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National wheat-growing experiment: interim report 1987/8

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Summary

[n] wheat-growing experiment was set up in Britain during 1987. On 22 plots across the country, three wheat species are being grown experimentally, in order to improve our knowledge of their growth requirements and yield potential. The three species involved are Triticum dicoccum (emmer), T. spelta (spelt) and *T. aestivo-compactum* (bread/club wheat), which are the important wheat species of the prehistoric and early historic periods in Britain. Soil and weather conditions are being monitored for each plot. The experiment will run initially for three years, after which the results will be assessed. The experiment is seen as the first step of a much larger research project. The first interim results are presented in this report.

Introduction

The analysis of charred plant remains from prehistoric sites in Britain has indicated that, during the first millennium B.C., a number of changes took place in the range of crop plants being grown. The change from emmer to spelt wheat is seen as a particularly important development. Of equal importance is the change from glume wheats (emmer and spelt) to a free-threshing type (bread/club wheat) in the first half of the first millennium A.D. While these changes are recorded across the country, differences in the timing have been found for the various regions of Britain.

The reasons behind these changes are poorly understood. The only explanation put forward so far is that by Jones (1981), who argues that these developments are a direct result of an intensification of agriculture, brought about by population pressure and the need to increase yields and expand onto previously marginal land. Spelt is thought to be tolerant of heavier soils than emmer wheat, to be hardier, and to be more resistant to wind damage, diseases and pests (Jones 1981).

During the first millennium B.C., changes occurred in the climatic regime over Britain, with a gradual increase in the amount of annual rainfall and a decrease in overall temperatures. The consequences of this climatic deterioration have often been used by geographers and archaeologists to divide the> country into a Highland and a Lowland Zone (Evans 1975) and to explain differences in settlement patterns and farming practices.

Very little is known about the climatic and soil requirements of the prehistoric wheat species. There are no historical records about their production in Britain (emmer and spelt not having been grown since the early Anglo-Saxon period). Most of our information about the growth and yield characteristics of emmer and spelt wheat comes from

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Percival (1921), although valuable knowledge about these crops is now becoming available from the research carried out at Butser Ancient Farm, Hampshire (Reynolds 1987).

The wheat-growing experiment has been set up in order to improve our knowledge of the growth and yield potentials of these wheat species in different parts of Britain. The purpose of the experiment is to try to establish what the possible yield differences are between emmer, spelt and bread wheat in the different ecological zones of the country. The experiment will run for a total of three years in the first instance, after which the results will be assessed. The experiment is seen as the first stage of a much larger research project. It is hoped that the results of the experiment will identify the most important variables influencing crop yields and the regions of Britain in which further, larger-scale experiments need to be set up.

Methods

A total of 22 plots has been established across Great Britain (with the exception of central and northern Scotland). There are ten plots situated in the Lowland Zone and 12 in the Highland Zone (see Fig. 13). The location of the plots was determined by the availability of volunteers to look after them; the total number of plots (22) was determined by the amount of seed-corn available. The seed for all three species was provided by Terry Miller of the Agriculture and Food Research Council's Institute of Plant Science Research, Cambridge Laboratory (formerly the Plant Breeding Institute). The seed for each species came from a single harvest. The three species grown are Triticum dicoccum, J._ spelta and !_,_ aestivo-compactum. All were autumn-sown examples. Their AFRC/IPSR accession numbers are: emmer - 1070024; spelt - 1220017; and bread/club wheat - 3260 (VH77267). The spelt is awned and with grey glumes. The bread wheat has short, compact ears (most prehistoric and early historic bread wheat grains found in Britain are short, rounded and plump), and with short awns. The emmer and spelt are similar to those grown at Butser Ancient Farm.

On each plot, the three species are being grown in one-metre-square subplots. The seed is randomly allocated to each plot and the allocation of each species to the subplots is also randomly determined in the first instance. Their location on the subplots will rotate each year, in order that each species will have been grown once on each subplot.

mmer and spelt are being sown as spikelets (50 per square-metre subplot), while bread/club wheat is sown as naked grains (100 per subplot). The spikelets of emmer and spelt are just covered with soil when sown; the grains of bread/club wheat are sown about 2-3 cm deep. The young seedlings are protected from birds by netting. Later, the netting is raised to give support to the tillers and to prevent lodging of the crop. The date of sowing was 15 October 1987. Some weeding was carried out during the growth of the crop.

In order to get the experiment started as soon as possible, certain compromises were necessary. The experiment is being run with the help of of volunteers who have provided part of their garden or allotment to grow the three crops; consequently, for lack of space, it has not been possible to grow more than one crop of each species. If the experiment is continued after the initial three years, the most important alterations will probably be an increase in the number of examples of each species grown, including both autumn- and spring-sown specimens, in addition to an increase in plot size.

For each of the plots, four categories of data are being recorded; they are listed in Table A.

