The University College Farm in the Agriculture of Rhodesia and Nyasaland

An Inaugural Lecture

GIVEN IN THE UNIVERSITY COLLEGE OF RHODESIA AND NYASALAND

Professor A. G. Davis

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by

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THE UNIVERSITY COLLEGE FARM IN THE AGRICULTURE OF RHODESIA AND NYASALAND

IN 1953 the Inaugural Board which was established to found the University College received from the government of the day a promise of a gift of 1,000 acres on a site yet to be selected for a College Teaching and Experimental Farm. The purpose of the Farm, like that of the Agricultural Department in the College, was to help to serve the agricultural interests of all three territories of the Federation. The College Council, which took over from the Inaugural Board, consulted Dr. Saunders for his experience and opinion on the subject. He was engaged on the task of creating a Faculty of Agriculture in the University of Natal. On his advice the Council appointed and waited upon the arrival of the Professor of Agriculture before choosing one of the available sites offered by the Federal Ministry of Agriculture.

The most suitable site was a portion of the Archie Henderson Research Station previously known as the 'Great B', totalling 7,000 acres. The portion was 1,200 acres and its excision from the station was endorsed and encouraged by its professional staff. Indeed, the College was offered a choice of three sites on the station. The final arrangement received government approval and the transfer of the land to the College was made known in May 1956.

During the three years since that date the young University College has become acquainted with the presence of agriculture in its midst.

Agriculture in the university is an applied science. Agriculture in practice is a way of life for the vast majority of mankind and its products provide us with our daily bread.

In the university, agriculture is a somewhat untidy subject. We are interested in history, in climate, in geography, in soils, plants and animals, in nutrition, in machinery, in irrigation, in buying and selling, and in human relations. We therefore require the services of specialist teachers in botany, chemistry, economics, zoology, as well as those more directly concerned with agriculture. Like our science colleagues we require good library facilities, offices, teaching and research laboratories. In addition we have to have a farm which is our field laboratory and on which experiments can be conducted under semi-controlled conditions alongside of the multiplicity of practical operations which are the feature of farming.

The historical precedent for universities possessing farms began when certain universities permitted the teaching of degree courses in existing agricultural colleges alongside of the diploma courses. Either over a long period or abruptly, the College with its Farm gained full university status with the dropping of diploma teaching. Other universities inherited or purchased suitable land for use by the teaching staff of their agricultural departments. In parts of Europe where the status of agriculture is still associated with peasant farming, agricultural education up to degree standard is undertaken outside universities in state institutions, each surrounded by demonstration and research facilities. The pattern is delightfully irregular. That which took place in the United States deserves mention because of its contribution to their agriculture. Known as the Land Grant College system, it was established in 1862. Grants of land in each state provided money to endow and support Colleges of Agriculture and the Mechanical Arts. Some were associated with universities already in being, others later developed into large universities, and again others remained as independent colleges gaining university status.

Among Commonwealth universities there are instances where there is a working liaison between the agricultural school or faculty of the university and a near-by research station in addition to the possession of a farm. Selected staff of the research station are *ipso facto* members of the university. They do some teaching, but, more important, they supervise research students who are working for a higher degree. The work is done on the research station. This is an excellent arrangement and of advantage to all concerned. The research stations must, however, have a large measure of independence and certainly be independent from direct government control. Here in Rhodesia the seeds of such an arrangement have already been sown.

The possession of a farm by the university is not readily understood or appreciated even in academic circles, nor, might I add, is it viewed with favour on the annual occasion of the presentation of its budget. This, of course, never ceases to surprise me and goes to show how prone non-agriculturalists are in their unfailing belief that farmers make money.

AGRICULTURAL LABORATORY

The Farm provides the main agricultural laboratory both for staff and postgraduate students. When it is well equipped it can provide a wide variety of facilities to enable staff and research students to prosecute experimental work and long-term projects, including the study of systems of mixed husbandry. The application in practice of the principles of crop and animal husbandry, and mechanization will be demonstrated to the students.

There is an aspect of a university farm which from the department's point of view is a two-edged sword. Whereas science laboratories are normally hidden behind four walls to be opened for public inspection on special occasions and only after a spate of spit and polish, the Farm is at all times in all seasons open to any farmer or other interested person who stops his car and looks over the fence. It is our shop window and quite naturally we should like to display only our finest goods. A few failures about the place will do us no harm, for it reduces our stature to the common level. The critics will then have something to get their teeth into. Our friends and well-wishers will drop in for a drink on the stoep, discuss the difficulty, and suggest how to avoid it in future, and, of course, everyone will be happy. As it is also the shop window of the department, it is necessary to keep the glass clean, otherwise farmers won't stop to look in. This of course costs money. Buildings, signboards, and machinery require routine painting, weeds cleared away, and the place generally kept tidy and shipshape.

SELECTION OF SITE

Prospective farmers are familiar with the difficulty of finding a farm suitable to their liking. The selection of an ideal site for a university farm presents even more difficulties. As a matter of principle it should be suitable for growing the more common crops and be representative of the farming potentialities of the region in which the university is sited. This region is not uniform. It possesses two contrasting soil types defined as 'coarse-grained sands derived from granite' and 'fertile red clays and heavy clays derived from banded ironstone, dolerite and greenstone' [6]. In addition there are belts of Tatagura and pockets of vlei soils. At the present time flue-cured tobacco is grown on the sands and maize on the red soils. Maize can be and is, of course, grown on the former, whereas the tobacco is largely confined to the sand. Both crops play a vital role in the economy of the country. In proximity to the urban area of Salisbury other crops, dairying, poultry, and pig enterprises, are sited irrespective of the two main soil types. Two enterprises associated with an urban area, dairying and vegetable-growing, would appear to require facilities for irrigation in Southern Rhodesia.

An impartial assessment of the choice of a university farm should also consider soil fertility, research facilities, and profitability. There are two views concerning the inherent and potential fertility of land which is to be used for agricultural demonstration and research. A sound opinion in agricultural circles is 'if you must farm, farm good land'. It expresses the wisdom of 2,000 years or more of farming experience. Good land gives a greater reward for effort expended than does poor land. The implication of this can be seen in the United States today, where the trend is one of increasing production and declining cultivated acreage, that is, only the good land is being cropped. The same concept applies where irrigation is to be practised or where drought conditions have to be surmounted. On the other hand, successful agricultural scientists have proposed and practised the thesis that research work should be carried out on the poorer, less tractable land, for improvements so achieved, would be more readily adopted by farmers than if they had been accomplished on good land. The subject is one in which there is fortunately room for both opinions.

Obviously the university farm must possess reasonably adequate facilities for research and demonstration which have pertinent relevance to the surrounding agriculture.

Table 1

Total Area of European Farm Land and Number and Size of Holdings in Southern Rhodesia, 1956–7

Classification	Holdings: Number	Holdings: Percentage distribution	Area: 1,000 acres	Area: Percentage distribution
50 acres and under	150	2·26	5	0·02
51 acres to 100 acres	217	3·26	18	0·05
101 acres to 250 acres	437	6·57	73	0·22
251 acres to 500 acres	413	6·20	147	0·44
501 acres to 1,000 acres	459	6·90	354	1·05
1,001 acres to 2,500 acres	1,608	24·18	2,808	8·33
2,501 acres to 5,000 acres	1,713	25·76	5,923	17·57
5,001 acres to 7,500 acres	594	8·93	3,641	10·80
7,501 acres to 10,000 acres	218	3·28	1,873	5·56
10,001 acres to 15,000 acres	248	3·73	3,020	8·96
15,001 acres to 20,000 acres	104	1·56	1,798	5·33
20,001 acres and over	230	3·46	14,048	41·67
Size not known	260	3·91	—	—

Ref. *C.A. Statistical Office Report for 1956–57*; 6,651 holdings totalling 33·7 million acres.

