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Accuracy of Field Experiments

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The breeding of stocks of insects for weed control in New Zealand was continued, and further consignments of insects attacking bramble, ragwort and gorse were sent out, including 15,260 *Tyria jacobæae*, 23,300 *Apion ulicis* and 350 root stocks containing *Coræbus rubi*. They arrived safely and in sufficient numbers to permit the New Zealand staff to take up their part of the investigation. As this work has now passed out of the research stage, it has been handed over to the Farnham Royal Laboratory of the Imperial Bureau of Entomology, which is specially equipped for the breeding and supplying of large quantities of insects.

Dr. Davidson having been appointed to the Waite Research Institute, South Australia, the investigations on aphides, with which he was associated, have been discontinued.

The insecticide investigations have been mainly concerned with pyrethrum, one of the most promising of vegetable products, as it can apparently be grown satisfactorily in this country.

Bees. The investigations on bees have followed the lines of previous years, and the accumulated data are being worked up in conjunction with the Statistical Department. The relative advantages and disadvantages of the "warm way" and "cold way" of arranging the frames, of having double walls for the hives, and of packing them in winter with insulating material, are studied. Feeding tests have so far shown no differences in effect between cane sugar and beet sugar as winter food, nor anything to justify the preference for the cane sugar. The "brood food" swarming hypothesis is being tested, and valuable information obtained, by the study of marked bees, about the ages at which they are engaged upon specific activities.

THE ACCURACY OF THE FIELD EXPERIMENTS.

The advantage of the modern Rothamsted field technique is that the results can be checked. The "standard error" per plot can be calculated; the degree of trustworthiness is therefore known. Usual standard errors per plot on our present methods of good working are:—

USUAL STANDARD ERRORS PER PLOT FOR GOOD WORKING			
		Weight per acre	Per cent. of yield
Potatoes	0.4 tons	... 7
Sugar Beet...	...	0.5 ,,	... 9
Barley: Grain	...	1.3 cwt.	... 9
,, Straw	...	2 ,,	... 7
Oats: Grain	...	2 ,,	... 8
,, Straw	...	2 ,,	... 6

The standard error precisely measures the accuracy of the experiment and it includes errors of working, inequalities due to variable natural agencies, such as weather, birds, insects, diseases, and also soil variations within the individual plots, but not the large variations between plot and plot which are eliminated by the method of arranging the experiment. It is not, however, an absolute measure, since it depends to some extent on the size and arrangement of the plots. Thus, a standard error of 0.4 tons per acre of potatoes in a latin square experiment is not strictly comparable with a standard error of 0.4 tons in a randomised block experiment having more plots. Nevertheless, it is a useful guide to the experimenter as showing the standard of performance he is attaining in

his work. The standard error is much the same whether the crop is large or small, so that a heavy crop has a lower percentage error than a light one.

There are several plots of each treatment, and the standard error of the final result is much less than these figures of errors per plot; it is usually now at Rothamsted about 2 to 4 per cent. of the mean yield.

Examination of the standard errors showed that the degree of accuracy attained at Rothamsted is also attained at the outside centres where supervision is exercised by the Rothamsted staff; Woburn, however, does not reach the same standard, not through the fault of the staff, but mainly through soil irregularities and the depredations of pheasants and hares. We are hoping to overcome this latter trouble.

The standard errors of our experiments are collected in Tables III and IV. An examination of the Broadbalk data during the past 78 years has brought out the interesting fact that the standard errors, so far as they can be calculated, have varied at different periods, but except for one year they are no greater now than in the past. For the past 200 years it has been commonplace among agricultural speakers and writers that the farm worker is not what he used to be: it is satisfactory to know that the Rothamsted plots, at any rate, are as well cared for as ever. The possibility of improvement is constantly being tested. Inequalities arise through irregularities in sowing seed and applying manure, especially farmyard manure, where this is used; in the distribution of weeds; the attacks of insect and fungus pests, birds, vermin and game; damage by storm and many other causes. The chief sources of trouble are, however, irregularities in seeding and manuring, and in weed distribution. We are constantly striving to improve in these directions.

TABLE III.
Standard Errors of field experiments per plot.
Weight per acre.
Rothamsted.

Year	Potatoes.	Swedes.		Sugar Beet.		Barley.		Wheat.		Oats.	
	tons.	Roots. tons.	Tops. tons.	Roots. tons.	Tops. tons.	Grain. cwts.	Straw. cwts.	Grain. cwts.	Straw. cwts.	Grain. cwts.	Straw. cwts.
1925	0.4	—	—	—	—	—	—	—	—	2.1	1.5
	0.7	—	—	—	—	—	—	—	—	—	—
1926	0.4	0.7	—	0.6	1.0	1.9	1.9	2.3	4.6	2.3	6.2
	1.0	—	—	—	—	—	—	—	—	1.7	1.7
1927	0.4	0.5	0.3	0.3	1.2	1.7	2.1	2.9	4.2	—	—
	—	—	—	—	—	0.9	0.8	—	—	—	—
1928	0.8	1.0	0.1	0.9	1.1	1.7	2.7	3.1	5.2	—	—
	—	—	—	—	—	1.2	2.2	—	—	—	—
1929	0.4	—	—	0.5	0.3	1.9	2.4	4.0	4.0	—	—
	—	—	—	—	—	0.9	1.6	—	—	1.5	2.0

In a mangold experiment in 1925 the standard error was 2.5 tons for roots and 0.6 tons for leaves.