At the end of the first year it has become clear that running an experiment like this is much more difficult than had been envisaged. Several unexpected problems arose. Many volunteers found themselves unable to visit their plots regularly enough to make accurate records of the date of germination, ear emergence and flowering; damage by birds and/or mice was much more extensive than had been anticipated. One plot (no. 3) was destroyed by rabbits and/or deer in early spring and had to be abandoned for the rest of the year. On

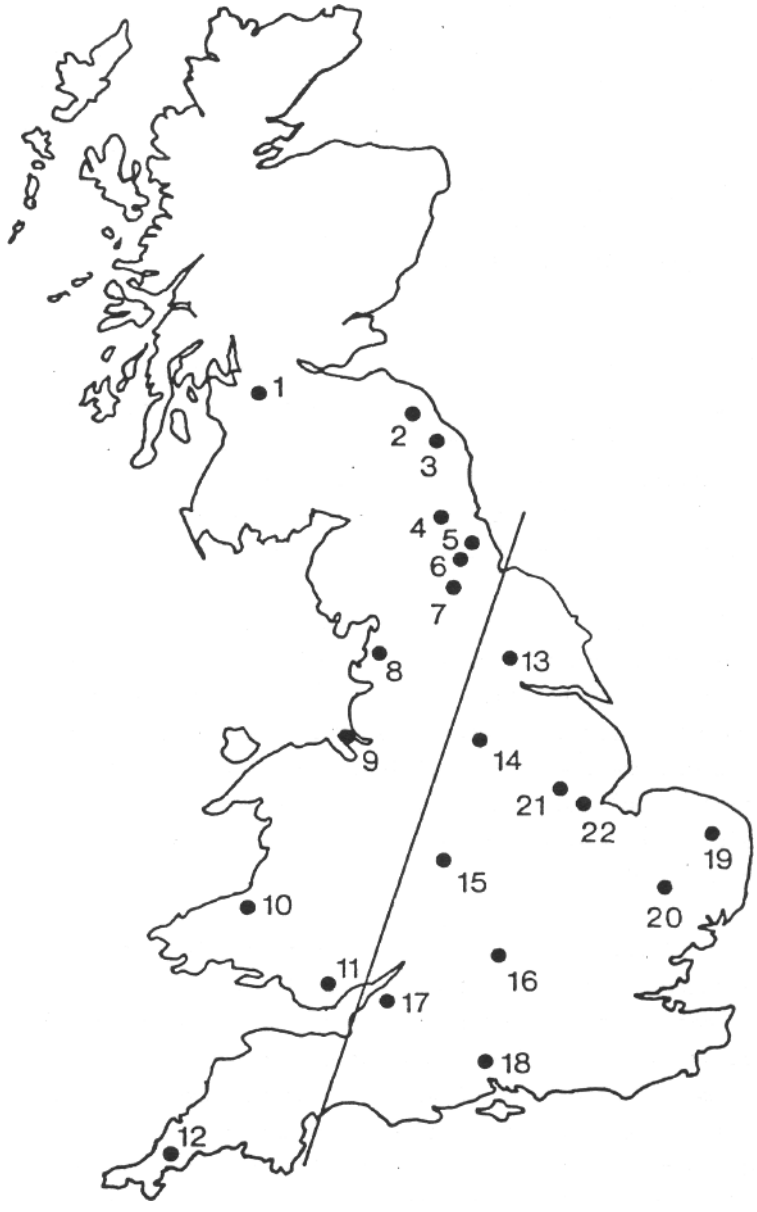

Figure 13. Map showing distribution of plots in wheat-growing experiment. The line from the mouth of the R. Exe to the mouth of the R. Tees defines the traditional division of Britain into Highland (north and west) and Lowland (south and east) Zones. Plot numbers: 1 Glasgow; 2 - Jardinefield; 3 - Doddington; 4 - liJhitchester; 5 - Durham; 6 - Oakenshaw; 7 Dalton; 8 - Lancaster; 9 - Liverpool (New Brighton); 10 - Lampeter; 11 - Castellau; 12 - Truro; 13 - York; 14 - Sheffield; 15 - Birmingham; 16 - Oxford; 17 - Bristol; 18 Romsey; 19 - Norwich; 20 - West Stow; 21 - Sleaford; 22 - Bicker.

Table 4. Data recorded for the wheat-growing experiment.

Growth Data
1. Date of sowing
2. Date of germination
3. Date of ear emergence
4. Date of flowering
5. Date of harvest
6. Mean height of tillers
7. Total number of ears
8. Number of grains from 25 ears
9. Weight of grains from 25 ears

WeatherData
1. Monthly air temperatures
2. Monthly soil temperatures (at 3D cm)
3. Monthly rainfall figures

Plot Data
1. Altitude
2. Orientation and aspect
3. Underlying sediments

Soil Data
1. Particle size
2. Organic matter content
3. Calcium carbonate content
4. Magnesium content
5. Phosphate content
6. pH

six plots (nos. 5, 7, 13, 16, 20 and 21) birds and/or mice ate the entire crop just before harvest time, while on two plots (nos. 15 and 22) few seeds/spikelets germinated, possibly because of slug damage or because the seeds or young sprouts were eaten by birds. One volunteer withdrew from the experiment at the end of the first year. Consequently, as much as 40-50/S of the data are missing, which makes it impossible to give any reliable statistical interpretation of the results from this year.

