MEMORANDUM ON SOIL EROSION

EVIDENCE SUBMITTED TO THE SOIL EROSION COMMITTEE BY THE TEA RESEARCH INSTITUTE.

As a preliminary to the consideration of methods of combating soil erosion, it is advisable to review briefly a number of soil properties which contribute to, or tend to prevent, soil wash.

(1) PARTICLE SIZE.

Eroded soil contains particles of varying size according to the severity of climatic conditions and of land contour, but by far the most important fraction of this soil is what is analytically designated "clay." This fraction is the most chemically active of all, and is the seat of many of the processes that provide the available nutrients for the crop. The particle size of clay is very small, its diameter according to the latest convention being 0·002 mm. (less than one-ten thousandth of an inch). Consequently, it is easily held in suspension by water for considerable periods, and when once in suspension settles out only very slowly. In undisturbed water, clay particles settle out at a rate which does not exceed 30 cms. (about 1 foot) in 24 hours. The importance of this rate of settling in relation to silt-pitting schemes will be considered later.

(2) AGGREGATION OF PARTICLES.

It is possible to make these fine particles adhere together in crumbs which are more difficult to take up in suspension, and conversely more rapid in settling. The chief factor in producing this effect is humus which acts in two ways. Firstly, it acts as a cementing material binding individual particles, since its jelly-like nature allows it to form a thin coating round small mineral particles. Secondly, it brings about a complicated chemical effect usually spoken of as mutual flocculation. The result of this flocculation is that particles which are sustained in suspension by the water are precipitated and coalesce, the water thus losing its turbidity.

(3) WATER RETAINING CAPACITY.

Soils vary enormously in their capacity to hold water without water-logging, and in the rate of absorption of moisture. The conditions suitable for rapid erosion are those in which the top layer of soil rapidly becomes bathed in sufficient fluid to allow the particles to slip easily over each other. Anything which increases porosity and water-holding capacity and facilitates percolation will tend to prevent erosion. Again, humus plays an important part. The channels left by decaying organic matter provide both for intake of water and what is equally important in assuring absorption, outlet of air. Trapped air in the soil capillaries is one of the most formidable barriers to absorption. In addition, the moisture-holding capacity of soils is beneficially effected by organic matter. A sample of soil, from which organic matter and humus have been removed by natural or artificial agencies, attains at a lower moisture content than the original soil : the state at which free movement of soil particles takes place.

Applying the knowledge of these properties to the prevention of erosion, the task becomes a question of:—

(1) Checking the beating action of rain which churns up the surface soil.

(2) Maintenance of soil porosity which prevents the very severe loss from normal surface run-off.

(3) Fostering conditions which produce soil flocculation.

(4) Interposition of barriers to catch soil unavoidably lost, particularly such obstacles as will allow the tardily settling fine fractions to be recovered.

The rest of this memorandum will be devoted to the assessment, in this light, of some of the methods outlined in the Questionnaire as possible preventatives.

WEEDING.

The process of weeding as distinct from deeper cultivation loosens the surface soil to a degree sufficient to hasten the washing out of the fine fractions without effecting any marked amelioration in porosity. The surface water soon finds an impermeable layer and merely takes in its stride the loosened surface. On the occasion of the next weeding a further amount of soil is prepared for the erosive action of surface water. From this point of view clean weeding stands condemned.

With regard to the effect of clean weeding on leaching, this operation stands in the same category as any form of cultivation. Undisturbed soil, whether covered with vegetation or not, loses less nutrients than cultivated land, but losses on cultivated land are not all ascribable to leaching. Nitrogen is lost from cultivated soil where leaching is practically absent. On balance, the actual soil losses are more important than the leaching losses.

The disadvantages of clean weeding have to be weighed against possible advantages. Precise data are lacking. Of the two causes of crop deterioration, (a) competition of other plants, and (b) loss of soil, the first appears problematical, whilst the second is undoubted. In the long run erosion leads to a condition of soil poverty which even the lack of competition cannot counterbalance. Furthermore, there is no reason why, if clean weeding is abolished, the 'competing' crop should not be made actually beneficial in the end. The whole theory and practice of green manuring supports this view. With regard to covers of Oxalis, to quote a case in point, we have seen no evidence of competitive harm if growth through the plucking table is prevented, whilst its anti-erosive action is valuable. This does not imply that we regard Oxalis as being in the front rank of cover crops. The latter question is dealt with in a succeeding section.

