

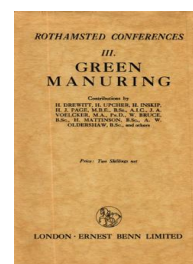
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Green Manuring

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Some Recent Experiments on Green Manuring

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The control plot and the mustard plot were ploughed in November, before the winter frosts had killed the mustard, but of course the other plots could not be ploughed until the spring. When this was done early in April the rye was about 2 ft. high, and it should have been turned into the soil several weeks earlier, for the reasons I have already stated. When the potato plots were dug in October it was found that no very definite results had been achieved. Owing to the fact that all the plots had received a fairly liberal supply of manure and artificials, and also that the summer rainfall had been above the average, there was not a great variation in the yield on any of the plots. The tares plot was certainly the best, and gave a yield of 10 tons 13 cwt. per acre (including seed and chaff), but the nothing plot came second with a yield of 10·5, and the mustard next with 9·15. These two latter results seem to point to the value of an additional ploughing of the land in the autumn.

I cannot say that this experiment has made me enthusiastic about the value of ploughing in autumn-sown green crops as green manure, especially when the cost of producing them is considered, but at the same time I have learned by experience that it is not wise to base one's judgment on one year's results.

On other matters connected with farming I have often proved that a course of action which is right one year proves to be entirely wrong the next, owing to the vagaries of our British weather conditions.

I have no doubt, however, about the value of spring-sown clovers for green manure, and can heartily commend the practice to all those who have to deal with land such as mine.

SOME RECENT EXPERIMENTS ON GREEN MANURING

BY H. J. PAGE, M.B.E., B.Sc., A.I.C.

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Introduction.—The trials on green manuring that were commenced in 1924, under the Research Scheme of the Royal Agricultural Society, were undertaken with the object of fostering the extension of this system of manuring in this country. Such an extension, if it could be effected with profit to the farmer, is particularly desirable in these times when farmyard and stable manures are increasingly scarce and costly.

In principle the possibilities of green manuring for British agriculture are attractive, but in practice a number of serious difficulties arise. There is, in fact, a striking contrast between the *possibilities* of

green manuring as exemplified by its successful use overseas and in certain regions of this country, on the one hand, and, on the other hand, the *limitations* to its *general* application to British agriculture.

The Possibilities of Green Manuring.—In order that we may have clearly in our minds some idea of the benefits that are obtainable from green manuring, let us first briefly review the existing state of our knowledge with regard to the influence that green manuring may have on crop yields, under *favourable conditions*.

In tropical countries, where animal manure is scarce, green manures form an essential feature in the system of crop husbandry employed in the growth of such crops as rice, tea, coffee, rubber and tobacco. The maintenance of an adequate supply of organic matter in the soil carrying these crops depends largely on the frequent turning under of green manure crops.

In the United States and in South Africa green manures are extensively used, although they do not usually figure to such an important extent as in more tropical countries.

In many European countries green manuring is practised, but in general to a lesser extent than in the Tropics, or even in the United States. We find on the Continent a tendency for the system to be extensively applied only to special crops—such as sugar-beet—or in regions where the soil or climatic conditions are specially adapted.

This tendency towards the more specialized utilization of green manures becomes still more marked in our own country. Apart from the purely incidental ploughing down of mustard or other catch crops that may occur from time to time, when seasonal conditions are specially favourable, green manuring is a regular feature of the system of husbandry principally only in potato-growing and market-gardening districts, such as the Fens, the Biggleswade district, and in the Lothians and Ayrshire.

The following are actual examples of the benefits that have been obtained with green manuring. These results have been specially selected—not typical of the results that can ordinarily be expected, but in order to show that the practice *can*, under certain conditions, be well worth while, and also to show that there is a definite goal, well worthy of being sought.