Table 2

Land Utilization in Reserves and Special Native Areas of Southern Rhodesia

Region	*Total area (1,000 acres)*	*Estimated usable land (1,000 acres)*	*Estimated arable (1,000 acres)*	*Usable as % of total*	*Arable as % of total*	*Arable as % of usable*
N. Mashonaland	6,278	5,403	877	86·0	13·9	16·2
S. Mashonaland	4,696	4,162	827	88·6	17·6	19·8
Matabeleland	10,293	7,282	425	70·7	4·1	5·8
Midlands	7,216	4,750	716	65·8	9·9	15·0
Manicaland	2,327	1,715	259	73·7	11·1	15·1
	30,810	23,312	3,104	75·6	10·0	13·3

Ref. Chart VI, *Report of the Sec. Native Affairs for 1957, S.R.*

The large proportion of land in Southern Rhodesia which cannot be used for agricultural purposes, that is neither for cultivation nor grazing by cattle, is quite surprising. Detailed surveys for the Reserves and Special Native Areas reveal instances where as much as half the acreage is classed as waste or non-usable. Details of land use on a regional basis are set out in Table 2. The average for the 30·8 million acres in African occupation is 24·4 per cent. A detailed survey of land in European occupation has been completed and is shortly to be published. On the university farm one-quarter of the land cannot be used for agricultural purposes.

In terms of land capability this waste or non-agricultural land, defined as Class VIII, provides an environment for wild life, an undisturbed flora of considerable interest to my botanical colleagues, and inspiring subjects for the artist. On the mundane level it provides firewood and harbours wild pigs, baboons, and leopards, three of the many hazards of Rhodesian agriculture. Also on the debit side such land overlies mineral wealth which if exploited under the terms of the present Mining Laws of Southern Rhodesia could ruin the Farm. By those terms mining is permitted within 250 yards of any dwelling and within 50 yards of arable land, while all timber is at the disposal of the miners.

History records that the Mining Laws were patterned on those in operation in California at the end of the last century. They have served this country well for over sixty years. New laws are required to meet the conditions of the present day, for agricultural production now exceeds that of minerals. Intensification of farming cannot be carried out so long as the farmer is not master in his own farm. Our present Mining Laws should be removed from the statute book and given a decent burial. In conformity with the English tradition of acknowledging the wealth of her wool industry by the regular use of the Woolsack in the House of Lords, here in Southern Rhodesia a bar of gold might be provided as a foot-rest for the Speaker.

Apart from non-agricultural land the Farm has some 300 acres of potential arable, that is, one-quarter of the Farm, although by no means all of this is under the plough at the present time. None of this is Class I, that is, land which can be continuously and intensively cultivated. In the region in which the Farm lies, only 6·32 per cent. is at present arable [3]. It is interesting to note, however, a statement made in a report to the Legislative Assembly [21]: '. . . it was suggested in evidence that 30 per cent. of land in European occupation was arable . . . this figure is undoubtedly too high'. Actually it is between 3 and 4 per cent. The comparable figure for the Union is barely 4 per cent. [40].

The area of arable land in the Reserves has been carefully estimated in connexion with the implementation of the Land Husbandry Act as part of the task of allocating farming rights. From Table 2 it can be seen that only 10·0 per cent. of the total land and 13·3 per cent. of the usable land is cultivated. Students who are interested in land use would do well to remember the Russian peasants' outlook on the subject. 'How much land does a man need?—6 feet.'

The remaining half of the Farm is suitable for grazing and re-afforestation. In kinder climates this particular land could be cultivated but, owing to a combination of slope and torrential rainfall, to do so would be to invite serious erosion. As Hudson [9] states, 'it is not sufficiently appreciated that the erosion hazard in Rhodesia is as great as anywhere in the world'.

SOILS

In describing the soils of Mashonaland, Ellis [5] has pointed out that they are 'hard to classify—strange dependence on the parent rock in apparent defiance of the laws of pedology due to possible reasons—not very immature due to the fact that many exist to a depth of 18 feet above parent rock but natural erosion may slowly have removed the critical upper layers so that the profile is in a sense immature—alternating wet and dry season—high temperatures—no marked layer of accumulation or alluviation—few horizons—generally follow the nature of parent rock and geological map of the area'. The soils on the Farm fit into this general description and are strikingly related to the geology over which they occur.

The soils on the western side comprise greyish silty clay loams of the Tatagura series. They are derived from schists and related rocks of the Iron Mask range. They are shallow, high in silt content, and reputed to be immature and moderately fertile. They possess an unstable structure, being readily pulverized when dry, and when wet they tend to become compacted to give a hard surface crust on drying out. According to Hudson [9], 'from the farmer's point of view it is a difficult soil', while three seasons of cropping have lent substance to the view that whereas germinating maize finds great difficulty in breaking through the crust, not so the plethora of weed seedlings. It would be exceedingly interesting to know why there is this difference. Hudson [10] and Jackson [12], investigating the soil slope/water/plant population/crop rotation relations of the Tatagura, have clearly shown that in spite of the difficulty of handling the land at seeding time it can be most productive.

Heavy red soils of considerable depth occupy the central part of the Farm. They do not belong to any named series, being intermediate between the Salisbury and Tatagura series. They are derived partly from basic igneous rocks (epidiorite and dolerite) and partly from sedimentary rocks. The influence of the latter is seen in the structure of the topsoil, which tends to break down under cultivation and under abnormal water concentrations [37]. Their inherent fertility is comparable with that of the Salisbury series, which under ideal conditions has a potential of 30 bags (6,000 lb.) of maize per acre.

Between the red soils and the Dassura River are pockets of black vlei soils which are virtually under water during the rainy season.

On the eastern side there is a strip of granite soils which, in spite of its steep slope, was cultivated and contoured some years ago. In terms of soil classification it belongs to Thompson's [38] Category III, being 'to all intents and purposes sands', passing to Category IV at the bottom of the slope, where it is a poorly drained vlei. The principles underlying the correct usage of the well-drained sands for tobacco cropping and to prevent soil erosion are based upon a number of experiments, one of which is currently under way on a similar soil further along the valley on the Henderson Station. Methods to combat erosion, six in number, include early planting, full-stand, correct layout of contour ridges, short rotation, getting back into grass as quickly as possible, and grading the rows on a slope of 2 per cent. [10].

VEGETATION

We agriculturalists are all too conscious of the importance of vegetation as an indication of differences in soils as well as reflecting climatic changes of temperature and rainfall [22]. This is particularly evident on the Farm. I trust that my ecological colleagues will take advantage of their opportunity to establish that concept firmly in the students' minds. There are at least two main contrasting types of vegetation, indicating the presence of the sandy and heavy soils, and numerous plant associations of grasses and herbs.

It is a woodland vegetation apart from the areas which have reverted from earlier cultivation and are now in grassland. A cross-section of the valley presents a number of catenas. On the eastern side there is mountain acacia, *Brachystegia tamarendiodes*, at the top among the granite boulders together with groves of tree aloe *Aloe excelsa.* On the better-drained sand there is the *Burkea africana* and *Termanalia sericea* woodland and species of the Protea family, e.g. *Protea abyssinici, Faurea saligna*, and *Faurea speciosa.* Occasional trees of *Cassia singueana, Peltophorum africanum*, and *Strychnos* species are seasonally colourful or obvious by their fruits.

