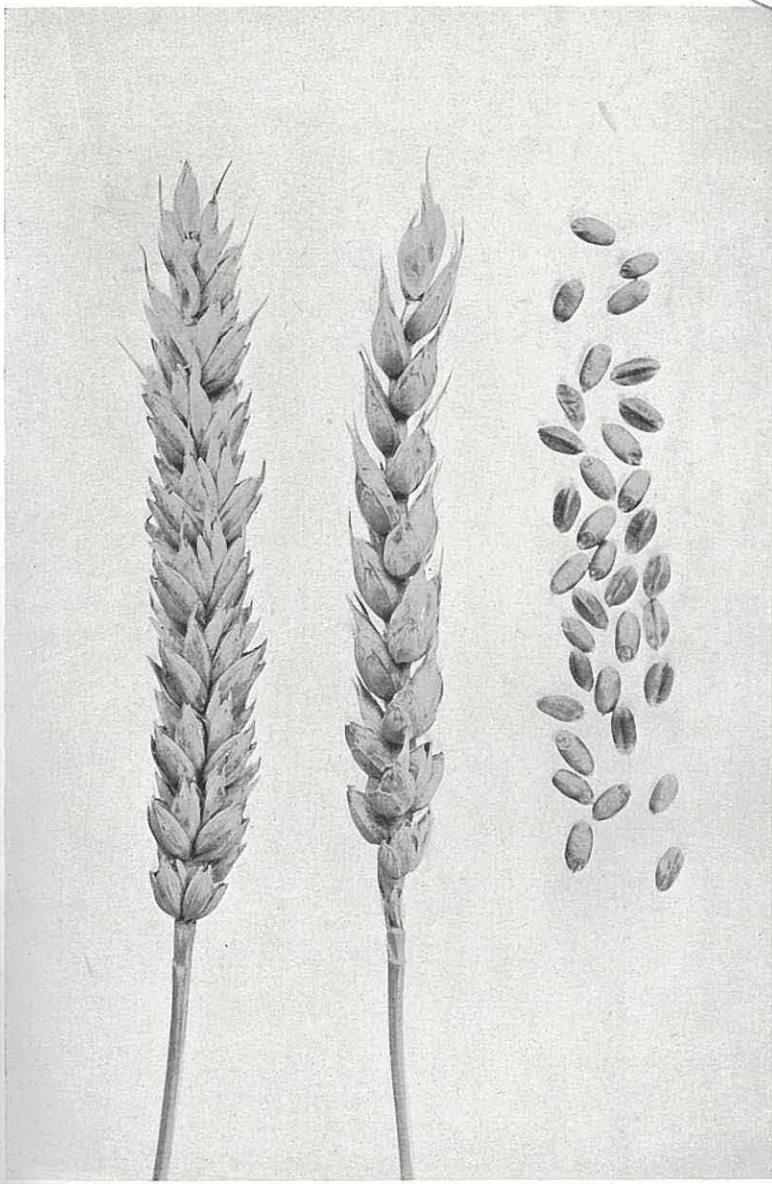

Fig. 47. BERSÉE.
(*T. vulgare*, var. *lutescens.*)

Fig. 48. CROWN.
(*T. vulgare*, var. *lutescens.*)

Fig. 49. EXTRA KOLBEN II.
(*T. vulgare*. var. *lutescens.*)

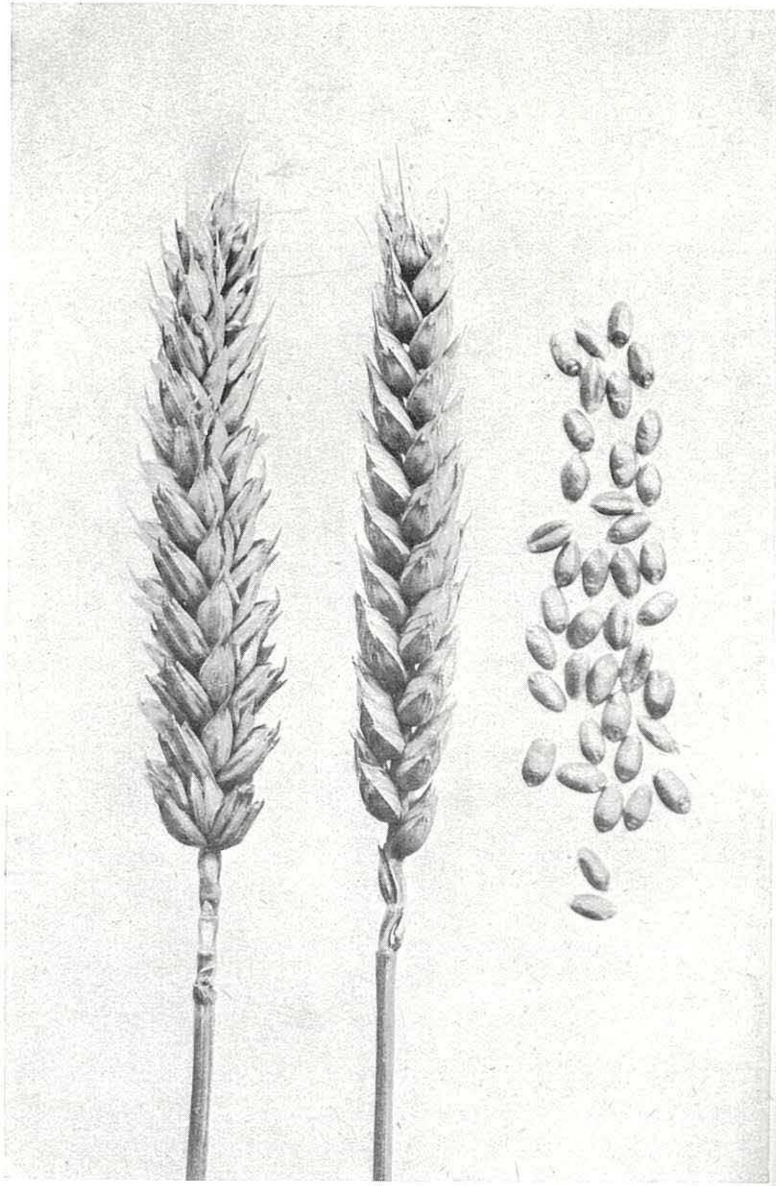

Fig. 50. GARTON'S SIXTY.
(*T. vulgare*, var. *lutescens*.)

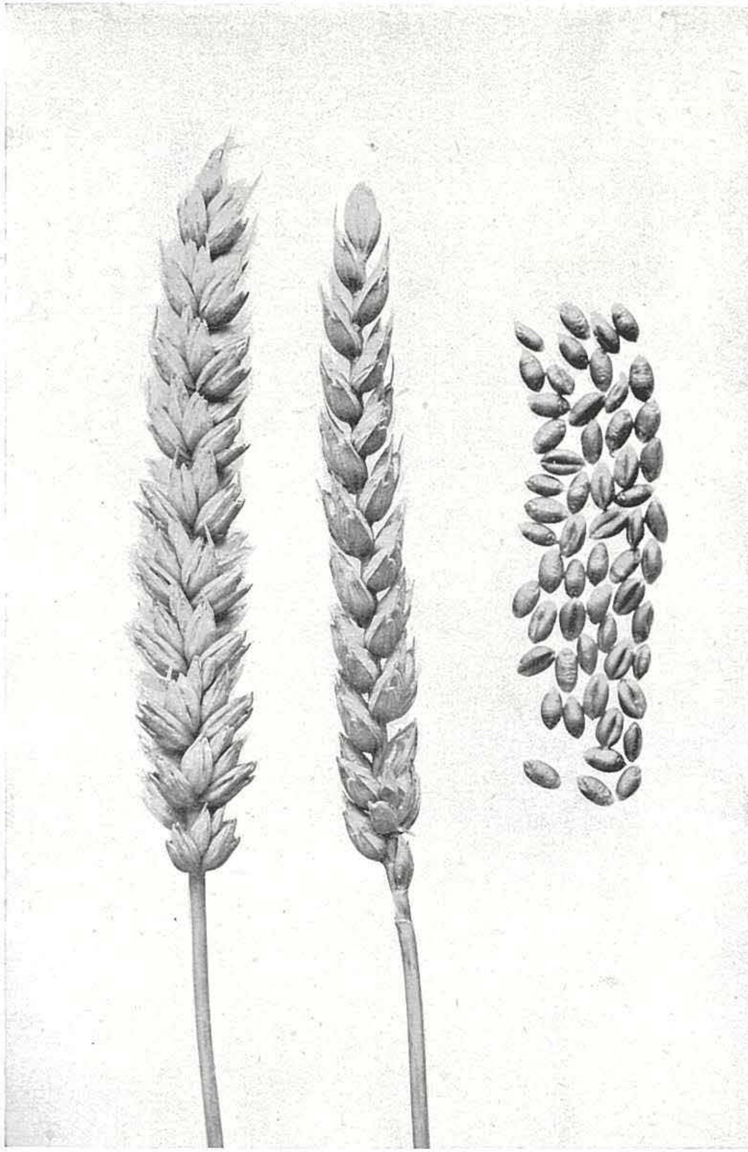

Fig. 51. JUBILÉGEM.
(*T. vulgare*, var. *lutescens*.)