[TABLE

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SELECTED RESULTS OF GREEN MANURING EXPERIMENTS

<i>Locality</i>	<i>Green Manure</i>	<i>Crop</i>	<i>Effect of Green Manure on Yield</i>	
			<i>Yield After</i>	
			<i>Green Manure</i>	<i>No Green Manure</i>
Rothamsted	Mustard	Oats	48 bushels	28 bushels
Wisley, Surrey	Crimson Clover	Turnips	10 $\frac{1}{2}$ tons	4 $\frac{1}{2}$ tons
Notts	Blue Lupins	Oats	58 bushels	12 bushels
Lupitz, Germany	Blue Lupins	Potatoes	9 tons	6 tons (with dung)
Lupitz, Germany	Blue Lupins	Rye	27 bushels	12 bushels
Gr. Lübars, Germany	Trefoil	Potatoes	7 $\frac{1}{2}$ tons	5 $\frac{3}{4}$ tons
Lauchstädt, Germany	Trefoil	Sugar-beet	14 tons	12 tons
California, U.S.A.	Rye and Vetches	Wheat	54 bushels	33 bushels
Wisconsin, U.S.A.	Clover	Potatoes	241 bushels	174 bushels
North Carolina, U.S.A.	Crimson Clover	Maize	54 bushels	37 bushels
Piet Relief, South Africa	Cow Peas	Maize	16 bags	3 bags

The Limitations of Green Manuring in Practice.—In attempting to extend the practice of green manuring in ordinary British farming it is necessary that the green crops should be grown without disturbance to the rotation or the cleaning of the land. In practice this means : (a) catch crops sown in summer or in autumn ; (b) under-sown crops.

In both of the seasons 1924-1925 and 1925-1926 a certain number of experiments with summer catch crops were arranged. The remainder of the experiments tried in the first season were concerned with autumn-sown catch crops, whilst the second season more attention was devoted to under-sown green crops. We can most conveniently consider the experiments under these three heads.

Altogether 30 experiments were arranged, at 21 centres, divided thus :

Summer catch crops	14
Autumn-sown catch crops	6
Under-sown crops	10

In 5 cases the experiment, although arranged, was not started, but in the remaining 25 cases it was successfully put in hand. In 13 cases, however, the green crop failed, leaving only 12 experiments in which results could be expected ; in 4 of these cases the experiment was abandoned. The remaining 8 experiments were carried out to a conclusion.

Two aspects of these experiments can be separately discussed : (1) the problem of growing the green manure crops ; (2) the effect of the green manure crop on the yield of the following crop.

With regard to the first aspect, the proportion of crop failure varied greatly between the three types of experiment, as shown below :

	<i>Arranged but not Started</i>	<i>Started but Crop Failed</i>	<i>Started and Crop Grown</i>	<i>Total</i>
Summer catch crops	4	3	7	14
Autumn-sown catch crops	...	2	4	6
Under-sown crops	1	8	1	10

It is perhaps fairest to leave out of consideration at present the cases where the experiment was arranged but not started, and to confine attention to those experiments that were actually started. In the case of summer or autumn sown catch crops the green crop was successfully established in about 70 per cent. of the experiments. With under-sown green manure crops, however, in eight of the nine experiments started the crop failed.

The contrast between these results reflects the relative importance of these three systems in existing British green-manuring practice. The growing of mustard as a late summer catch crop is the commonest form of green manuring in ordinary practice, whilst the use of autumn-

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sown catch crops is common in the West country. The use of under-sown crops for green manuring is, however, chiefly confined to one special district in this country. The experiments in which an attempt was made to extend this practice to other districts failed, with one exception. Six of the eight failures in these experiments were due to the severe late spring drought that occurred in 1925. That this was the main cause of the failure is shown by the fact that large areas of "seeds" sown in the ordinary way also failed in that year. Thus in the case of Centre No. 11, not only did the under-sown green manure crops fail, but also practically all the red clover sown on the same farm on a commercial scale, although this is a centre where the use of under-sown green manure crops is a regular feature of the ordinary farm practice. Similarly, at Centre No. 2, out of 80 acres sown with red and white clover, 70 acres had to be ploughed up. However, since the sowing of green manure crops in corn differs in no essential detail from the ordinary well-established practice of sowing "seeds" in barley, it would appear that the system is one well meriting further trial.

Turning to the results of those experiments in which the green manure crop was successfully grown and ploughed in, as already mentioned, in four cases out of twelve the experiment was abandoned; this was owing to unauthorized departures from the agreed programme. In one case the farmer failed to leave any control plots, and in the others either the cropping scheme was changed or the main crop harvested without being weighed, these facts not being discovered until it was too late to remedy matters. In the remaining eight experiments the main crop has been harvested and weighed in six cases, whilst in the other two this has still to be done.