At the bottom of the Farm there is a riverine woodland of acacia and other species which is much frequented by what I take to be the Blue Monkey. Where the granite sands are very wet it is entirely open and the herbage is dominated by sedges; also *Eragrostis, Sporobolis, Setaria*, &c.

On both sides of the river, species of *Hyparrhenia* dominate the reverted lands. In places the succession to this stage is via species of *Compositae* and I suspect that its presence is a function of the existence of buried weed seeds and availability of light at the surface of the soil. We must look into that one. The quarry which provides the sand for building has also yielded interesting evidence of long-dormant tobacco seeds: these have germinated to produce numerous plants of tobacco wherever building operations have been under way.

Coming down the catena on the west side, I am told there is bracken *Pteridium aquilinum* on the crest of the Iron Mask. The scree grows stunted trees of Mahobohobo *Uapaca kirkiani* and Msasa *Brachystegia spiciformis*. These increase in size as the soil improves in depth and fertility where the slope flattens out and includes Monondo *Julbernardia globifora*. Apparently the presence of Mahobohobo is not only due to its being a fairly cosmopolitan species where soils are open or intermixed, but also because its prolific rooting system enables it to send up suckers in areas where the Msasa or Mnondo has been felled. Mufuti *Brachystegia boehmii* was the dominant tree on the Tatagura and red soils but it had been cleared for cropping long before we took possession of the Farm. Cabbage tree *Cussonia kirkii*, wild gardenia *Gardenia spatalifolia*, wild violet tree *Securidaca longepedunculata*, and *Faurea speciosa* are some of the numerous other trees present. Mushava *Monotes glaber* is characteristic of the gravelly outcrop towards the bottom of the catena. The dry water courses carry *Hyparrhenia* and no trees. Across the wet vlei at right angles to the main catena are grass-land species which have yet to be identified.

The cultivated lands produce a weed flora in great abundance, the most prevalent being Rapoko grass *Eleusine indica*. At times it appears as if the lands carry all the weeds in Dr. Wild's book [42]. We have not used any selective herbicides to control them, but we shall do so. There is already much spectacular evidence demonstrating the value of this agricultural technology in Southern Rhodesia [36].

RAINFALL

Great variability in the intensity, seasonal distribution, and total amount of rainfall is associated with the climate of southern Africa. Our dependence upon rainfall is much more obvious than in temperate climates. Rainfall records collected at two stations north and south of the Farm, and both within a radius of five miles and at the same elevation as the Farm, go back over 35 years. The highest figure was 56·9 inches and the lowest 17·4, with a mean of 35·7 inches. The 32- to 36-inch rainfall belt covers 12·5 per cent. of Southern Rhodesia [33]. The variability of the rainfall in the zone centred on Salisbury expressed in terms of standard deviation over a period of 28 years was found by Robertson [29] to be 26 per cent. It is interesting to note that only 5·1 per cent. of the country has more than 36 inches [33].

Of vital interest is the amount of the rainfall retained on the Farm. Indications, let alone precise figures, are wanting. Furthermore, the lie of the land is such that it would be very difficult to determine. Studies of the water table commenced by my colleague Mr. Watson initially reveal that it is to be found at considerable depth on the west side, whereas it is all too near the surface in the granite sand. I would hazard a guess that we lose one-third of our rainfall as run-off. Knowing the seasonal rainfall over a run of years we should be able to prognosticate its reliability for critical periods of crop growth, as is being done by Manning [15] in East Africa.

Although it is recognized 'that soil moisture is the most important single factor affecting the distribution of grasses' [27] in Southern Rhodesia, we do not yet know how much water is used by any of our crops when grown under particular sets of conditions. This applies to all of them, including tobacco, tea, maize, and groundnuts, which together exceed £35 million per annum in value. This state of affairs can be rightly attributed to an obvious weakness in the courses given at university level to students entering agriculture.

It is, however, very difficult to correct, that is, to introduce, the necessary mathematics and physics which would be required to support agricultural climatology and crop physiology. The agricultural course is already overloaded and there is a marked prejudice in certain university circles to introducing subjects which have peculiar local relevance.

WATER

Turning next to the all-important matter of water-supplies for man and beast here in Rhodesia, the statement has been made: 'The ultimate development of this country will be controlled by the available water resources' [28]. Wellington [40], in opening his review of the subject, states: 'It is generally recognised that the settlement of the greater part of Southern Africa has been made possible by the borehole.' It is therefore remarkable in a country like Southern Rhodesia, having a regular drought of 5 to 7 months' duration, to find that there does not appear to be a census of boreholes in use or of their current yields. Scanning departmental reports it appears that over the past 25 years government drills have put down over 8,000 boreholes with successes ranging from 60 to 84 per cent. [28].

A summary of the boreholes put down by government prior to 1954 taken from the *Rhodesia Agricultural Journal* follows [2]:

Underlying geology	*Boreholes investigated*	% *success over 200 g.p.h.*	*Average depth, ft.*	*Average yield, g.p.h.*	*Average w./table, ft.*
Granite	2,400	60	128	815	38
Sediments	1,303	67	146	720	53
Schist	1,409	77	124	930	44

It can be seen that the granite which occupies so much of the country is not a good water-bearer. This in combination with the topography, coupled with seasonality and the torrential nature of the rainfall, makes for limited supplies of water from boreholes.

Geophysical methods were introduced in the mid-thirties, which greatly improved the chances of finding a successful borehole; nevertheless, private drillers still appear to practise with the divining willow or rod. There is no record of the number drilled by private drillers nor of their successes. The boreholes in the Banded Ironstone (schist) which underlies part of the Farm yielded 1,000 and 600 gallons per hour as their maximum output, from depths of 115 and 148 feet, respectively. The water from the Ironstone is rich in ferrous particles which do not separate out even after long standing unless treated with alum.

FARMING POLICY

In very general terms European agriculture in Rhodesia is characterized by singleness of enterprise. There are good and sound reasons for such development. Climate and soils have led to the development of cattle ranching in the low veld, tobacco on the granite sands of the high veld, and maize on the high-rainfall heavy soils overlying the gold-belt complex. The necessity for constant European supervision, particularly with tobacco, seed crops, and dairying, is well known. The capital necessary for the development of farms has been limited, and therefore farmers have had to restrict their efforts to the development of the one enterprise which promised a reasonable return. This in turn was dependent upon a suitable and often limited market. Such was also the experience of farmers in New Zealand, Australia, Canada, and the United States.

However, people with a European heritage possess a strong desire to engage in mixed farming. In temperate climates much evidence—husbandry, technical, and economic—points to the advantage of such a practice. Indeed, we read that New Zealand's leading livestock scientist advocates a degree of mixed farming in his island [16]. The ideal of mixed farming can only become a reality with consistent co-operation of labour in lieu of adequate supervision and the drastic adaptation of the farm to mechanical aids—a state of affairs not yet reached in Rhodesia. A form of mixed farming is practised, but it requires the employment of managers to look after each enterprise as well as a great deal of capital and competent ability of the owner.

Looking about one cannot but be impressed with the merits of singleness of enterprise for successful farming in Rhodesia, and to farm in face of that fact, which we shall be doing on the Farm, is to court calculated risks. On the highest advice I was pressed to attempt to put mixed farming into operation on our Farm. This we intend to do, subject to the needs and demands of *ad hoc* experiments and research projects.