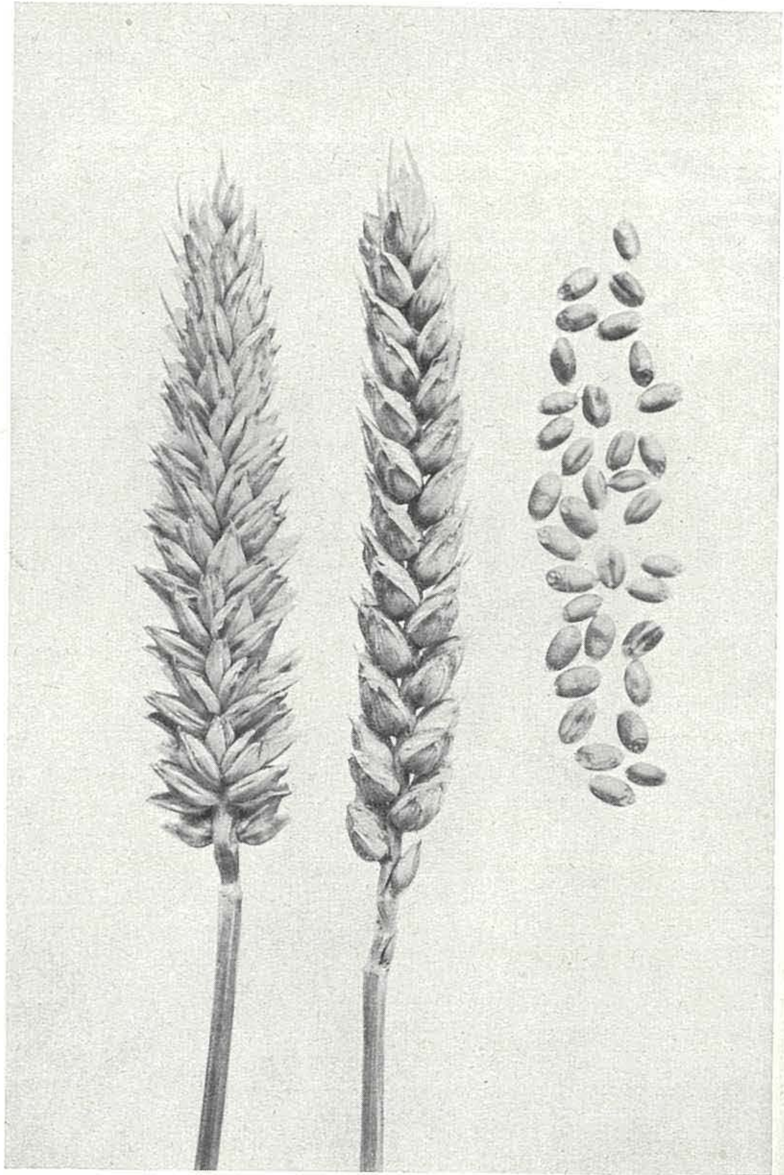

Fig. 52. QUOTA.
(*T. vulgare*, var. *lutescens.*)

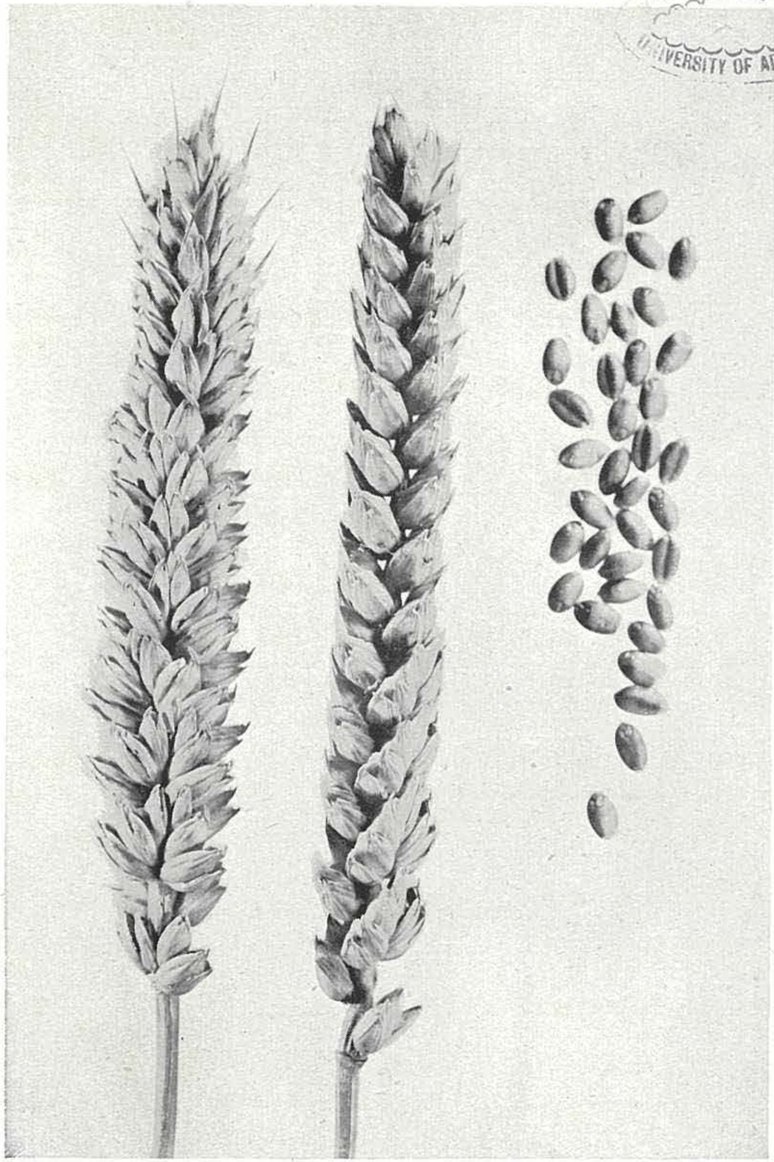

Fig. 53. SCANDIA.
(*T. vulgare*, var. *lutescens.*)

Fig. 54. VILMORIN 27.
(*T. vulgare*, var. *lutescens.*)

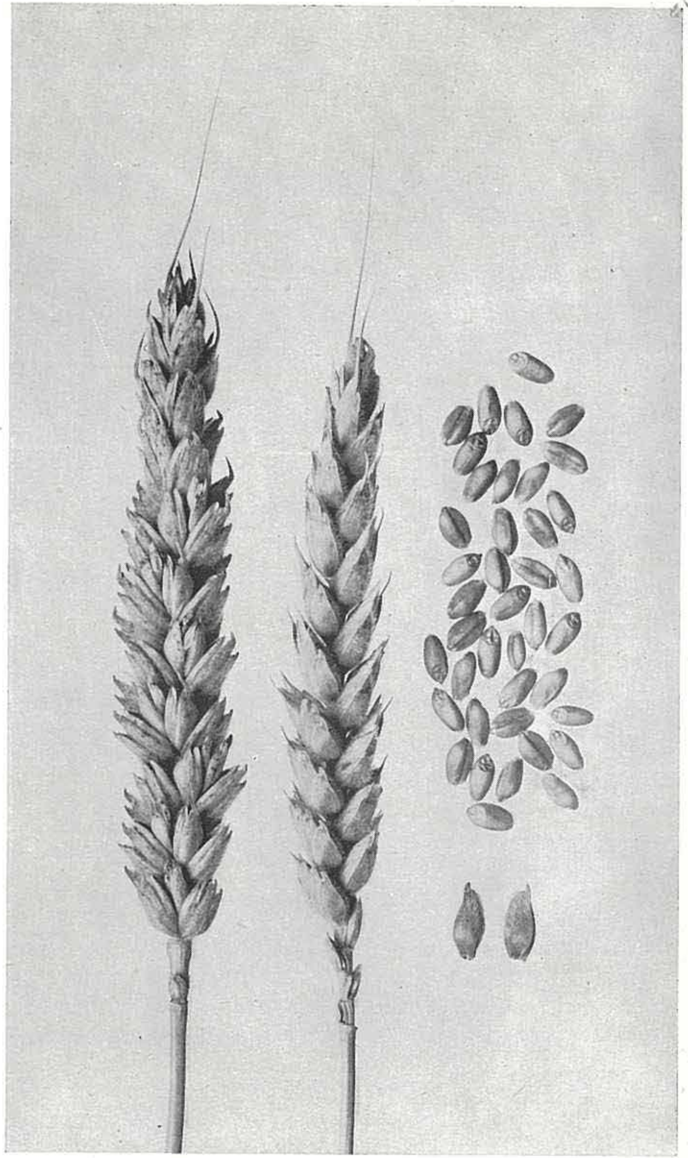

Fig. 55. ROUGH CHAFF WHITE OR OLD HOARY.
(*T. vulgare*, var. *leucospermum.*)