HIGH SHADE AND GROUND COVER.

From general observation, high shade prevents two adverse conditions:—

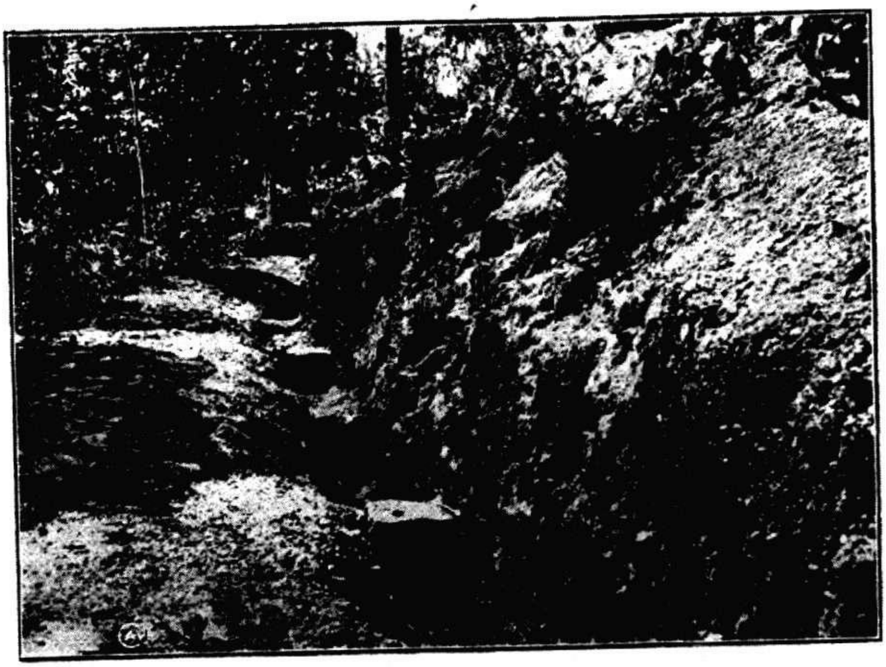
(a) The churning of the surface soil by heavy rainfall.
(b) The rapid baking and caking of the top soil which reduces the permeability of the soil to water.

Inasmuch as high shade provides leaf-fall and mulch this beneficial effect is further enhanced. Generally, however, it does not prevent surface run-off. *It cannot be too strongly insisted that this latter is by far the most potent factor in producing erosion.* Even with high shade there will be great losses if the ground conditions are such that porosity is poor or opportunities for aggregation and flocculation of particles are absent.

The efficiency of ground cover is much greater, and it is to low cover that one must look for the greatest help in combating erosion. The mechanical resistance it offers to soil movement, the increased porosity derived from a much finer root system and the better distribution of organic matter entailed, operating on the principles outlined above, give ground cover a special value. As examples, may be mentioned the contrast in turbidity of drainage water on rubber estates planted with Vigna or left bare, and the still more striking contrast between bare tea and adjacent patna. The extra care in management which ground cover needs is amply repaid by the increased efficiency obtained.

CONTOUR HEDGING.

Hedges of *Tephrosia candida* or other material seem efficient in holding up soil and in giving general soil improvement. Much of the benefit of these hedges is lost if, when the material is growing old and losing leaf, they are uprooted or cut very low before a new and supplementary barrier has had time to grow. It is recommended that judicious alternation in sowing and cutting should be practised, so that the



Felsinger's Lock-and-Spill System of Bunded Drains.

Du Pré Moore's Contour Drain with Stone-terraced Bund.

slopes are never left devoid of soil-wash barriers. This system will be further referred to under silt-pits and new clearings.

SILT-PITTING.

From the point of view of anti-erosion methods, silt-pits constitute a second line of defence. It is more profitable to prevent erosion than to try and recover eroded soil. Silt-pit systems vary in type and efficiency, and the more important methods are dealt with in turn.

(1) SILT-PITS IN THE BOTTOM OF EXISTING DRAINS.

The usefulness of this system is subject to severe limitations. The velocity of the water flow in ordinary drains is such that only the coarser fractions of the soil are deposited. Whilst a continuous stream is running above these pits, the valuable fine fractions remain suspended and are carried away. This point is clearly shown both by the examination of the contents of such pits and by the considerations of particle settling velocity referred to above.

(2) THE FELSINGER SYSTEM.