In practice we know that it is extremely difficult to carry out such a policy. We know on commercial farms how important it is to carry complementary enterprises, e.g. tobacco plus a breeding herd of beef cattle, maize production plus fattening cattle, dairying irrigation and vegetables work together, and so on. It is infinitely more difficult to carry these and other enterprises on a university farm where there are the competitive claims of good farm management and experiments; at times these bear little relation to practice. There are the claims of the farm manager whose yardstick is his profit and loss account versus the scientist studying the effect of supplementary light upon the reproductive potential of sheep or the grazing behaviour of dairy cows in the noonday heat.

In tackling this policy of superimposing experimental work upon a farming system under the university umbrella we have the advantage of noting how it is being carried out elsewhere. In the American Land Grant Colleges and their Experiment Stations the original farm land has become sectionalized and little empires compete for what appears to us as munificent funds. Edinburgh has five farms; King's College at Newcastle has two, one of which is primarily commercial in its running and the other devoted to research; Oxford has only one farm and the policy there is to farm round the experiments; Reading has three farms; Wye College has one farm, albeit a large one. It has been aptly described as a hybrid farm—a hybrid between research and sound profitable practice [41].

Different circumstances require different approaches. Flexibility must be our guide in the matter. I look upon the Farm as our Agricultural Laboratory, and at the present time all circumstances point to the desirability of concentrating our limited resources upon research projects. These must be fitted into our mixed farming economy and at times take priority over practical work. On the practical side we have a small committee of farmers to whom we can turn for advice.

When the policy to be adopted on the Farm was first under consideration it seemed right and proper to make some provision for the needs of African agriculture. However, a number of farmers have been at great pains to enlighten me as a new-comer to the African continent that there are few differences between European agriculture and African agriculture. At first, being a new-comer, I accepted this view. Later, travelling about the country in order to see its farming pattern and browsing through various government reports, independent surveys, and other sources of information, as well as coming under the influence of my colleague Professor Clyde Mitchell, the matter has revealed itself in a different light. Pierre de Schlippe [34] expresses the point as follows:

Is any understanding between the two worlds possible, or is the gulf too wide? On one side there is the curriculum of Cambridge, Grignon, Wageningen, Gembloux or Bonn, with, in the background, a field of uniform golden wheat falling under the blades of a McCormick Combine Harvester. On the other side there is this extraordinarily intricate fabric of a mottled pattern of grass-brush land which a small hoe and small axe, helped by fire, transform into a no less mottled pattern of crops, varieties and associations.

If there is any understanding possible across this gulf, it is certainly not under the present constellation of interests, authorities and responsibilities.

Originally, every human group has built its culture from the ground up. Food production, which in all except the most primitive societies takes the form of agriculture, is its foundation. Agriculture is one of the main links between a human group and the 'landscape' in which it lives and which it exploits. Through agriculture every environment has taught its inhabitants a certain way of life. The teacher of a culture is its environment, and agriculture is its classroom. The more refined functions of a culture, laws and customs, social and political organizations, morals and beliefs, are in a sense the superstructure on the foundation of agriculture.

As a culture develops this superstructure, it becomes gradually more and more oblivious of the importance of its foundation. In a social pyramid the most vital function, that of the food producer, becomes identified with the lowest, the most rejected, the most conservative social stratum. The superstructure of the culture, on the contrary, is not only glorified but also made into something absolute and infallible, and every group comes naturally to believe in its own way of life as the best and only right one.

When two cultures are brought into contact with each other, neither group has ever the wisdom to consider the way of life of the other group as the product of a different environmental education. It considers it as wrong and, therefore, only worth exterminating and replacing with the right one. The stronger group invariably imposes its culture on the weaker one.

Whether or not this is a fair statement of the position I do not yet know. Rather than remain on the fence as it were, I will crawl off at the end by hazarding the view that the principles of crops and animal production for European and African agriculture are the same, but the practices, at least at the present time, are different.

A study or survey of African farming practices would be of considerable interest and might help to explain the reasons for some of their methods. Investigations into their rotations, crops, and stock provides a wide field of study, parts of which could be undertaken on the Farm. Sir Joseph Hutchinson, in a deeply thoughtful paper [11] has drawn attention to the urgency of finding crop rotations which will meet the needs of the emergent African farmer. So far as I can find out little has been done in Central Africa.

That so little has been done could be a reflection of the widespread policy of making the scientist subservient to the administrator with his classical education, and respect for tradition, as was the practice in India [11]. An impartial observer of African agriculture in the Federation would note this same policy—or is it folly?

FARM PLANNING

The development of the College Farm owes a great deal to the modern concept of farm planning. This stems from a realization by agriculturalists working in easily erodible countries and possessing the mechanical tools of civilization, that farmers, however experienced they might regard themselves, did not in fact know the limitations and potentials of the land which they farmed. Where they adopted practices from the old world without making modifications to meet the vagaries of their own local climate, irreparable damage sooner or later took place. When a drought or heavy rainstorm struck them, the soil and much of their farm, often the best part, disappeared overnight. Desperate efforts to extract the last ounce of fertility out of the soil in the face of falling world prices for farm products magnified their plight.

Looking back over a space of thirty years I can still see the small parties of broken farmers and their families, with all their worldly goods piled high upon a couple of wagons, drawn by starving horses and followed by a few equally emaciated cows, trekking away from what had once been their farm into which their combined hopes and savings had been sunk and was now little more than a dust bowl. That was on the prairies of Canada.

In South Africa Alan Paton has vividly described the scene in his *Cry the Beloved Country*. America exploited her farming community to produce great commercial wealth, but at a terrible price. Steinbeck's *Grapes of Wrath* should be read by every agricultural student.

In Rhodesia the creation of the Natural Resources Board in 1941 arrested the destruction of soil resources. The country has been subdivided into 93 Intensive Conservation Area Committees. Each has a panel of voluntary farmers assisted by a technical officer of the Federal Department of Conservation and Extension. Good husbandry, that is in terms of conserving soil and water, has been enforced by public opinion. Powers to do so are on the statutes but are rarely used.

This policy is no longer adequate. The emphasis must be on good farming—high farming. That is Dr. Rowland's view and others. This is where the concept of farm planning comes to the fore. It focuses on one farm the combined resources of the many technical [14] and economic services which are at the farmer's command. The first half of the twentieth century saw the creation of these services. We now can use them in an orderly and understanding manner in the organization and management of farming.

Farm planning must be flexible in its concept and use as the basis for the trinity of technology of production, good husbandry, and the organization of the various enterprises on the Farm. The services of the technical officer require to be matched by those of the agricultural economist and both must be in sympathy with the farmer's day-to-day problems, for it is he who desires to put their ideas into practice.

Farm planning is no substitute for poor or indifferent farming, no panacea for easy profits. The rewards will be slowly realized. The next generation will be able to adopt enterprises suited to their times without being handicapped by mistakes of their parents. Finally, it gives high promise of the land being there long after we have departed.

A survey of land classes and capability carried out by officers of the Federal Department of Conservation and Extension was superimposed on an aerial photograph from which Fig. 1 has been drawn. From this information a plan, Fig. 2, was drawn up showing where a number of enterprises could best be carried out on the available land, with the proviso that experimental work may be superimposed upon these enterprises at some future date.

The intention is to forward the policy of mixed farming. It provides for a maize–green crop rotation; a maize–grass–beef enterprise coupled with fattening pigs; a breeding herd of indigenous cattle on the veld with supplementary winter feeding; a tobacco–grass–cattle enterprise; a dairy-irrigation unit; sheep; poultry; and lands which can be used for agronomy trials, including irrigation studies. That is the plan. Before commencing any one of the proposals it is our duty to make ourselves familiar with the best local practices and all that has or is being done by local research. Excellent co-operation from farmers and technical officers is making this duty possible and a profitable experience to ourselves.