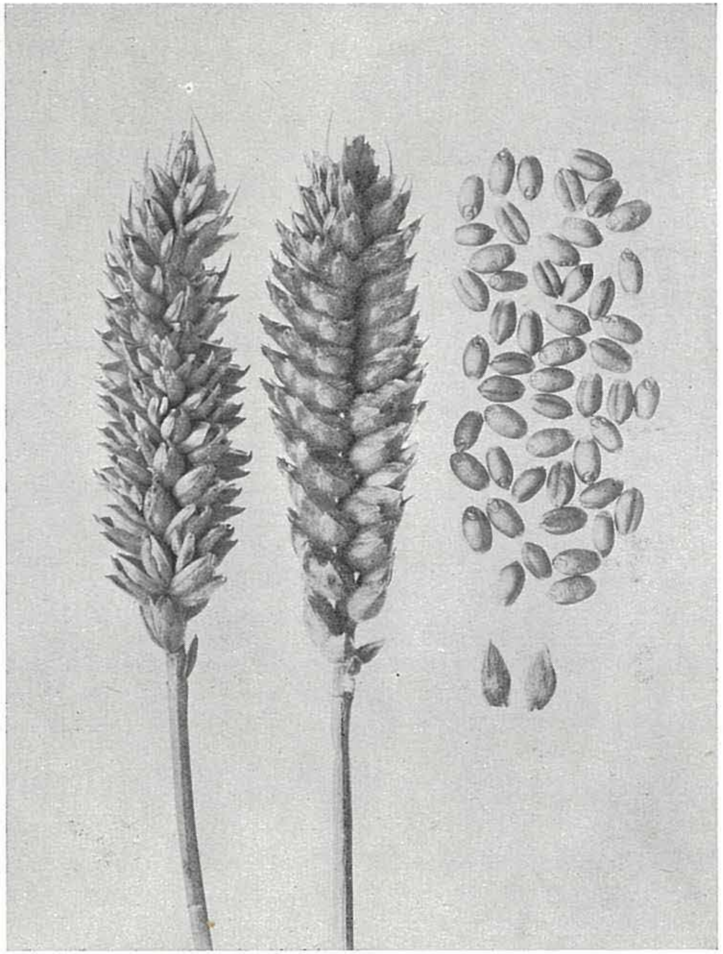

Fig. 56. BENEFACTOR.
(*T. vulgare*, var. *leucospermum*.)

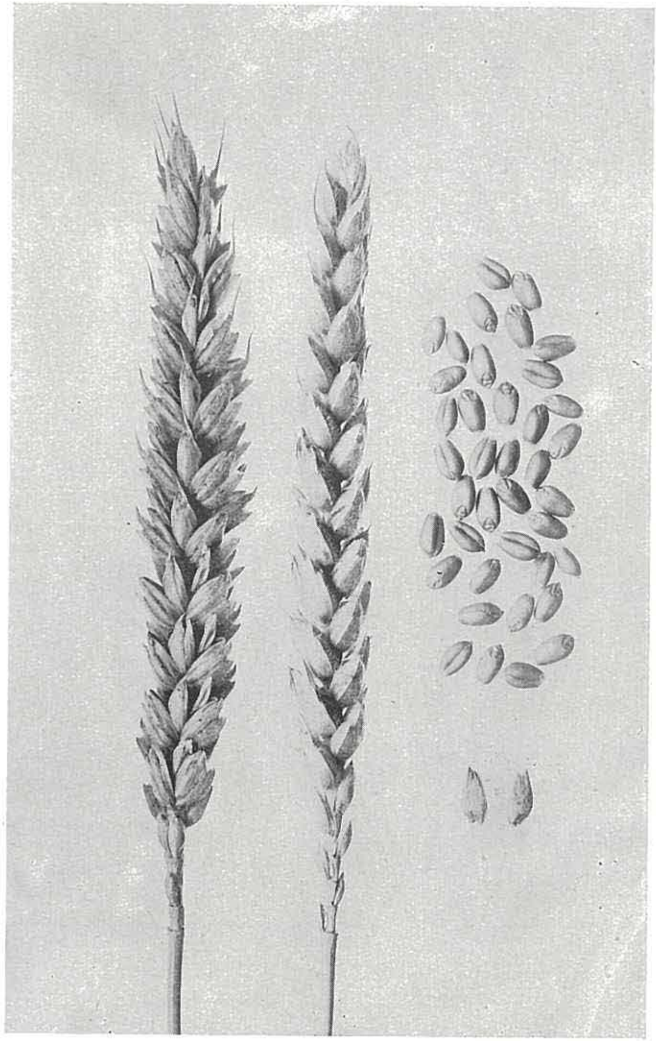

Fig. 57. ORANGE DEVON HOARY.
(*T. vulgare*, var. *velutinum*.)

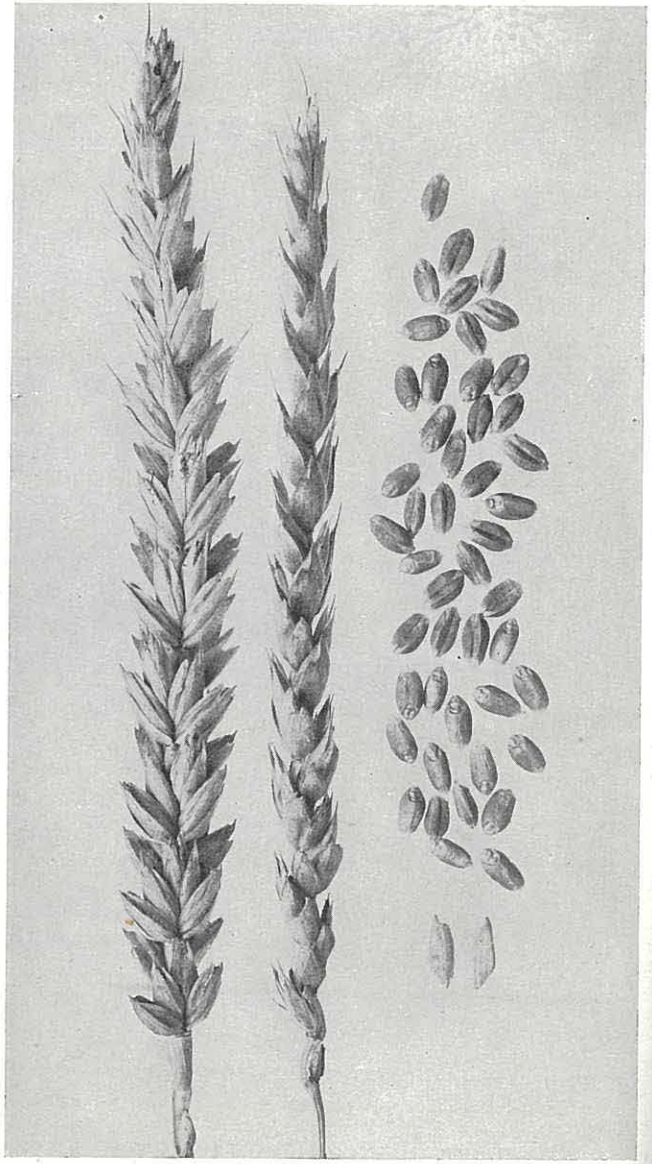

Fig. 58. OLD WELSH HOARY, Form I (Hen Gymro 274).
(*T. vulgare*, var. *velutinum*.)

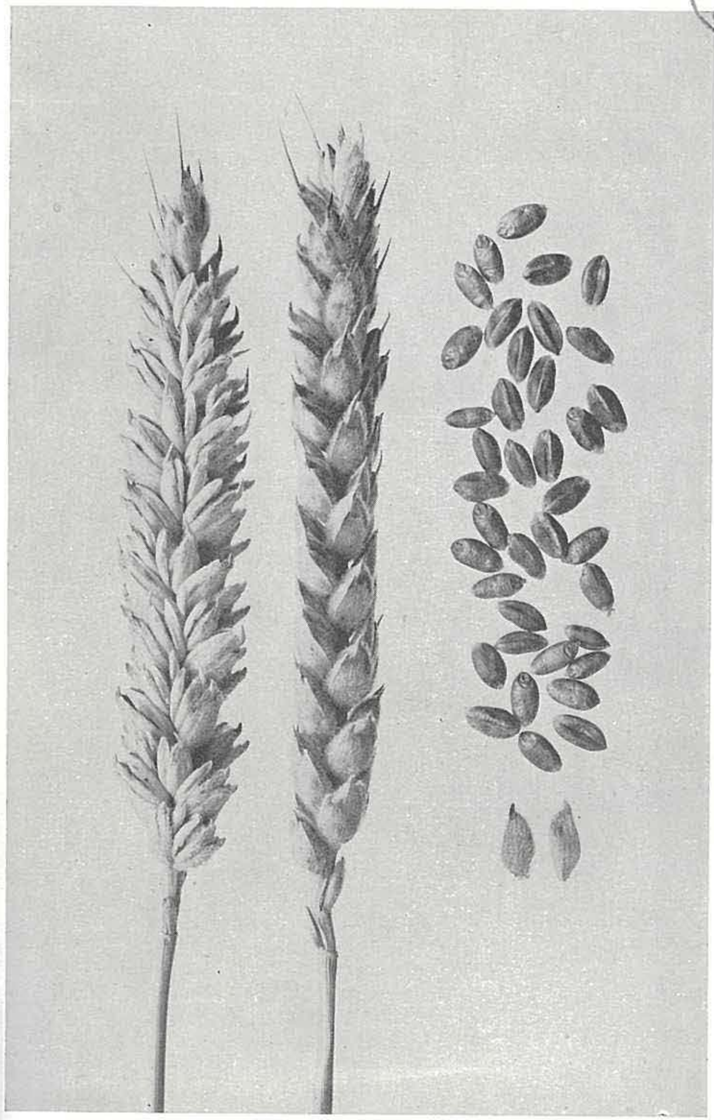

Fig. 59. OLD WELSH HOARY, Form II (Hen Gymro 789).
(*T. vulgare*, var. *velutinum*.)