Five of the experiments were with cereals following mustard ploughed in. The following Table is a summary of the results:

EXPERIMENTS WITH CEREALS FOLLOWING MUSTARD
PLOUGHED IN.

Centre No.	Crop	Yield of Grain, Cwt. per Acre		Yield after Mustard as Percentage of Control
		After Mustard	Control	
3	Wheat . .	25.7	23.5	109
15	Wheat . .	19.2	20.7	92
16	Barley . .	18.9	19.8	95
19	Winter Oats .	4.0	3.5	112
20	Winter Oats .	18.5	10.5	174

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The other experiment of which the final results are available was carried out with autumn-sown catch crops followed by potatoes. The results are summarized below :

YIELD OF POTATOES AFTER GREEN MANURE

Centre No. 11

<i>Green Manure</i>	<i>Total Yield Tons per Acre</i>	<i>Yield as Percentage of Control</i>
Rape	8.5	84
Turnip	9.1	90
Mustard	9.6	95
Rye	9.4	93
Tares	10.5	104
Rye and Tares	9.6	95
None (control)	10.1	100

In the remaining two experiments (at Centres Nos. 6 and 7) the results are not yet to hand.

The yield results summarized above are disappointing. In only one case has a marked increase in yield resulted from green manuring.

The conspicuous failure of the under-sown crops is due to the fact that most of these crops were sown late, so that the spring drought which occurs so often in our climate came before they were established, and burned them up. These under-sown crops were not sown until the farmers concerned had first got all their ordinary "seeds" sown and other urgent work done. In the absence of special help and supervision by someone specially charged with the care of these experiments this is bound to happen. The same causes account for the non-starting of some of the experiments and for the abandonment of others. Further, it is probable that the failure of the green manure to produce increased yields in the following crop is due in some cases to delay in ploughing in the crops.

The fact that a large number of the failures of the green manure crops can be justly attributed to abnormally unfavourable weather conditions merely serves to emphasize the extent to which green manuring is dependent on seasonal conditions and therefore, to that extent, not to be relied upon. At the same time, however, we cannot get away from the fact that highly profitable results *are* obtained by the use of green manures overseas, and even in certain districts of this country. The *possibilities* of green manuring, as typified by its successes,

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are sufficiently striking to warrant careful inquiry into its *limitations*, as exemplified by its failures. These limitations are due to two main causes: (a) technical difficulties on the farm; (b) variations in local conditions.

The technical difficulties on the farm arise from the fact that the green manures have first got to be grown on the land. If one favourable opportunity of applying dung is lost the chances are that others will occur before it is altogether too late. Green manures, however, have to be grown in short periods between main crops; if the first opportunity of sowing the green manure crop cannot be taken, probably it cannot be grown at all. The times at which green manure crops must be sown usually coincide with periods of special activity on the farm when there is already work enough for every man and horse in the sowing, cleaning or harvesting of staple crops.

These difficulties are not insurmountable and no doubt the farmer would manage to get over them if he knew that green manuring was likely to pay.

It remains to consider the limitations arising from variations in local conditions. If we compare the conditions of climate and soil and the systems of agriculture in those countries where green manuring is successfully practised with those obtaining in this country we find a strong contrast between uniformity on the one hand and diversity on the other. As we pass from the Tropics, through the United States to the Continent, and thence to this country, we find that the conditions favourable to the success of straightforward systems of green manuring disappear one by one. All are present in the Tropics: the climatic conditions are specially suited to the rapid growth of a large bulk of green crops, and the recurrence of these favourable weather conditions from year to year can be counted on with certainty; the chance of failure is largely eliminated. In the United States the climate is not so wholly favourable, but the uncertainty of the seasons is not specially marked, so that, provided a system of green manuring which is applicable to the local conditions is known, there is a reasonable chance of its being successfully carried through in most years: the large tracts of similar soil and cropping in that country are conducive to the development of a system generally applicable over wide areas. In Northern Europe the climate is less favourable, and the season less reliable, but not to such an extent as in this island. Green manuring can still be successfully used on extensive tracts of uniform soil, on which special crops, such as sugar-beet or potatoes, are grown. In this country, with its relatively short and cool summer, and its long "dead" period in the winter months, with its uncertain climate, in which weather conditions cannot be forecast even from one day to another, with its irregular topography—such that types of soil and systems of agriculture may vary radically even in adjoining parishes—everything is against the possibility of developing a system of manuring