ROTATIONS

Space does not permit of a review of current agricultural research work in the Federation even were I competent to tackle the task. There are, however, two subjects I would like to comment upon, namely, crop rotations and irrigation.

The basic principle of cropping practices is the rotation. Its ultimate purpose is at least to maintain and if possible increase production. It is also the chain which holds mixed farming together. Rhodesia possesses critical rotation studies dating back to 1913, that is, over a period of 46 years. Indeed, the Salisbury Experiment Station can rightly claim to possess the oldest rotation trials in southern Africa. The rotations have demonstrated the value of a leguminous

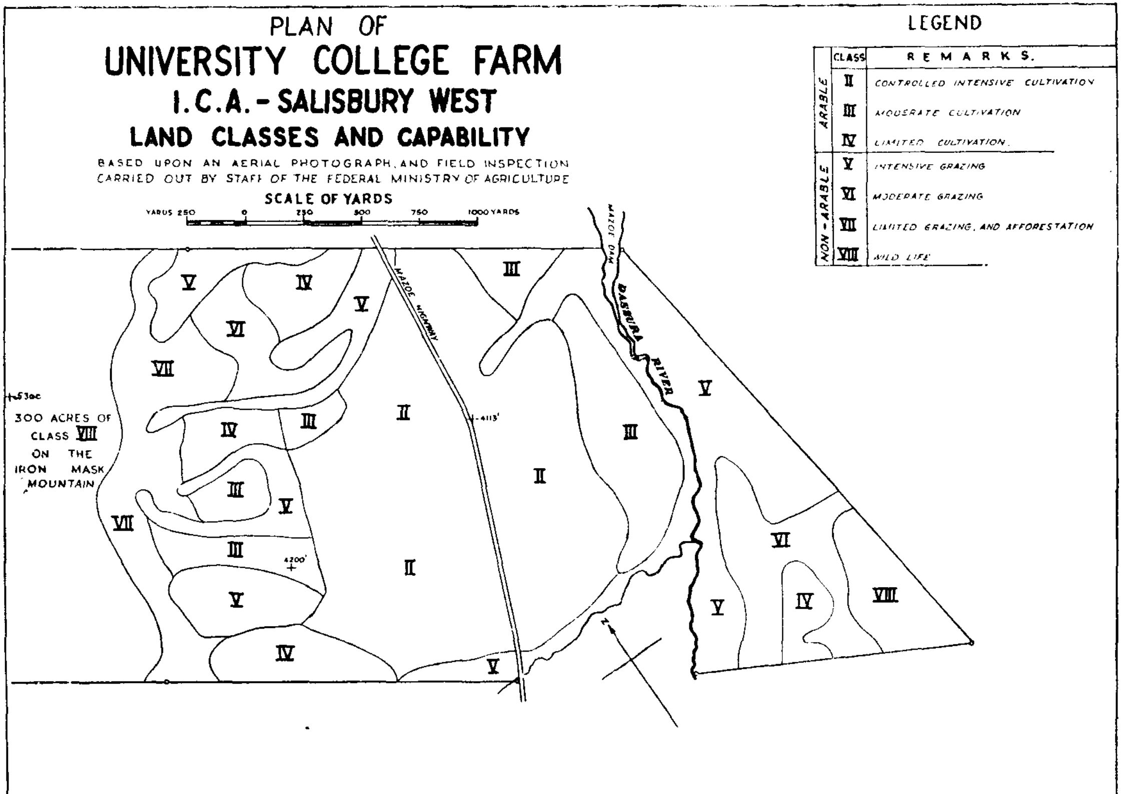
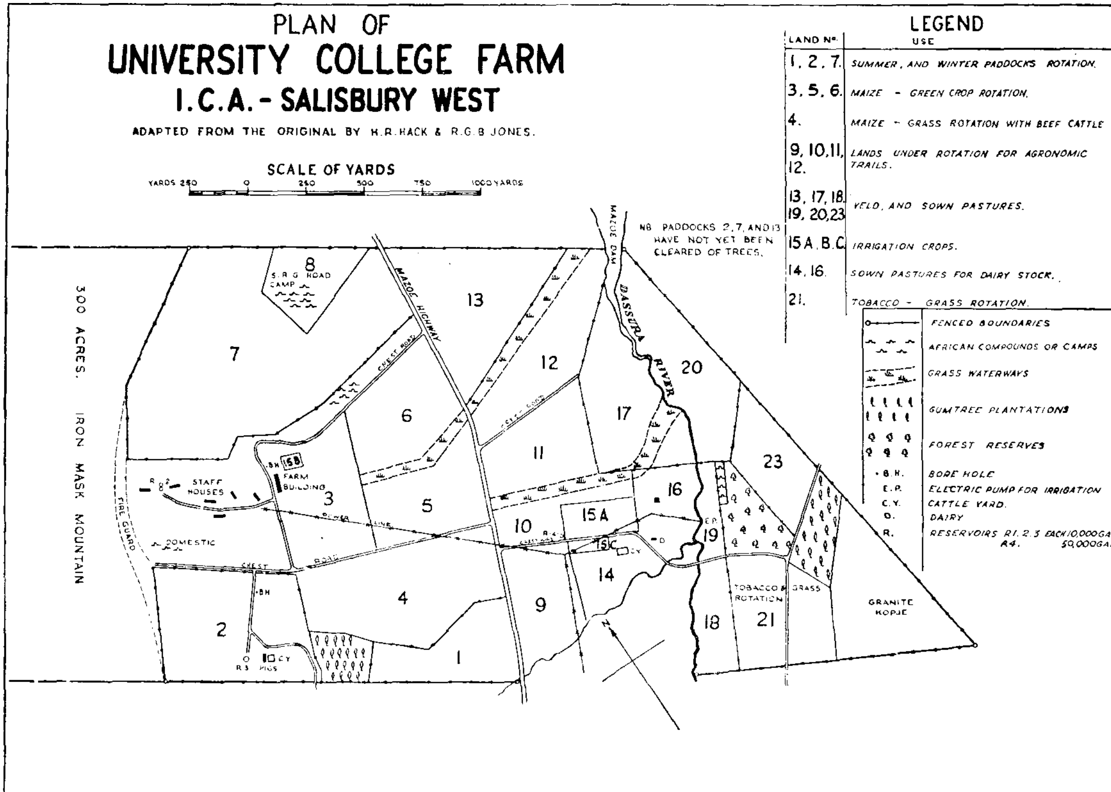

PLAN OF
UNIVERSITY COLLEGE FARM
I.C.A. - SALISBURY WEST
LAND CLASSES AND CAPABILITY
BASED UPON AN AERIAL PHOTOGRAPH, AND FIELD INSPECTION CARRIED OUT BY STAFF OF THE FEDERAL MINISTRY OF AGRICULTURE
SCALE OF YARDS
YARDS 250 0 250 500 750 1000 YARDS
LEGEND
CLASS
REMARKS.
ARABLE
II CONTROLLED INTENSIVE CULTIVATION
III MODERATE CULTIVATION
IV LIMITED CULTIVATION.
NON - ARABLE
V INTENSIVE GRAZING
VI MODERATE GRAZING
VII LIMITED GRAZING, AND AFFORESTATION
VIII WILD LIFE
300 ACRES OF CLASS VIII ON THE IRON MASK MOUNTAIN
MAZOE HIGHWAY
MAZOE DAM
GWEBI RIVER
4113'
4200'
N
DRAWN BY VICTOR E HORNE, SALISBURY, S R

FIG. 1



DRAWN BY VICTOR E HORNE, SALISBURY, S.R

green manure in maintaining the yield of maize as is indicated by the figures in Table 3. In recent espacement trials [24], also following a cow pea leguminous green crop with phosphate and various levels of applied nitrogen, yields of over 37 bags per acre were recorded, that is 7,400 lb.

