gredients, are peculiar to, and distinctive of, that area. For example, the well-defined culture-complex which is commonly called Neolithic (see NATURE, May 11, 1916) is characteristic of Europe and the immediate neighbourhood; nor, in fact, was it synchronous or of identical composition in different parts of Europe. But when one passes to the East or the South, although all the ingredients out of which the European Neolithic was compounded may be found, there is no phase of culture which can justly be labelled Neolithic in the same sense as the term is applied in Europe.

THE BRITISH ASSOCIATION AT NEWCASTLE.

SECTION M.

AGRICULTURE.

OPENING ADDRESS (ABRIDGED) BY E. J. RUSSELL, D.Sc., PRESIDENT OF THE SECTION.

I AM going to deal to-day with the possibilities and the prospects of increased crop production, which, both in its narrow aspect as a source of national wealth, and in its wider significance as the material basis of rural civilisation, must always remain one of the most important of human activities.

The main obstacles to increased plant-growth lie in the climate and in the soil. Climate apparently cannot be altered; so we have to adapt ourselves to it by growing crops and varieties suiting the conditions that happen to obtain. But soil can be altered, and it is possible to do a good deal in the way of changing it to suit the crops that are wanted.

On light soil the two great obstacles to be overcome are the lack of water and the poverty in plant nutrients. Both arise from the same cause, the lack of colloidal substances, such as clay and humus, which have the power of absorbing and retaining water and plant nutrients. There are two ways of dealing with the problem; one is to get round it by increasing the depth of soil through which the roots can range, and the other is to remedy the defect by adding the necessary colloidal substances—clay, marl, or organic matter. In practice it is not possible to add sufficient to overcome the defect entirely, and therefore both methods have to be used.

Depth of soil is perhaps the most important single test that can be applied to light sands. If the soil is shallow, and is underlain by solid rock, pebbles, or gravel, the case has hitherto been hopeless, excepting where the climate is persistently moist. I know of no instance of successful treatment in tolerably dry regions; the areas are generally left alone. They form picturesque heaths, some are used as rabbit-warrens or golf courses, some are recommended for afforestation.

If the rock, instead of being solid, is simply a thin layer separating the sand above from a great depth of sand below, then the improvement can be effected by removing it.

Once the light soil is made deeper it can be still further improved. The most permanent improvement is to add clay, or preferably marl; this used to be done in many parts of England, but it now only survives on certain fen or peaty soils.

The usual method of increasing the absorptive power of light sandy soils is to add organic matter, by dressings of farmyard manure, by feeding crops to sheep on the land, or by a method that wants much further investigation, ploughing crops or crop residues straight into the soil. But the organic matter disappears at a very rapid rate, so that the process needs repeating in one form or another every second or third year. The addition of organic matter must generally be accompanied by the addition of lime or limestone, otherwise the soil may become "sour"—a remarkable condition, detrimental to plant-growing, but not yet fully understood by chemists, and therefore more easily detected by the vegetation than by analysis. Few light-land farmers use lime or chalk as regularly as they should for the best results.

Further, it is necessary to add all the plant-nutrients, for sand is usually deficient in these, excepting in places calcium phosphate. The common English practice is to import feeding-stuffs to be eaten by sheep on the land, so that the great proportion of the nitrogen, potash, and phosphates thus brought on to the farm shall get straight into the soil. This is not sufficient, however, and artificial manures should be used as well and far more extensively than at present; nitrogen, potash, and phosphates are all wanted.

These additions do not end the matter. Light sandy soils are very prone to weeds, and constant cultivation is necessary to keep them down. Fortunately the cultivation serves another purpose as well; it helps to retain the moisture content of the soil.

Thus the management of a light sandy soil is a constant struggle; it demands constant surface cultivations, frequent additions of fertilisers, of organic matter and lime, and periodical deep ploughings to check any tendency to pan formation. When all this is done these light soils become very productive: they will grow almost any crops, and they can be cultivated easily and at almost, but not quite, any time. One of their chief defects is that cereal crops do not produce so much grain as might be expected; in the words of the practical man, they will not "corn out." This phenomenon requires further investigation.

On the other hand, neglect in any of these directions soon leads to failure.