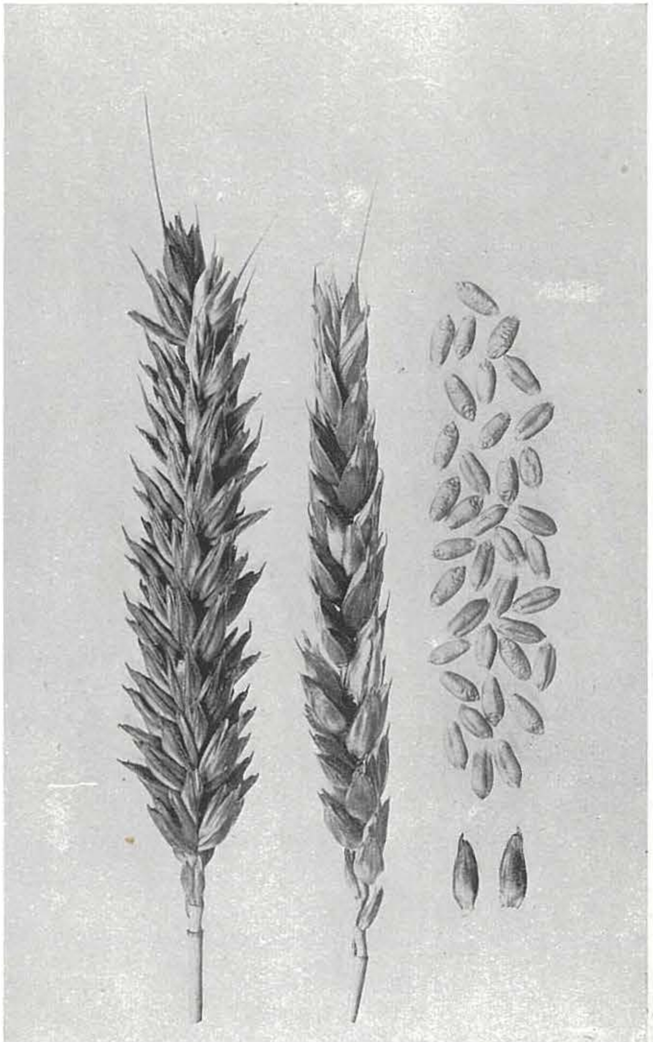

Fig. 60. IDEAL.
(*T. vulgare*, var. *albo-rubrum.*)

Fig. 61. STEADFAST.
(*T. vulgare*, var. *albo-rubrum.*)

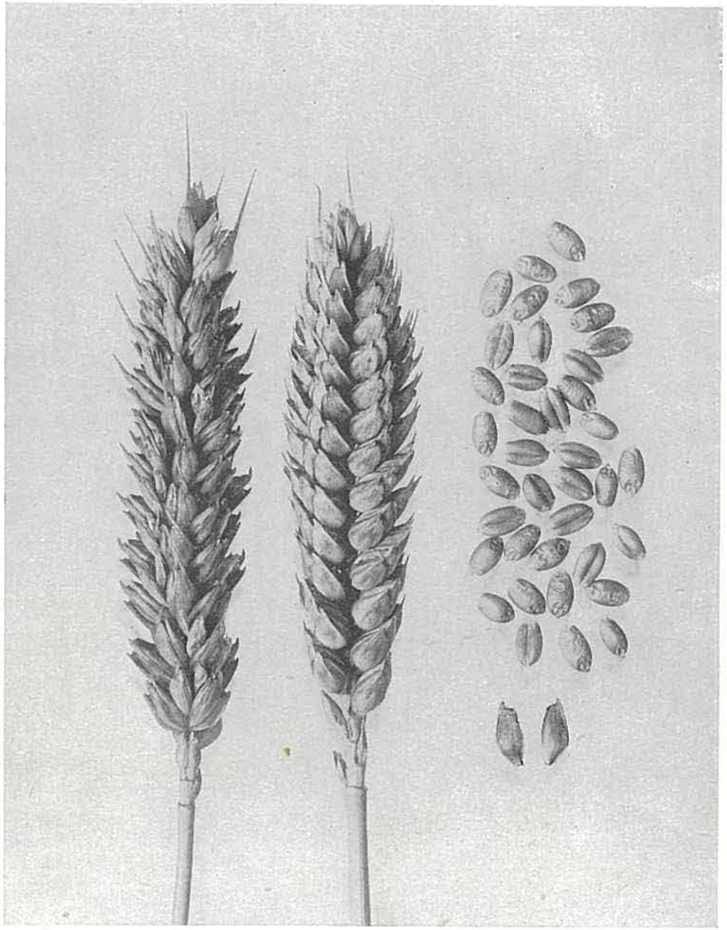

Fig. 62. PREMIER.
(*T. vulgare*, var. *albo-rubrum.*)

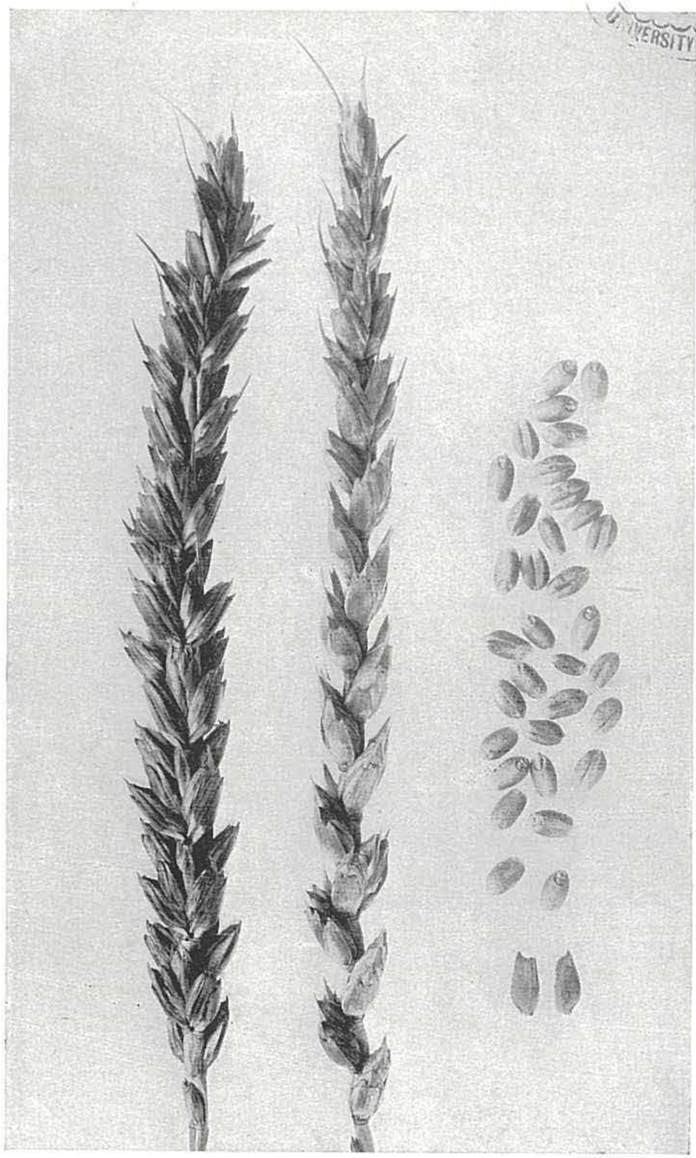

Fig. 63. OLD WELSH RED CHAFF 460.
(*T. vulgare*, var. *milturum.*)