This offers a real opportunity for the collection of eroded soil. The surface run-off is held up and the combined effects of settling and percolation cause all the fractions to be recovered. The efficiency should be measured not in terms of total solids that the bunded drains are capable of holding, but by the amount of water they can retain without overflowing the spills. As soon as rainfall is heavy enough, or continuous enough, to counterbalance temporarily percolation effects and bring the spills into operation, the efficiency is correspondingly decreased as far as fine fractions are concerned. When, on the other hand, the whole rainfall can be caught and percolated before another heavy downpour occurs, the system works admirably. In any event, the system is a very real and important contribution to the problem of soil erosion.

As an example of the capacity of Mr. Felsinger's system, the plan published in the *Tropical Agriculturist* for 1928 may be cited. With bunded drains 20 ft. apart the cubic contents will retain approximately an inch of rain before the spills operate.

The 20-in drain gauge at Rothamsted allows 50% of the rainfall to percolate, the rest being lost as surface run-off and evaporation.

Taking into consideration the lightness of precipitation and the condition of English soil, this is a liberal estimate of percolation if applied to Ceylon conditions, where slope, porosity, and rate of precipitation are not so favourable for absorption. Taking this figure, 2 inches of rain would fill and temporarily put out of action the system.

On Primrose Hill, Mr. Felsinger has enlarged and strengthened the system by a series of staggered silt-pits between the drains. Not only does this increase the capacity, but it arrests water before its velocity has been so accelerated that it produces a scouring effect. In addition the upper sides of the pits have Tephrosia hedges, the leaf-fall of which into the pits maintains the porosity of the deposited soil. The periodical clearing of the drains and the redigging of silt-pits, which Mr. Felsinger rightly locates anew, is fundamental to the success of the scheme.

(3) THE DU PRÉ MOORE SYSTEM.

This system also appears to work admirably on ground rather different from that suitable to the previous system. Since no spills are ordinarily provided, it suits medium rainfalls well distributed. Where the slope is moderate, a bund formed of the earth removed from the contour drain placed above it acts as a barrier for soil wash, all the water collecting above the drain in the fold of the bund having to percolate through into the contour drain. On the question of bunds above or below drains, Mr. du Pré Moore's system appears to have the advantage. The presence of a drain, which by reason of the bund above is at first relatively empty, (only becoming filled by percolation) provides an air outlet for trapped air and materially helps the percolation of any temporarily standing water in the fold. With bunds below, and drains consequently filled, this advantage is absent.

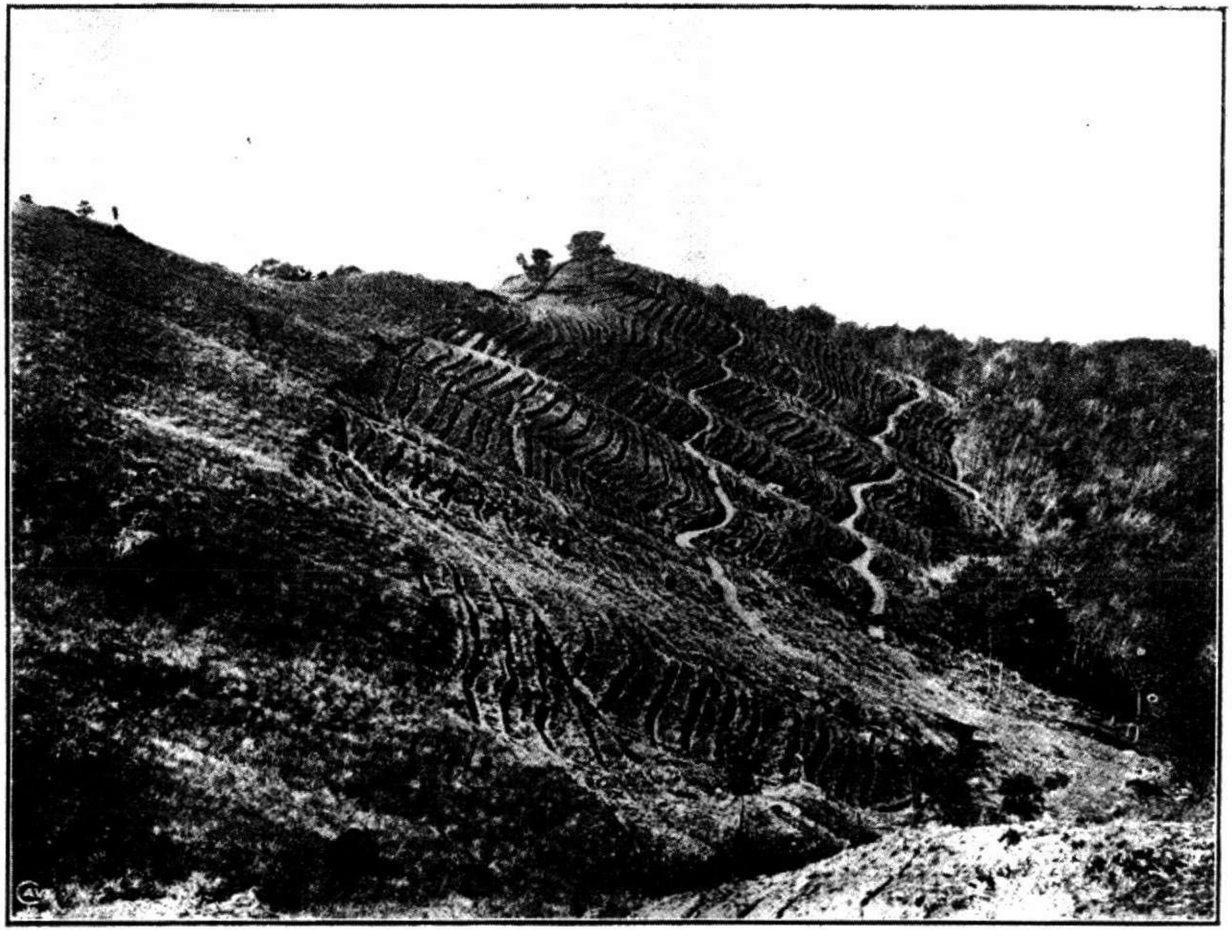
Further, the bund above minimises slope of land; the bund below accentuates it. A Tephrosia hedge would help to consolidate the bund of newly-turned earth and prevent breaching under severe conditions. In difficult circumstances, a stone terrace between the bund wall and the drain is sometimes necessary.