These are the conditions for the successful management of light soils; how far can they be attained? This is a purely economic question. It is obvious that success is only possible if the gross returns are sufficient to cover the costs. Now, a very great deal of experience has shown that the ordinary farm-crops—wheat, barley, swedes, etc.—do not bring in sufficient gross return to encourage good farming. Numerous instances occur on the tracts of light Bagshot sands. Some of the old four-course farms still survive—wretched little affairs, the tenants of which are constantly struggling against chronic poverty. Again, considerable areas of light land in Hertfordshire caused their cultivators to go bankrupt in the 'nineties when only these ordinary crops were grown. The old Townshend and Coke method of feeding sheep on the land is satisfactory, but it requires the triple, and not very common, qualifications of capital, good knowledge of sheep, and of crop management. The situation in Hertfordshire was saved by the potato-crop, which, on these farms, brings in a gross return of 25*l.* or more per acre, against a return of 7*l.* from wheat at pre-war prices. Of course, the expenditure on potatoes is much greater than on wheat, but that does not matter; the point is that the expenditure has to be incurred in any case if the land is to be kept in good cultivation, and potatoes bring in the necessary return, while wheat does not. Potatoes are the commonest of money-finding crops, but they are not the only one. Greens are in some places very successful, bringing in 17*l.* or more gross return. In North Kent various market-garden crops are used. In parts of Norfolk blue peas have answered satisfactorily. Clover-seed is a useful adjunct in places, but it is not sufficiently trustworthy as the chief money-maker.

It is not necessary to take the money-finding crop very often; once in four years may prove sufficient. But the system is capable of considerable intensifica-

tion if the farmer has sufficient capital, or if his holding is so small that his capital can be more intensively used. It is possible to grow nothing but crops bringing in a large gross return; in districts round Sandy, Biggleswade, etc., the market-garden crops have been exclusively grown for very many years with great success; this method also proves very successful on the Bagshot sands. It is not clear, however, that this type of farming could be indefinitely extended.

The best hope for improvement of these light soils lies in increasing the number of money-finding crops, improving the methods of growing them—*e.g.* the introduction of the boxing and spraying of potatoes—and their relation to the other crops or the live stock, and improving the organisation for disposing of them, so that farmers will feel justified in spending the rather considerable sums of money without which light soils cannot be successfully managed.

We can now leave these light soils and pass to the opposite extreme—the heavy clay soils. These suffer from the fundamental defect that the clay easily deflocculates and assumes a sticky, pasty condition when wet, and a hard, lumpy condition when dry. In spite of a good deal of laboratory work, deflocculation is not well understood; it is known, however, to be a special case of a very general phenomenon—flocculation of suspended colloids—and it will presumably succumb to treatment when the general problem is solved. Important advances have been made in the last few years by Perrin, and it would be interesting to apply his methods to clay.

For the time being the only feasible method of flocculating clay is to add lime or chalk, but experience shows that liming and chalking must be accompanied by drainage to be a complete success. Any attempt to improve crop production on heavy lands involves these as the first steps.

Where clay soils are drained and limed it is possible to begin to do something with them. Wheat, beans, mangolds, cabbages, and grass can all be produced. But, when all is said and done, clays still suffer from two disadvantages: they are only suited to a limited number of crops, and they are difficult to cultivate. The land may be too hard in autumn to be ploughed for winter corn; too wet in winter to be ploughed for spring corn; and too dry in spring to be prepared for mangolds. There are times in between when something can be done, but only the man who is skilful enough to take full advantage of these intervals has any hope of success. Most men, therefore, prefer not to run the risk of cultivation, and lay the land down to permanent grass.

There are two directions in which the risk can be reduced, though it will still remain a serious factor.

The great difficulty of cultivation arises largely from the circumstance that only on a relatively small number of days are both soil and weather suitable for ploughing. The result is that much of the work is left until late, and late work tends to be bad work. This can only be overcome by speeding up the process of ploughing during the favourable opportunities, and so far as I can see this is only possible by the use of motors. I believe, therefore, that motor-ploughs and cultivating implements will play a considerable part in the improvement of heavy land.

A second direction in which the risk can be reduced is by keeping up the supply of organic matter in the soil. Probably the cheapest and most satisfactory way of doing this is by ploughing in crop residues, such as, for example, are left by a seeds mixture, a clover ley, or ploughed-up grass-land.