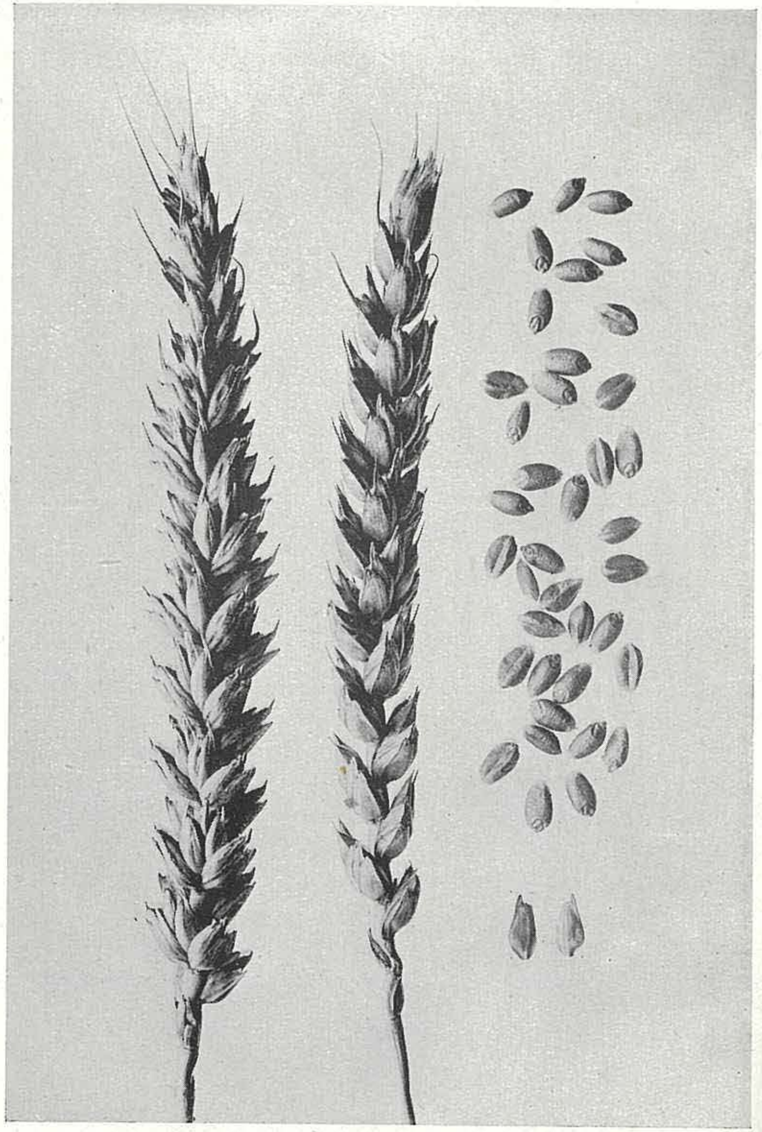

Fig. 64. OLD DEVON RED CHAFF.
(*T. vulgare*, var. *milturum*.)

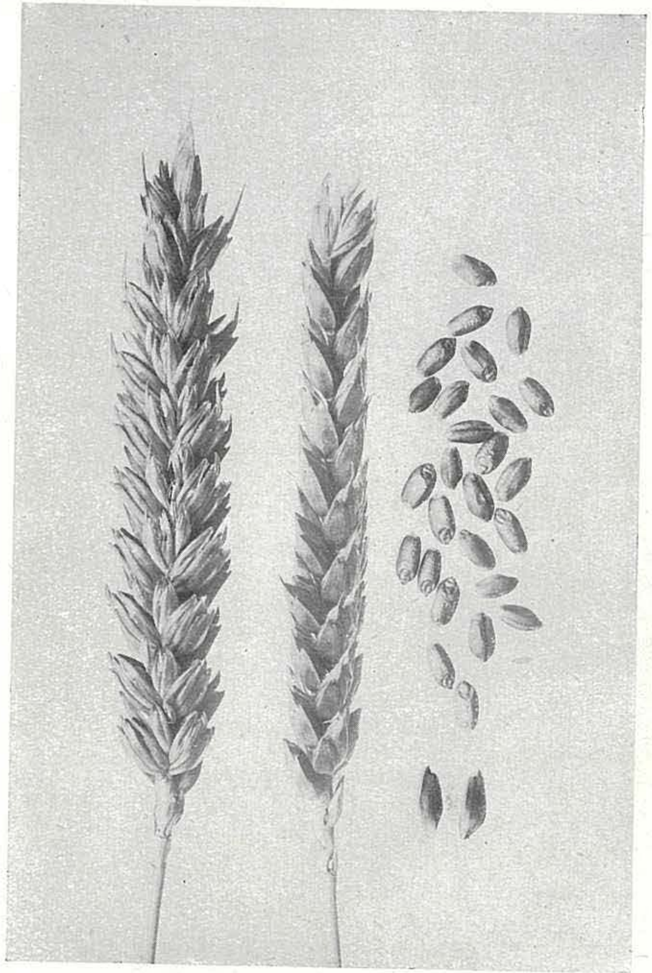

Fig. 65. OLD IRISH RED CHAFF.
(*T. vulgare*, var. *milturum*.)

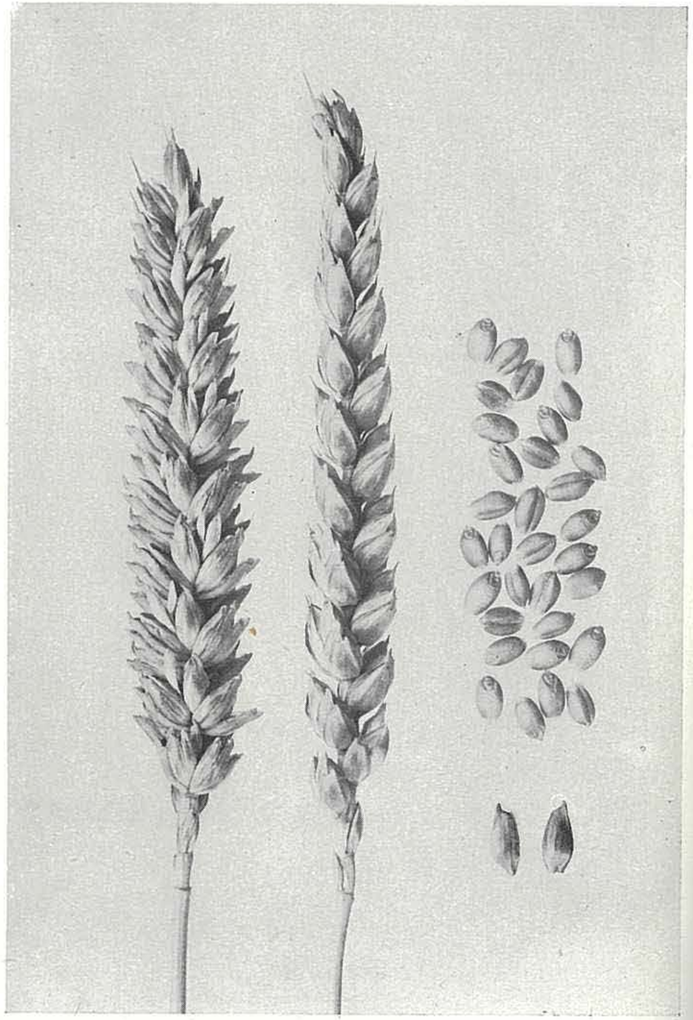

Fig. 66. LITTLE JOSS.
(*T. vulgare*, var. *milturum.*)

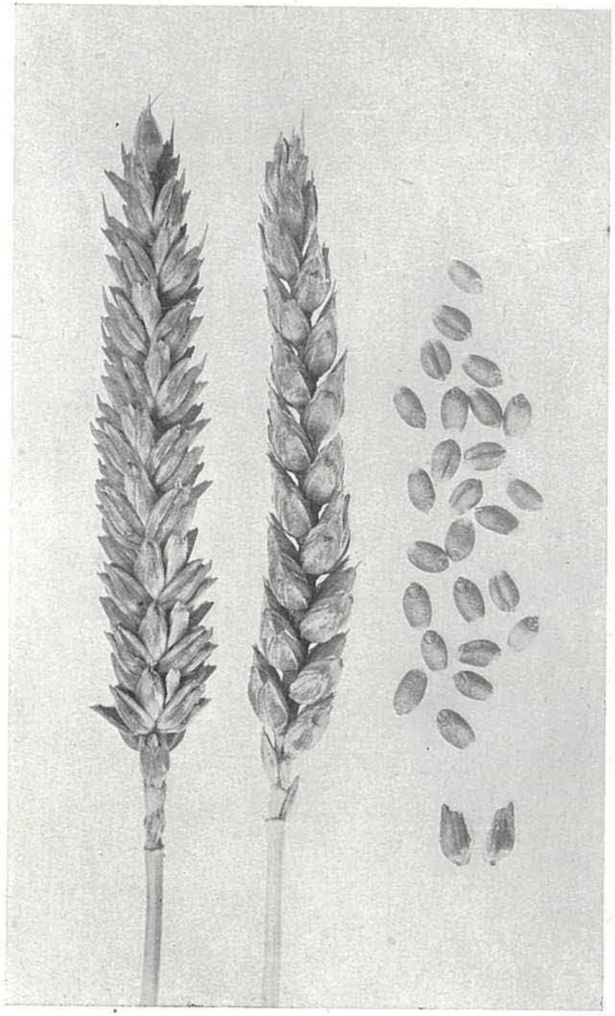

Fig. 67. IRISH CONEY ISLAND RED.
(*T. vulgare*, var. *milturum.*)