TABLE 3

Maize Yields, Agricultural Experiment Station, Salisbury
Mean Yield of Twelve Seasons in Bags of 200 lb./acre

Treatment	*per crop*	*per annum*	*Commencement of experiment*	*Plot ref.*
Maize continuously . .	4·25	4·25	1919	E 1
Response to Phosphate(†) .	1·07	1·07	1913	A 1/E 1
Complete fertilizer(†) .	3·18	3·18	1946	N 2/E 1
Green manure . .	6·08	3·04	1938	E 2/E 1
Phosphate+green manure	11·95	5·97	1928	A 2/E 1
Compost(‡)+complete fertilizer . . .	9·60	9·60	1946	P 2/P 1
Maize and green manure alternately . . .	10·33	5·16	1938	E 2
Response to Phosphate(†) .	5·87	2·93	1928	A 2/E 2
Legume green crop cut for hay	−5·22	−2·61	1915	B 1/E 2

Ref. Annual Report 1957/58. (†) 300 lb. alternate years. (‡) 8 tons.

Nevertheless, green manuring remains a controversial subject and has recently been utterly and irretrievably damned by the evidence from soil conservation studies [9] revealing soil losses of up to 40 tons per acre from the land in green-crop.

Rowland and his team [30] have advanced the concept of continuous cropping, dense plant population, heavy fertilization, and disking the maize stover into the land. Why not, if it works? If 20 bags/acre [24] can be maintained every year by this method, such a yield far exceeds the figures recorded in Table 3. Technically, it may be possible to do so and right to do so from the point of view of conserving the soil, and economically it looks good. But it has to be fitted into a farming system.

Meantime, for Major Mundy [17] and the adherents to green manuring, they can find support from Joffe [13], who as a pedologist holds the view that 'green manuring in the scheme of tilling the soil for bigger and better crops has been appreciated for a long time, especially by progressive farmers whose experiences have contributed a great deal to present the problems involved'. He goes on to say: 'The scientific agriculturalists lag behind in interpreting gains made and explaining failures, thereby causing confusion and misunderstanding on the value of green manures.' Perhaps enough has been said.

When more equable prices are reached between maize and beef I believe that the maize–grass rotation will come to the fore. Current investigations both on the red soils [32] and the granite sands [4] are demonstrating that high maize yields can be obtained from the residual fertility of properly fertilized and grazed grass.

This is being done in the face of the concept that 'there is generally enough marginal ground on any farm for adequate pastures, and the broad justification for the general introduction of rotated grass into the best arable soils must be sought on other grounds' [7]. It is also being done in the face of reputed transient effects of grasses on so-called tropical soils [20]. As and when the two crops are grown in a rotation and incorporated into a farming system with stock, it will be more practicable and useful for both European and African agriculture than will continuous maize cropping. At least, that is what I believe.

Throughout the world farmers are conscious of the importance of dung and urine in maintaining soil fertility. Agricultural scientists now refer to them as the animal factor. The expression that 'muck is the mother of money' is no less true today than it was before the advent of the internal-combustion engine. Also true is that we do not quite know how to realize that money. It would be helpful to know what insects eat the dung and to what extent their presence is beneficial or harmful in opening up clay soils. If their activity bears any relation to that of earthworms in kinder climates, the subject is certainly worthy of close study.

If any of my audience suspect that I am pronouncing from an ivory tower, I would place on record that experimental and practical rotations are already in progress on the Farm. The pronounced effect of muck plus artificial fertilizers is too obvious to be ignored. Also, we have not been without failures of planting both green crop and grass —a salutary experience.

In contrast to maize, whose handmaiden is still the green crop in spite of the luscious fertility of nitrogen, flue-cured tobacco retains an obstinate singleness of status. Efforts to rotate it with a suitable crop are handicapped by the latter acting as an alternative host to tobacco eelworm (nematodes). Where the crop is a grass one it cannot be made productive, otherwise the succeeding tobacco crop will be of poor quality. For its successful culture it demands a high input of money, labour, and constant, careful, detailed supervision. That being so, the prospect of fitting it into a truly mixed farming economy has to be seriously questioned, unless of course the farm is sufficiently large as a business to carry two or more competent assistants to supervise the daily operations.

On the other hand, we must not lose sight of the fact that a single-crop farm enterprise is very vulnerable in the economic wind. Therefore, science must obtain mastery over the eelworm and find out how to use grass or other crops in a rotation dominated by flue-cured tobacco. It will not be easy.

Nothing must be done, however, which will impair the quality of our best tobacco. The soils upon which this tobacco is grown are a national asset producing today some £25 million per annum in tobacco exports. It is in the country's interest to survey and determine their extent in order that they may be used to greatest advantage both in the present and in the future. That there is a need for this is indicated by the report from Northern Rhodesia [39] which states that the 'best' tobacco farms comprised only 5·6 per cent. of the stumped land in European occupation in 1953.

IRRIGATION

The practice of irrigation in Rhodesia precedes its recorded history. We can only speculate why the water furrows of Inyanga were constructed, for they have long since fallen into disuse. It is one of the oldest forms of farm practices. Its reintroduction to Rhodesia dates back to the beginning of the century when Rhodes made provision for irrigation on his Westacre property at Matopos. The Charter Company later commenced citrus estates under irrigation at Old Umtali, Sinoia, and in the Mazoe Valley following their construction of the Mazoe Dam.

The abstraction of water from streams and rivers for irrigation purposes is subject to the terms of the Water Act. Water for irrigation can only be effected after a right has been obtained from the Water Court presided over by a

Judge of the High Court. The Court awarded the Farm water sufficient for 10 acres of irrigation. Actually we need water for 40 acres. To provide this a dam will have to be built at a point at least 6 miles upstream. Meantime we are pumping from the Dassura River for our 10 acres, since it is not possible to lead a furrow on to the lands. This is a common practice on farms on the high veld.

Today there are numerous large dams across the country, others in the process of construction like Kariba and Kyle, thousands of small dams, and a number of river pumping schemes, weirs, and furrows. At the present time there are over 40,000 acres under irrigation in Southern Rhodesia and over 4,000 in Northern Rhodesia [3, 18]. In 1952 it was estimated that some two and three-quarter million acres [35] could be supplied with irrigation water, and that figure excluded the potential from Kariba and the Kyle dam, the Kafue flats, and the Shire Valley project. The combined estimate for these four is in millions of acres.

Our farming is becoming irrigation conscious. But, and it really is a big 'but', there is a dearth of technical knowledge, as well as capital to finance all these schemes. Of the two, the former presents the greater challenge. Enormous acreages of soils require very careful and long-term study before we are justified in financing their irrigation, while little is known about the response of various crops to these particular environments. Over all hangs the dark shadow of bilharzia. It must be stamped out if the practice of irrigation is to play an increasing part in the expansion of agriculture.