Once these great fundamental things have received attention, all these soils—loams, sands, and clays—can be further improved by proper treatment with fertilisers. A great deal of good work has been done on this subject, and the results are steadily being diffused among farmers.

In most field experiments there is no indication of any end-point, and apparently the more the crop is fed the larger would be the yield. But the process does come to an end. The final limit is reached by the inability of the plant to stand up any longer or to grow any bigger. When the corn-crop gets beyond a certain size it is almost invariably beaten down by the wind and rain, so that the difficulty of getting it in becomes considerable. Heavy dressings of nitrogenous manures also predispose the crop to fungoid disease, attacks apparently being facilitated by the thinning of the cell-walls and the change in composition of the cell-sap.

The way for further progress is then to seek new varieties that can stand up and resist disease. And here a good deal has been done. Biffen has shown how desirable properties may be transferred from one wheat to another, and his investigations are revealing the limits within which it is possible to construct a variety of wheat according to the grower's specification. Similar work is badly wanted for other crops. Fortunately our great seedsmen are fully alive to the possibilities in this direction, and have already done much useful work. It is not only in the case of cereals and potatoes that new varieties can be sought; there is great scope also for new varieties of all other crops.

But there is another way in which science can further the problems of crop-production. Instead of aiming solely at increased yields per acre, attempts may be made to reduce the cost and increase the certainty of production per acre.

One of the most hopeful ways of attacking this problem is to increase the efficiency of the manurial treatment. No manurial scheme is perfect; no farmer ever recovers in his crop the whole of the fertilising constituents applied to the soil; there is always a loss. In our Broadbalk experiments, where wheat is grown year after year on the same land and large dressings of artificials are used, we do not recover in the crop more than about 30 to 40 per cent. of the added nitrogen.

Now, whilst we can never hope for perfect efficiency, *i.e.* for 100 per cent. recovery, we can hope to do better than this. On our own fields we improve considerably on it every year by the adoption of a proper rotation.

Further experiments on the relationship between the efficiency of fertiliser action and the rotation are very desirable.

Another great direction in which economy is possible is in the management of farmyard manure. It has been a common complaint against agricultural investigators that they have concerned themselves exclusively with artificials, and left untouched the greater problem of the manure-heap. For farmyard manure is the staple manure of the countryside, about 37 million tons being made per annum in this country The value at 5*s.* per ton is 9,250,000*l.*; all the artificial manures consumed in Great Britain probably do not much exceed 6,500,000*l.* in value each year.

Through the generosity of the Hon. Rupert Guinness we have been able at Rothamsted to attack this important subject, and Mr. Richards has obtained some striking results, showing what losses may take place and indicating methods of avoiding them.

Another direction in which saving is possible is in the soil itself. It is now forty-six years since Lawes and Gilbert built those remarkable drain gauges at Rothamsted which for the first time enabled chemists to determine precisely the quantity of fertilising material washed out from the soil by rain. When there was no crop on the ground the soil lost by drainage about 40 lb. of nitrogen in the form of valuable

nitrates, a quantity as great as is contained in a 24-lb. bushel crop of wheat.

It appears that this wastage of nitrates in winter can be greatly reduced, but the process requires suitable crops and rapid cultivation methods. Neither of these ought to be beyond the power of the agriculturist to provide. The possibilities are many. Wibberley has discussed several schemes of continuous cropping that satisfy these requirements, giving a succession of crops which cover the land at the critical time when losses would occur. And our implement-makers are steadily increasing the number and effectiveness of the implements, while motor traction promises also to increase the speed of working.

A further direction in which improvement is possible is in cultivation. Reference has already been made to the necessity for increasing the speed of ploughing so as to get the work forward and enable the farmer to plough just as much as he likes in autumn, or, if he wishes, to get in a bastard fallow or a catch-crop. The motor-plough seems the only solution, and as soon as the difficulties of engine construction are got over and the price becomes sufficiently low, I think it must displace the horse-plough as inevitably as the railway displaced the stage-coach. Both the soil and the human factors tend this way. So long as a man and two horses, and in some parts of the country a man and a boy and three horses, can only manage to plough an acre a day, it is obvious that the farmer cannot afford to pay more than a small wage for the work; but when a man on a motor-plough can do several acres a day a considerably higher wage becomes possible.