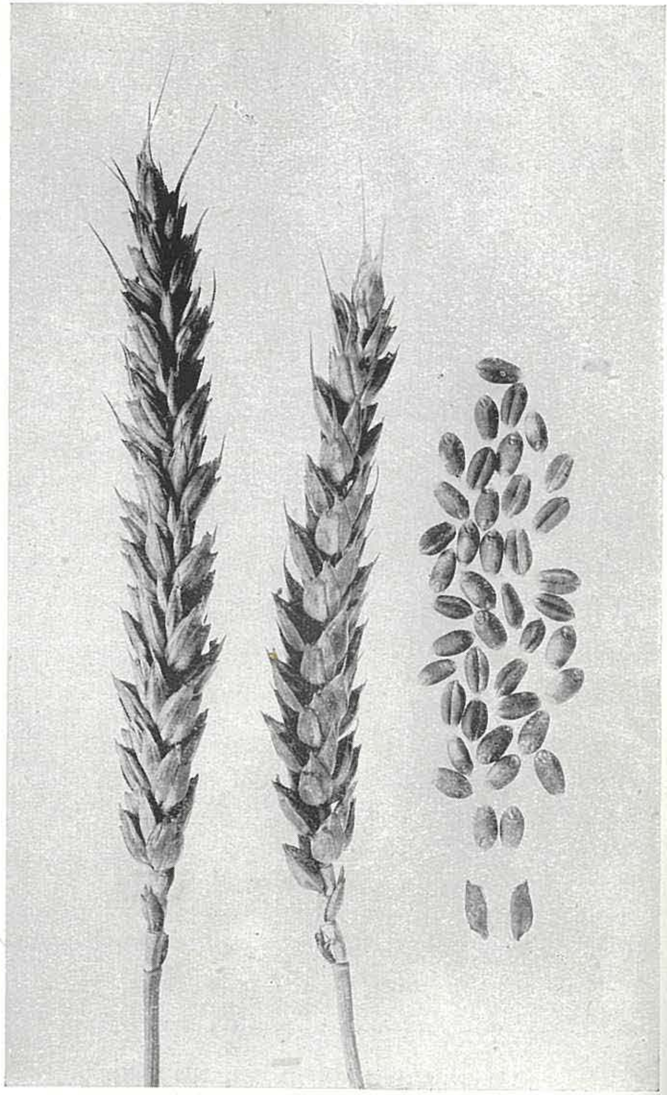

Fig. 68. OLD WELSH RED CHAFF 326 (Hen Gymro 326).
(*T. vulgare*, var. *milturum*.)

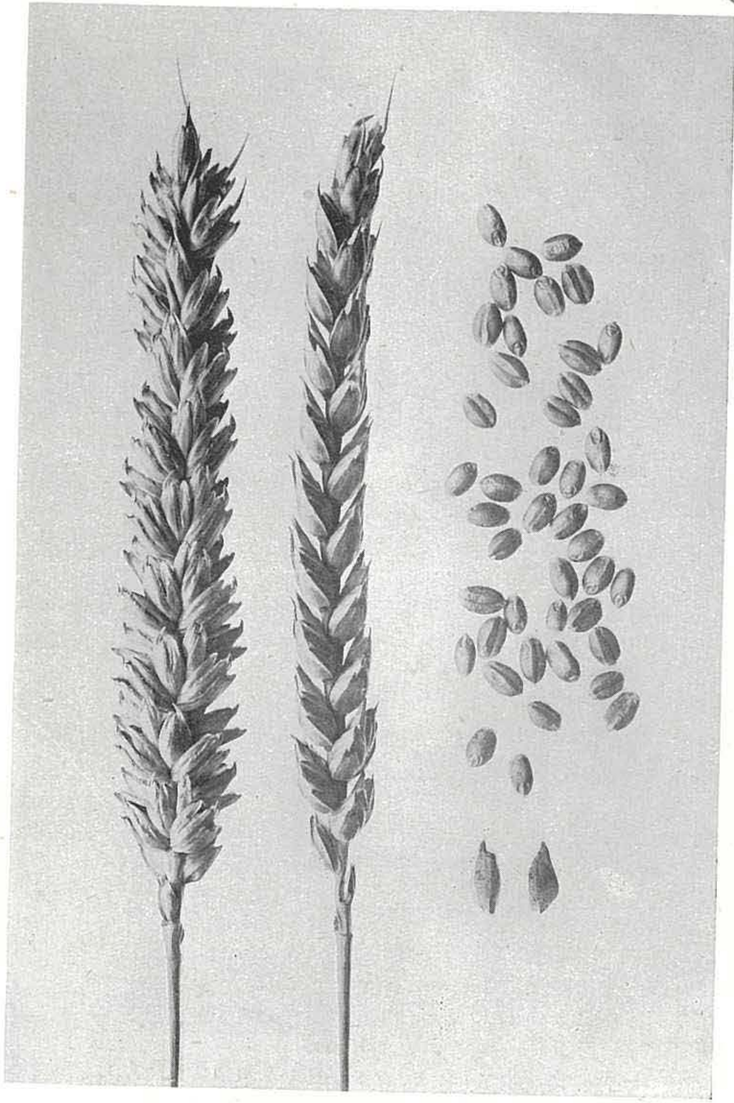

Fig. 69. MONTGOMERY RED.
(*T. vulgare*, var. *milturum*.)

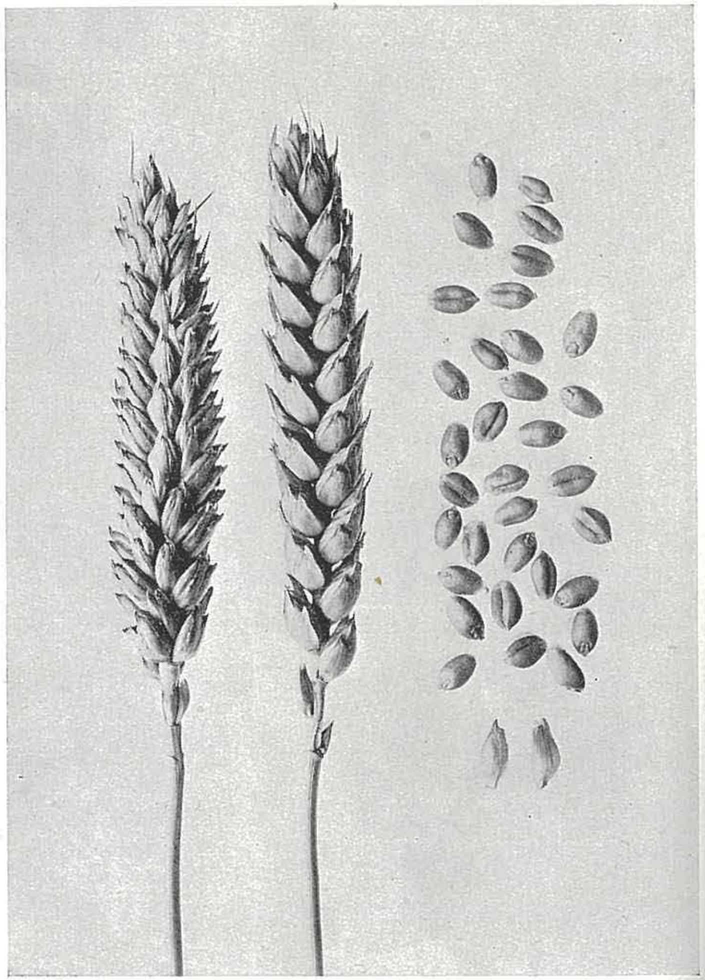

Fig. 70. ORANGE DEVON RED SQUAREHEAD.
(*T. vulgare*, var. *milturum*.)

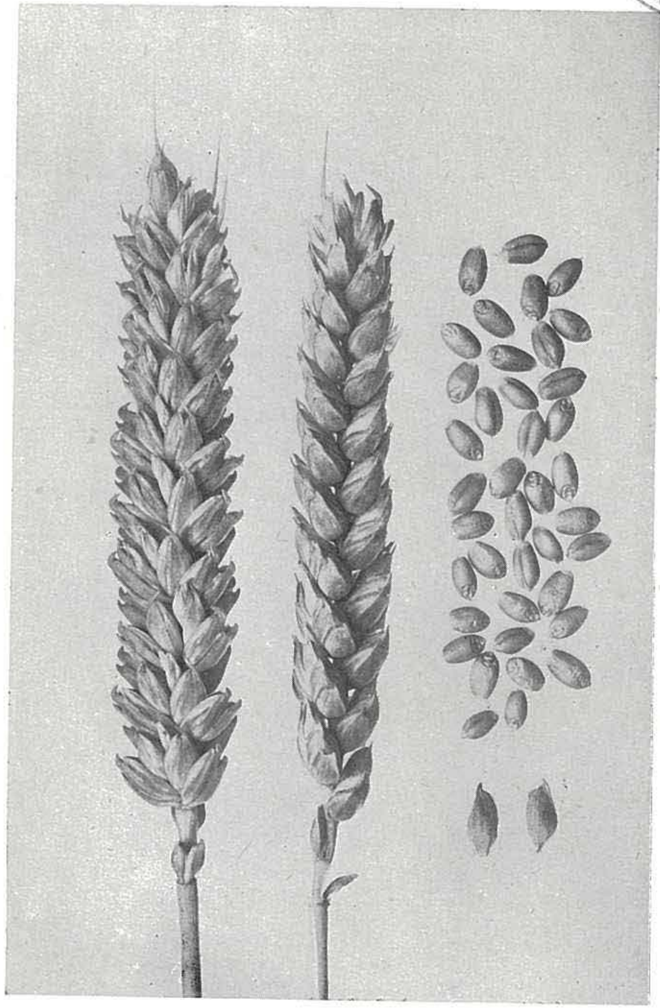

Fig. 71. SQUAREHEADS MASTER OR RED STANDARD, Form I.
(*T. vulgare*, var. *milturum*.)