Woburn.

Year.	Potatoes tons.	Sugar Beet.		Barley.	
		Roots. tons.	Tops. tons.	Grain. cwts.	Straw. cwts.
1926	0.4 —	0.6 2.4	0.9 1.8	— —	— —
1927	0.5 0.2	0.4 —	0.8 —	— —	— —
1928	0.9 0.5	1.3 —	1.9 —	4.1 —	4.6 —
1929	0.6 —	1.5 0.7	1.7 1.7	2.8 —	4.8 —

Outside Centres.

Year.	Potatoes. Tons.				Sugar Beet. Tons.				
	Norfolk (Stow- bridge).	Wis- bech.	Aber. (Bangor).	Owmy.	Colchester. Roots.	Tops.	Welshpool. Roots.	Tops.	Wye. Roots.
1927	—	—	—	—	0.6	—	—	—	—
1928	1.4 0.7	0.5 —	0.7 —	0.5 —	0.6 —	— —	1.2 —	1.7 —	— —
1929	— —	0.4 —	0.3 —	0.3 —	0.5 0.4	— 0.3	0.5 —	1.9 —	— 1.0

TABLE IV.
Standard error per plot : Per cent. of Yield.
Rothamsted.

Year.	Potatoes.	Swedes.		Sugar Beet.		Barley.		Wheat.		Oats.	
		Roots.	Tops.	Roots.	Tops.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.
1925	4.9 8.6	—	—	—	—	—	—	—	—	8.9	4.8
1926	3.8 11.0	6.5 —	— —	3.5 —	4.1 —	9.0 —	5.0 —	14.0 —	10.4 —	7.9 6.4	12.5 4.4
1927	6.1 —	3.2 —	5.2 —	10.2 —	10.9 —	10.3 8.5	10.7 4.1	11.6 —	8.6 —	— —	— —
1928	9.4 —	4.8 —	12.1 —	9.6 —	10.0 —	10.1 7.7	8.9 7.2	— 12.5	— 15.6	— —	— —
1929	8.2 —	— —	— —	6.3 —	5.2 —	8.5 3.8	10.0 6.3	— 22.5	— 15.1	— 11.1	— 7.9

Mangolds in 1925, 14.8% for roots and 10.8% for tops.

Woburn.

Year	Potatoes	Swedes		Sugar Roots	Beet Tops	Barley		Wheat		Oats	
		Roots	Tops			Grain	Straw	Grain	Straw	Grain	Straw
1926	6.1	—	—	4.3	8.5	—	—	—	—	—	—
	—	—	—	14.5	15.0	—	—	—	—	—	—
1927	7.4	—	—	13.7	17.2	—	—	—	—	—	—
	5.2	—	—	—	—	—	—	—	—	—	—
1928	7.1	—	—	9.3	15.1	22.5	19.4	—	—	—	—
	4.0	—	—	—	—	—	—	—	—	—	—
1929	11.6	—	—	18.0	21.0	9.6	12.3	—	—	—	—
	3.4	—	—	8.9	23.0	—	—	—	—	—	—

Outside Centres.

Year	POTATOES				SUGAR BEET				
	Norfolk (Stow- bridge)	Wisbech	Aber	Owmbly	Colchester		Welshpool		Wye Roots
					Roots	Tops	Roots	Tops	
1927	—	—	—	—	7.4	—	—	—	—
1928	15.4	3.4	4.4	6.6	8.6	—	11.0	9.5	—
	6.7	—	—	—	—	—	—	—	—
1929	—	3.3	2.4	4.1	7.6	—	3.4	8.3	—
	—	—	—	—	5.4	5.3	—	—	10.5

THE EFFECT OF FALLOWING: HOW LONG DOES IT LAST?

In 1925 the Broadbalk wheat field became badly infested with weeds in spite of much stubble cleaning, and as there seemed no hope of coping with them during the growth of the wheat, it was decided to fallow the field. It was, however, important to maintain continuity of cropping, there having been no break since 1843. The field was therefore divided into five parts: the eastern two-fifths continued to grow wheat as usual, but the western (top) three-fifths were fallowed from October, 1925, to October, 1927, when the western two-fifths were sown with wheat, leaving the central fifth bare. The eastern two-fifths and the central fifth were then fallowed from October, 1927, to October, 1929, the western two-fifths being meanwhile cropped. Then in October, 1929, the whole field was sown with wheat.

Thus a crop was grown each year, but during the years 1926 and 1927 it was on the eastern part only, during 1928 and 1929 on the western part only, the remainder being fallowed, the end two-fifths for two years and the central fifth for four years.

The 1928 crop, after the fallow, was remarkable, the yields being high and the proportion of grain to straw unusually high. The 1929 crop on the same land was, however, nothing like so good: the yield of straw remained high but the grain fell off, and