The last economy to which I shall refer is the choice of crops. The farmer grows his crops for profit, and clearly ought to select the most profitable for the purpose. This can only be done by keeping accounts. No crop ought to be grown that does not pay its way; it should be displaced by one that does. On our own farm we find that wheat, oats, and barley are about equally profitable; but the crops in the root- or fallow-break vary enormously—potatoes bringing in most profit, while swedes, on the other hand, are invariably grown at a loss on our land. I believe this would be found not uncommon in the southern part of England. Amos and Oldershaw have recently gone into the cost of silage crops in these conditions. More experiments and inquiries are greatly needed to widen the range of this class of crops, and give us something that will be as useful as swedes but more profitable.

Besides these improvements in crop-production which affect all farmers, even the best, there are two other ways in which we can hope for further developments.

One is to raise up the ordinary farmer to the level of the good one. The average crop of wheat for the country is officially reported to be 32 bushels, but no good farmer would be content with less than 40. If we accept the official average there must be a good amount of wheat grown at much less than the best that is possible even now. A vast amount of educational work has to be done to spread the knowledge of the best methods, varieties, manures, etc.

The other is to extend the area of land under cultivation. There are still wastes to be reclaimed, as Mr. Hall is reminding us, while even on farmed land the proportion under the plough each year is only small, and is constantly decreasing. Grass-land only produces about one-half of what arable-land yields, and it is imperative to the proper development of the country that some of it should be broken up. The farmer knows this, but he does not put his knowledge into practice. He cannot always afford the risk. There is a fundamental distinction between farming and manufacturing that is often overlooked in discussions on the subject. Except in rare cases—sugar beet and some kinds of seeds—the farmer does not grow for contracts, but always for what manufacturers would call "stock." The manufacturer makes a contract to supply certain goods at a certain price; he knows what his machinery will do, he can insure against many of his risks, and get out of the contract if others befall him. He knows to a penny how much he will be paid, and so he can calculate to a nicety how much he can afford to spend, and how far he can go in introducing new methods. Now the farmer cannot do this. He cannot be certain what yield or what price he will get. He starts spending money in August on a crop that will not be sold for fifteen months, and he has no idea how much money he will receive in return. The whole thing is a hazard which cannot be covered by insurance. Obviously, then, the farmer must leave a big margin for safety, so he balances his risks by laying down some of his land to grass, where the risks are at a minimum. But when you ask him to intensify his methods, and, as a necessary corollary, to break up some of his grass-land, he has a perfect right to ask who is going to bear the extra risk.

The problem has been burked in the past, but must be faced in the future. It is essentially a question of distribution of risk, and it ought not to be beyond the political insight and economic wisdom of those whose business it is to settle these matters.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

SHEFFIELD.—Dr. W. E. S. Turner has been appointed lecturer in charge of the new department of glass technology. Mr. G. A. Birkett, formerly of the University of Liverpool, has been appointed to the new Vickers lectureship in Russian. A permanent appointment is deferred until the conclusion of the war.

The council has nominated Mr. A. J. Hobson, J.P., to be a pro-chancellor of the University in succession to the late Sir George Franklin.

MISS H. DE PENNINGTON, assistant lecturer in chemistry at the Blackburn Technical School, has been appointed research assistant to Prof. J. B. Cohen at the University of Leeds.

WE learn from the *Münchener Medizin. Wochenschrift* that the medical faculty of the University of Göttingen has received two legacies, each of 10,000 marks, under the wills of the late Prof. von Esmarck and of the late Prof. Paul Ehrlich, of Frankfurt. The money will form a fund for assisting needy medical students.

IN connection with the present campaign for the preservation of infant and child life, the governing body of the Battersea Polytechnic has arranged for a public lecture to be given by Dr. C. W. Saleeby. The lecture will be entitled "The Saving of the Future," and will be held at the Battersea Polytechnic, Battersea Park Road, S.W., on Thursday, December 7, at 7.30 p.m. No tickets of admission are required.

THE fifth annual Conference of Educational Associations is to be held in the University of London on January 1–6 next. The inaugural address is to be delivered on January 1 at 3 p.m. by Mr. A. L. Smith, master of Balliol. Among the associations taking part in the conference this year are the School Nature Study Union, the Child Study Union, the Committee for the Development of Regional Survey, the Association of Science Teachers, and the National Association for Manual Training. Among the large number of addresses arranged for may be mentioned the following:—The possible educational value of kinemas, by