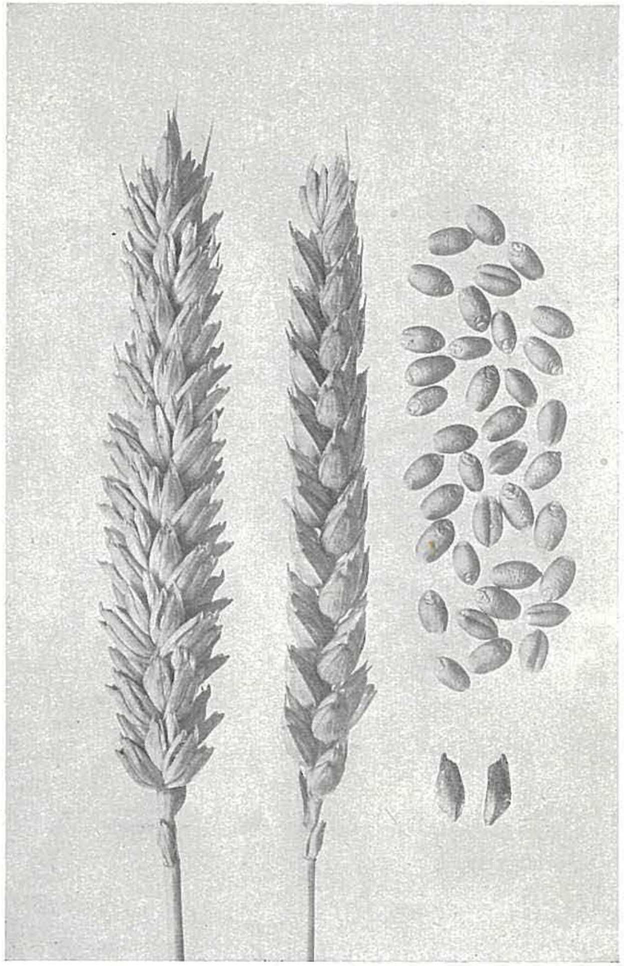

Fig. 72. SQUAREHEADS MASTER OR RED STANDARD.
(*T. vulgare*, var. *milturum.*)

Fig. 73. DIAMOND II.
(*T. vulgare*, var. *milturum.*)

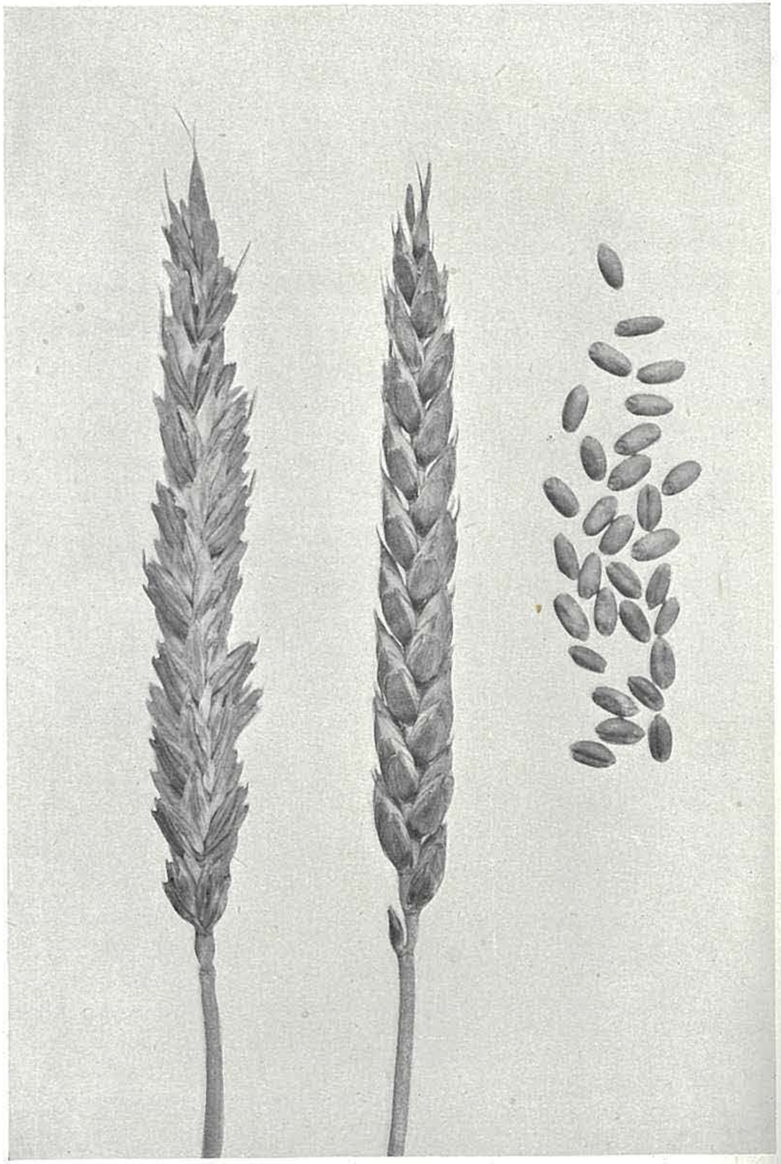

Fig. 74. FYLGIA.
(*T. vulgare*, var. *milturum*.)

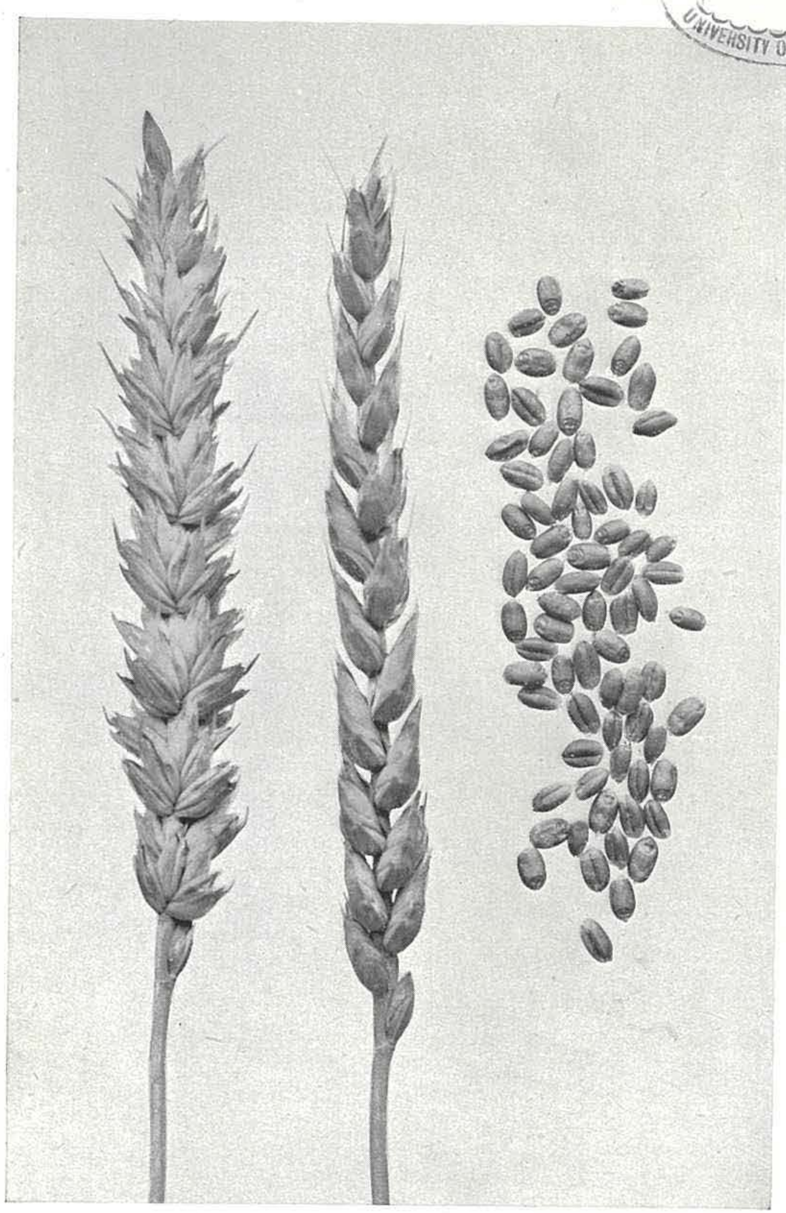

Fig. 75. PROGRESS.
(*T. vulgare*, var. *milturum*.)