For this reason, the only results given are a list of plots in order of yield for each of the three species (Table 5). It must be stressed, however, that the order of the plots may not be representative at all, and may largely be the product of the great volume of missing data. From the present results, it would appear that no one region of Britain can claim to produce the highest yields, suggesting that the location of the plots (aspect and wind protection) and local soil conditions play a very important role. It has not yet been possible to compare the yield results with the results of analysis of the soil samples from the plots.

On all plots, the total number of ears of emmer wheat was much greater than for spelt, although in all cases but one (no. 17) the spelt grain yields were higher than those of emmer. This is a function of the different number and weight of grains in a single ear. In emmer, the mean number of grains per ear was 25.8 (standard deviation 5.5, n = 4), compared with 39.9 (SD 4.7, n = 13) for spelt. The figures for bread wheat are difficult to interpret because of erratic germination (see below). The mean number of grains per ear was 45.2 (SD 10.9, n = 13), but the yields of this species were not consistently higher or lower than those of either of the glume wheats.

A number of observations have been made during the course of this first year of the experiment:

(i) Germination usually took place within 2-3 weeks of sowing, but on a few plots (nos. 1, 4, 6 and 14) it took 4 weeks.

(ii) While there was little difference between the three species in the time of earliest germination, there were differences in the rate. Bread wheat had a very poor

germination rate on all plots, with often less than 50$ of the seeds germinating at all. It is possible that, as they were sown as naked grains, they were more susceptible to slug damage or to waterlogging than emmer or spelt which were sown as spikelets. (October 1987 was an extremely wet month and the soil on most plots was waterlogged, or at least wet.)

(iii) On some plots (e.g. nos. 15 and 22), emmer and spelt wheat germinated very badly, even though on the other plots the germination rate was often 90-95/S, suggesting that the bad germination rate could not have been caused by bad seed.

(iv) The time-lapse between the date of sowing and the date of ear emergence was ca. 32-33 weeks on plots in the south of England, 34-35 in Wales, and about 36 weeks on the northern plots. This probably reflects the slower rate of soil warming and consequently of delay in the start of the growing season. Flowering usually took place within about one week of ear emergence, but this date was not often accurately recorded.

(v) The time lapse between the date of sowing and the date of harvest varied from 41-44 weeks in the south and west to 47 in the north and 48 in Sheffield (plot no. 14). Insufficient information is available at the moment to comment on any differences between species.

(vi) On several of the northern plots bread wheat was affected by a fungal disease (Septoria) in early spring, when the weather was mild but wet. The very warm and dry spell that followed prevented the disease from spreading onto the top leaves and ears. It was interesting to note that the emmer and spelt plants growing next to the diseased bread wheat did not become affected. On two southern plots (nos. 18 and 19), aphids were a serious pest, although it is difficult to assess to what extent this affected yields. On plot no. 18 the aphids were largely restricted to bread wheat, while on plot no. 19 all three species were attacked. On plot no. 10, emmer and spelt were affected by a black mould, and on plot no. 14 spelt and bread wheat were affected by rust.

Triticum dicoccum	Triticum spelta	Triticum aestivo-compactum
Whitchester	Whitchester	Norwich
Truro	Glasgow	Whitchester
Bristol	Truro	Jardinefield
Sheffield	Romsey	Glasgow
Romsey	Castellau	Bristol
Castellau	Norwich	Birmingham
Glasgow	Sheffield	Oakenshaw
Norwich	Jardinefield	Castellau
Jardinefield	Bristol	Lampeter
Oakenshaw	Bicker	Sheffield
Dalton	Oakenshaw	Truro
Lampeter	Lampeter	Romsey
Birmingham	Liverpool	Liverpool
Liverpool		

Table 5. Some results of the wheat-growing experiment, 1987/8. Plots are listed descending order of crop yield (plot numbers are given in the caption to Fig. 10. in

(vii) At the time of harvest it was noted that the ears of bread wheat took much longer to dry than those of emmer or spelt. The tendency of the ears of the glume wheats to bend over, and the presence of tightly-fitting glumes caused the rain water to run off the ears, while the ears of bread wheat remain upright and this, together with the open glume structure, means that the ears fill with water and remain wet. This resulted in some cases in germination of the grain (plot no. 11).

During the next two years it will be necessary to cover the entire plots down to the ground to prevent the damage done this season. Mouse traps may be necessary. Obviously, prehistoric farmers will have suffered similar damage to their crops. In our case, however, the one-square-metre subplots are the only areas we have: we cannot afford to lose the entire crop.

Acknowledgements

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