Nearly one-third of the present irrigated area is covered by sprinklers, and this proportion seems likely to increase for three main reasons. On the high veld, dams do not command sufficient arable land by furrow. In the low veld they do, but the undulating topography of the valley bottom and the nature of the soils may give the sprinkler an advantage over gravity feed. An adequate supply of electrical power, albeit never likely to be cheap, an increasing number of large and small dams within existing settled and established farming communities, and the sprinkler layout will enable many farmers to incorporate an irrigation unit into their farming system and so add to its flexibility. I and my colleagues will press this last concept because I am of the view that it will mean much to the future of the country.

The impact of irrigation farming upon the history and socio-economic development of countries has recently been examined and discussed by Karl Wittfogel [43]. He advances the theory that where the agriculture is dependent upon irrigation (which he defines as 'hydraulic agriculture with large productive and protective water works') it has led to a socio-economic civilization associated with central or government control. On the other hand, where irrigation has been practised on a small scale only, it is associated with a multi-centred society.

This is an interesting concept. The hydrology of our country is such that irrigation schemes will have to be developed as small units. This will be accomplished by small groups or individuals and they are then in a position to retain control and create a multi-centred society. As a people this suits our temperament, for we do not take kindly to regimentation from the centre.

FINANCE

This is not the proper occasion to discuss the financial affairs of the Farm *per se*, but I am permitting myself a few comments. Our experience, and I am sure that it is shared by all new-comers to farming, has once again revealed that today a large amount of capital is required to commence farming operations. Add to this the cost of land in a good farming district plus the running expenses during the early years before there is any material income and the sum cannot be less than five figures. Good potential recruits to farming or farm managers aspiring to own their properties do not possess a tithe of this sum and are, therefore, denied the opportunity to farm on their own.

Grants of land and long-term loans on favourable terms have the dual objective of providing farms for selected individuals as well as opening up farming areas in outlying districts. These are for the pioneering types. There are also men and women who will make good farmers but are not pioneers, and these now deserve attention.

Circumstances today, however, lend themselves to the creation of a form of landlord and tenancy in agriculture which would provide for a class of tenant farms on which they could operate. My view is, and fortunately it is shared by others in the agricultural community, that a recognized form of farm tenancy must be placed on the statute book as soon as possible.

The task of finding and obtaining moneys has dogged the steps of all who have been engaged in agricultural research. Looking back into history it is interesting to recall one classic successful method of doing so. In 1911 a tax was imposed by Lloyd George, the then Chancellor of the Exchequer, upon whisky. It proved so bountiful that it became known as the 'whisky money' and it was used to create a Development Fund. This was set aside to develop transport and agriculture, and Commissioners were appointed to administer the funds. One of the Commission was Sir Daniel

Hall, who had been successively schoolmaster, Principal of Wye Agricultural College, Director of Rothamsted, and a member of the Board of Agriculture which preceded the Ministry of Agriculture. Hall was a scientist. He saw to it that agricultural development, including research at all levels, received the lion's share of the whisky money. This had a profound effect upon the course of agriculture in Britain.

Apart from government grants, gifts, and endowments, the most obvious source is the levy on production. However, taxation of production long preceded agricultural research so that there is often considerable and justifiable opposition to any form of levy. Nevertheless, it is by means of levy funds that commodity research stations are financed, e.g. sugar, tea, and tobacco. The University College, however, is not in a position to carry out research on any one commodity to the exclusion of others, but it can, I feel, look to grants from levy funds. Meantime, through the generosity of contributors to the Agricultural Faculty Appeal, the British Government, the Rockefeller Foundation, and the other donors, development of the Farm has gone forward.

MANAGEMENT

I come now to the subject of management on the Farm. Defined it is the sensible and efficient use of money, land, labour, machinery, and technology in the day-to-day operations on the Farm. Good management is a gift, a flair backed by a variety of experience without which it is very apt to be inflexible. Agricultural students must in their own interests obtain that variety of experience and in particular must do so away from the parental farm. The manager of a university farm, where there are always competing claims between the needs of science and of practice, and between staff for facilities and services, must also be a philosopher and psychologist. Long experience of this occupation has demonstrated the fact that one day he is in the position of Farm Director and the next he is merely the Foreman. His office is the Clapham Junction of all the diverse needs of this peculiar farm which is an agricultural laboratory, and if he is to survive and maintain a perspective of his subject, I think that he must cling tightly to the concept of good farming and all that that means.

My experience of the subject is limited. When I was a lad we saddled up the ponies twice a week and rode round the ranch to inspect the cattle. First it was a pleasure, later it became an onerous duty, particularly in winter. In England they told me that 'the master's foot is the best muck'. Here in Africa where I have been fortunate in visiting farms and estates, the farming has usually been done in the ubiquitous Land Rover. There is the drive round the lands inspecting the crops; the stock boys bring their cattle to a convenient vantage place; the buildings and their layout are noted. Then we are driven over to see the dam. Perhaps it is seed-bed time, in which case we walk through them in detail. If it is Sunday, the farm tour ends at the swimming-pool. Whatever the day, we eventually look forward to a drink on the stoep as the African sun in all its glory drops over the horizon. On the stoep the progress of crops and stock is recapitulated by our host and then the inevitable questions are asked. What do you think of this or that crop? How does it compare with crops elsewhere? What fertilizers were used? and so on. There is a battery of questions culminating in how to improve efficiency, production, and sales from the farm. The extension officer is trained and groomed to deal with these. In addition, he has a fairly detailed knowledge of what the other farmers are doing in this particular district. Academic agriculturalists are therefore somewhat at a disadvantage. A disadvantage, however, which is greatly mitigated if they can speak with the personal experience of their own work and knowledge of the university farm. Such experience can only be obtained and kept up to the minute by day-to-day contact with the activities in progress. To me at any rate it is a good and sufficient reason for living on the Farm.

The weekly inspection of the Farm is often a salutary experience to me as a new-comer to the Rhodesian environment. The vicissitudes of the rainfall repeatedly remind me of Secrett's dictum as applied to market garden crops in the south-east of England—there are three days on which to plant, the right day, the day before, or the day after—for it seems peculiarly appropriate during our planting season. I can see that it is not easy to resolve the demand for the use of labour with the potential power and use of the internal-combustion engine and other mechanical aids on the Farm. On European farms there is one tractor per 94 acres of cropped land [3] compared to one per 38 acres in Britain and Germany which possess the greatest tractor density in the world. We must grapple with our problem. No farming system can carry for long both a seeming abundance of labour and the heavy cost of machinery which are so peculiar to this country. It seems pointless to cavil at the efficiency of either. Farm mechanization has arrived late on the African scene, indeed a good deal later than on the prairies of Canada where I remember all too clearly the arrival of tractors and combines. A generation of farmers properly trained in the understanding and use of farm machinery is only just emerging from Gwebi College. Machinery locks up capital and so they will see to it that it is efficiently used. As for university graduates in Agriculture, I consider it is just as important for them to know how a machine works as to know whether or not they should use it. Rowland [31] has drawn attention to the need to provide training facilities for labour. As regards cost of machinery the answer may well be in singleness of enterprise.

I have ranged far and wide in connexion with the many factors which affect the planning, development, and operation of the University College Farm; factors which bring us into close contact with the agriculture of the Federation. It is our agricultural laboratory in which we have to combine practice with research. Without the one we cannot accomplish the other. Nor can we face our students without the confidence which the Farm gives with its day-to-day experience in technical and practical matters, management, and organization. In order to teach the subject of agriculture in the university it has been found necessary to commence with the biological, physical, and social sciences. These have then to be related to the various parts of agriculture—soil, water, crops, stock, machinery, and the commercial and sociological nature of the subject. Finally, these parts have to be brought together in order that the student can grasp and appreciate the unity of a single subject, namely agriculture.