Fig. 76. REDMAN.
(*T. vulgare,* var. *milturum.*)

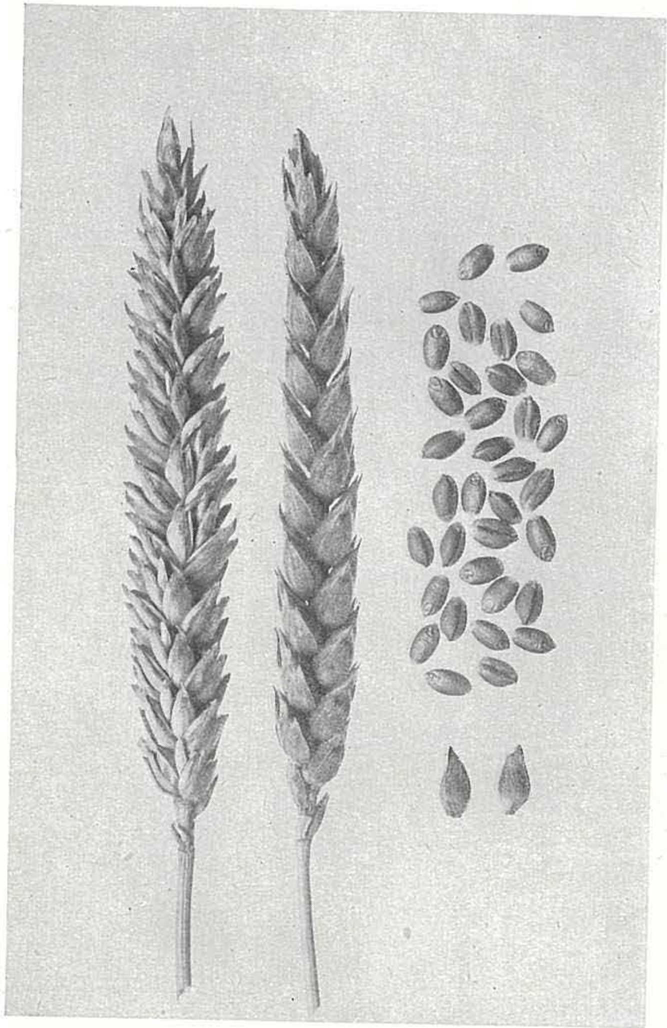

Fig. 77. FOX.
(*T. vulgare,* var. *pyrothrix.*)

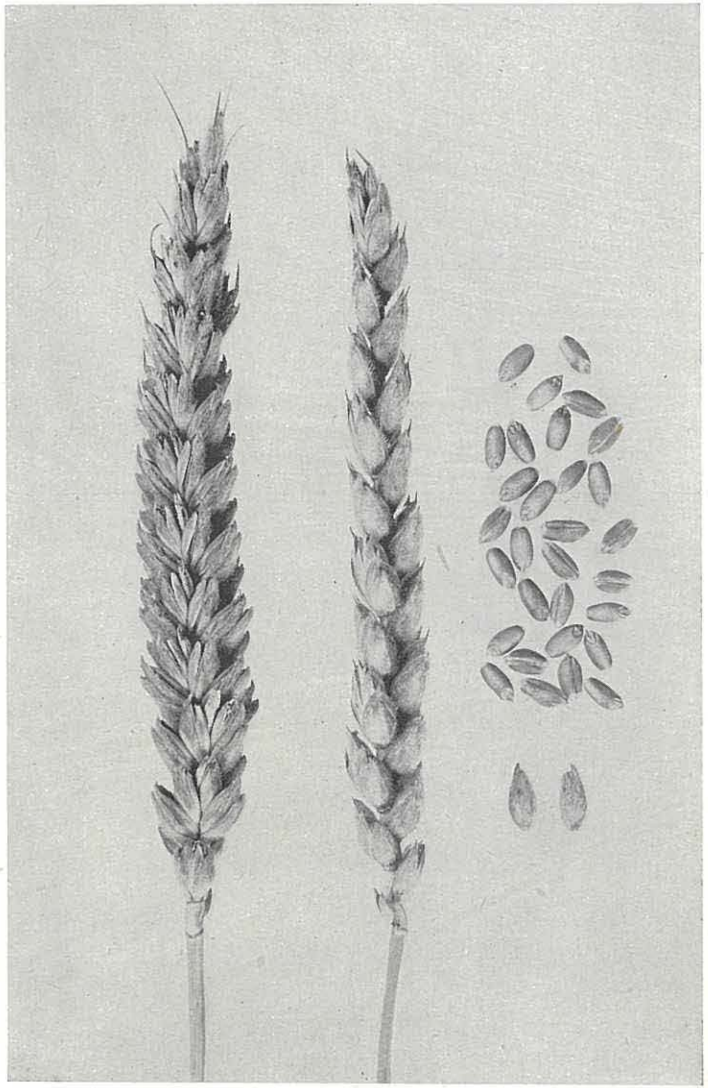

Fig. 78. RED STETTIN.
(*T. vulgare*, var. *pyrothrix.*)

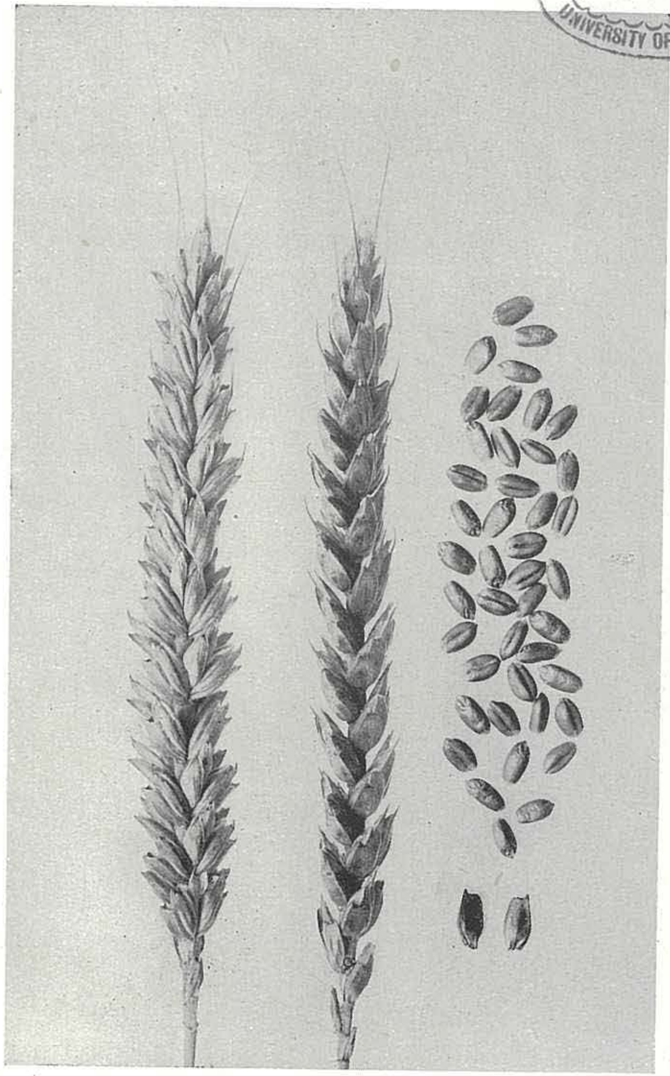

Fig. 79. OLD DEVON RED ROUGH CHAFF.
(*T. vulgare*, var. *pyrothrix.*)

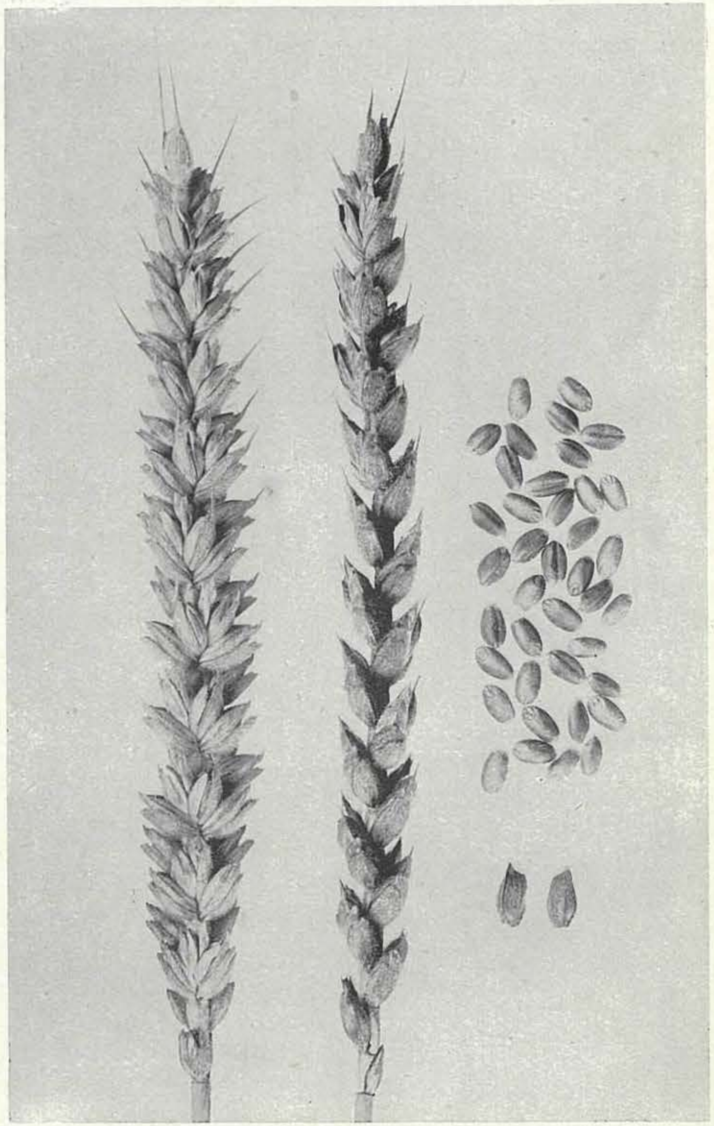

Fig. 80. ORANGE DEVON BLUE ROUGH CHAFF.
(*T. vulgare*, var. *cyanothrix*.)