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which is generally applicable. The following Chart illustrates the above considerations :

SCHEMATIC REPRESENTATION OF THE FACTORS FAVOURABLE TO THE EXTENDED USE OF SIMPLE SYSTEMS OF GREEN MANURING

TROPICS	↓	(1) SUITABLE CLIMATE
U.S.A.		(2) RELIABLE SEASONS
N. EUROPE		(3) UNIFORM SOILS
BRITISH ISLES		(4) UNIFORM CROPPING

Passing from the Tropics to the British Isles, as shown in the left-hand column, the factors shown in the right-hand column, which are all present in the Tropics, disappear gradually in the above order, until in the British Isles they are all practically eliminated.

It has been truly said by a farmer that "No farmer is any good ten miles from his own farm"; this is specially true with regard to the development of modifications in established systems of husbandry. Farming practice varies so much from place to place that success in extending the use of green manuring depends first and foremost on an intimate knowledge of the local conditions. The possibilities of green manuring, as of any other agricultural practice, will always vary from season to season. That is no reason why it may not be feasible so to adapt the system to local conditions that, on a run of seasons, the results would be definitely beneficial instead of being not worth while in all but a few districts.

The discouraging results obtained in these trials prove merely that there has not been an opportunity of keeping sufficiently closely in touch with the precise local requirements of the centres concerned. Given an adequate experimental organization, more successful results could probably be obtained.

It is impossible to control and supervise such experiments from a central station unless the person in charge of the experiments is able to give them a first call on his time. Further machinery is needed to effect a closer and more intimate co-operation between the central authority and the local centres.

The aspect of the matter which is of the most direct concern to the farmer is that which touches his pocket, and the economic value of green manures as alternative to dung is a question that opens up

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striking possibilities. The costing of manure-making by beasts is a subject on which very little reliable information exists. The results of an experiment carried out recently at the Seale Hayne Agricultural College illustrate what a heavy price may be paid for the manurial value of dung, and in the present state of the beef trade such results must be common. These results showed that, at the lowest estimate, the net cost of the dung, when applied to the land, was 35s. per ton, or £15 per acre for a ten-ton dressing, after allowing for the value of the increase in weight of the stock. The disparity between the cost of manuring with dung and with green manures is so large that a further attempt to work out a practical means of utilizing the latter more generally in British agriculture seems to be urgently called for.

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By J. A. VOELCKER, M.A., Ph.D.

AFTER Hellriegel had made clear the method by which certain of the leguminosæ were able to avail themselves of nitrogen from atmospheric sources, and thereby supplied the long-wanted explanation of the independence of the clover for direct supply of nitrogenous manures, while providing in itself the nitrogenous need of a succeeding corn crop, it struck me as being well to ascertain, by actual field experiment, whether the same power was possessed, and to equal extent, by other leguminous crops—*e.g.* tares (or vetches)—ordinarily grown on the farm as green crops. If this held good for such, probably the most economical way of growing a corn crop would be alternating it with a leguminous green crop, either ploughed in or fed off upon the land. For the purpose of comparison a leguminous crop—tares—was taken on the one hand, and on the other a non-leguminous one—mustard. The experiment was carried out on two different fields of the Woburn farm, green crops being grown one year and cereal crops the next. In the one case the green crops were ploughed in, in the other they were fed off. The soil of either field was a light sandy loam but poorly supplied with organic matter and deficient in lime. The work began in Lansome Field—the less even and less satisfactory of the two—in 1892, and on this the green crops were ploughed in, two such crops being grown each alternate season and a corn crop followed—generally wheat, though, occasionally, barley has been taken. On the other field—Stackyard Field—which is of very even character and well adapted for experiment, the work began in 1911, and here the green crops grown have been fed off on the land by sheep, which received cotton-cake in addition. This modification of the original plan as adopted in Lansome Field was introduced in