This method of approach has to be kept constantly in mind, for it might not be the best. Sir John Russell in reviewing agricultural research in the first half of this century called attention to the thesis: 'that which is accepted as fact is most in need of questioning'. This also applies to our teaching of agriculture.

Having prepared and delivered this inaugural lecture, I am conscious of the fact that I have said very little about the actual experimental work which we intend to conduct on the Farm. The agricultural literature abounds with reports and technical papers of what has been accomplished on university farms, but I have yet to see a statement of anything more than policy prepared in advance of such work. This omission is an awareness shared by occupants of chairs of agriculture, including myself, that long ago Burns, the ploughboy poet, anticipated our experience in the words: 'the best laid schemes o' mice an' men gang aft a-gley'.

What has been done is what really matters. In the space of 2½ farming years, which is infinitesimal in the long history of both agriculture and universities, another attempt has been made to draw the two together. The former is well known as a way of life and one that has been materially improved over the past 100 years with the aid of science and technology. The latter has its roots deep in the concept of teaching men and women to think, and consequently the provision of ideas.

The university world does not have a monopoly of them, only the means to digest ideas and pass them on to the community. In our case I hope the University College with its Farm will provide some service, however modest, to the agriculture of Rhodesia and Nyasaland.

REFERENCES

1. Ainslee, K. S., and Elliot, R. C. 'Observations on Beef Production in the High Rainfall Areas of S. Rhodesia.' *Rhod. Agric. J.* **55**: 2. 1958.
2. Anon. 'Natural Water and its Use in S. Rhodesia.' Ibid. **49**: 5 to **51**: 6.
3. Central African Statistical Office. *Report on the Agricultural and Pastoral Production of S. Rhodesia, N. Rhodesia and Nyasaland for 1956–57*. 1958.
4. Corby, H. D. L. 'Experiments in Growing Maize on Sandveld Soils.' *Rhod. Agric. J.* **54**: 2. 1957.
5. Ellis, B. S. 'Guide to Some Rhodesian Soils.' Ibid. **44**: 3. 1947.
6. —— *Provisional Soil Map of S. Rhodesia*. 1951.
7. —— 'Soil and Farming Systems in S. Rhodesia with special reference to Grass Leys.' *Rhod. Agric. J.* **50**: 5. 1953.
8. Hoffman, H. J. 'Brief Survey of Water Legislation in S. Rhodesia.' Ibid. **55**: 1. 1958.
9. Hudson, N. W. 'Erosion Control Research.' Ibid. **54**: 4. 1957.
10. —— 'Erosion and Tobacco Growing.' Ibid. **54**: 6. 1957.
11. Hutchinson, Sir J. 'Objectives of Research in Tropical Agriculture.' *Empire Cotton Growing Review*, xxxv. 4. 1958.
12. Jackson, D. C. 'Some Preliminary Indications of Soil Moisture Changes under Arable Crops.' *Rhod. Agric. J.* **55**: 4. 1958.
13. Joffe, J. S. 'Green Manuring viewed by a Pedologist.' *Advances in Agronomy*, vol. vii. A.P. 1955.
14. Jones, R. G. B. 'Application of Air Photo-Analysis and Interpretation to Soil Survey and Land Classification.' *Rhod. Agric. J.* **55**: 2. 1958.
15. Manning, H. L. 'Statistical Assessment of Rainfall Probability and its Application in Uganda.' *Agriculture Research Memoir, No. 23*. Empire Cotton Growing Corporation. 1956.
16. McMeekan, C. P. *New Zealand J. Agric.* **97**: 2. 1958.
17. Mundy, H. G. 'Arable Farming Problems in S. Rhodesia.' *Emp. J. Exp. Agric.* **21**: 82, pp. 123–30. 1953.
18. Native Affairs. *Report of the Secretary for Native Affairs, etc., for 1957*. S. Rhodesia. 1958.
19. O.E.E.C. *Agricultural Extension Services in the U.S.A.* O.E.E.C. Publication. 1951.

20. Pereira, H. C., Chernery, E. M., and Mills, W. R. 'Transient Effects of Grasses on the Structure of Tropical Soils.' *Emp. J. Exp. Agric.* **22**: 86. 1954.
21. *Proceedings of the Legislative Assembley S. Rhodesia on 2.2.1956.* Salisbury.
22. Rattray, A. 'Maize Production in S. Rhodesia.' *Proceedings 2nd An. Conf. Prof. Officers Dept. Res. & Spec. Services.* 1956.
23. ——'Annual Report of Experiments for 1955–56, Salisbury Exp. Sta.' *Rhod. Agric. J.* **54**: 1. 1957.
24. —— 'Annual Report of Experiments for 1957–58. Salisbury Exp. Sta.' Ibid. **56**: 6. 1958.
25. —— and Ellis, B. S. 'Maize and Green Manuring in S. Rhodesia.' Ibid. **49**: 4. 1952.
26. Rattray, J. M. 'Some Plant Indicators in S. Rhodesia.' *Rhod. Agric. J.* **51**: 3. 1954.
27. —— 'Grasses and Grass Associations of S. Rhodesia.' Ibid. **54**: 3. 1957.
28. Roberts, R. H. *Annual Reports of S. Rhodesia Dept. of Irrigation.* Salisbury.
29. Robertson, C. L. 'Variability of Rhodesian Rainfall.' *S.A. J. Sc.* **24**, pp. 102–9. 1927.
30. Rowland, J. W. 'Maize Production in S. Rhodesia.' *Proceedings 2nd An. Conf. Prof. Officers Dept. Res. & Spec. Services.* 1956.
31. —— 'Need for Modernization of Farming Methods.' *Rhod. Agric. J.* **54**: 5. 1957.
32. Sanson, T. K., *et al.* 'Maize Production in S. Rhodesia.' *Proceedings 2nd An. Conf. Prof. Officers Dept. Res. & Spec. Services.* 1956.
33. Southern Rhodesia. *Rainfall Handbooks.* Dept. of Meteorological Services, Salisbury. 1952.
34. de Schlippe, Pierre. *Shifting Cultivation in Africa.* Routledge & Kegan Paul, London. 1956.
35. Staples, R. R., *et al. Report on Large Scale Irrigation in Southern Rhodesia.* Salisbury. 1952.
36. Tattersfield, J. R., and Cronin, C. H. 'Weed Control in Maize in S. Rhodesia with special reference to the use of Herbicides.' *African Weed Control Conference.* 1958.
37. Thomas, R. G. 'Soil Survey to select land for Experimental Purposes on Henderson Research Station.' Departmental Report in the Office of the Chief Chemist, S. Rhodesia. 1951.

38. THOMPSON, J. G. 'Granite Soils in S. Rhodesia.' *Rhod. Agric. J.* 54: 2. 1957.
39. TROUP, L. G. *Report on a Commission of Inquiry into the Future of the European Farming Industry of N. Rhodesia*. Lusaka. 1954.
40. WELLINGTON, J. H. *Southern Africa, II*, p. 3; *I*, p. 487. C.U.P. 1955.
41. WIBBERLEY, G. P. Private communication. 1958.
42. WILD, H. *Common Rhodesian Weeds.* Govt. Printer, Salisbury. 1957.
43. WITTFOGEL, KARL. *Hydraulic Civilizations in Man's Role on Changing the Face of the Earth*. Ed. W. L. Thomas. 1955.