(3) THE DENHAM TILL SYSTEM.

As far as our knowledge goes this system is also of great usefulness in rubber. We foresee difficulties with tea.

These three systems have a further great advantage which, apart from prevention of soil wash, undoubtedly contributes to their usefulness as practical planting measures. They all retain the water on the land instead of conducting it away. Soil samples taken from Mr. Felsinger's drains on November 4th after the drought of October and no recent precipitation, gave an average moisture content of 17·2%. Throughout the estate there was abundant evidence of good moisture relations. The question arises as to whether this retention of moisture can be overdone. Our impression is that on slopes such as merit the employment of soil erosion measures, the natural seepage which takes place is sufficient to maintain something like

PLATE II.



Du Pré Moore's Contour Drains. The heavy shadow is cast by the bund above each drain.

optimum water relationships without fear of water-logging. Furthermore, from the point of view of crop growth, the retention and percolation of the water brings great benefit since the rainwater contains dissolved oxygen which renovates the soil atmosphere. It should be remembered that this distribution of dissolved oxygen constitutes one of the major methods of securing soil aeration, particularly, for subsoils. Provided, therefore, that the seepage is adequate, the retention, temporarily, of the increased bulk of water is a very real asset both from consideration of moisture and aeration. Some increase in leaching may be expected which can be counteracted by other methods of soil amelioration.

CONTOUR PLANTING.

Whilst contour planting will undoubtedly tend to prevent acceleration of running water, it cannot be regarded as contributing largely to the prevention of soil erosion since the barrier provided by the stem is not great. In connection with the systems of silt-pitting and draining discussed here, it has the advantage of making those systems more simple and effective. For example, the staggered silt-pits referred to on Primrose Hill would be difficult to accommodate on land planted vertically up and down. A similar break in water channels can be effected by triangular planting, a method which also produces a very satisfactory articulation of the bush frames, and consequently a good cover in the mature bush.

NEW CLEARINGS.

The treatment of new clearings is undoubtedly unsatisfactory, but it is realised that the opening of land presents difficult problems. From the start some such system as the Felsinger and du Pré Moore systems should be adopted for drainage, and at the same time soil amelioration methods should be carried out both before and after planting.

We are under the impression that the very fine cover of 3-year-old tea exhibited by Mr. du Pré Moore is largely due to his drainage system coupled with the fact that he does not burn his patna. The land is well holed and forked for seed at stake. The maana grass rots, and other tuberous grasses are hand picked. Though this is at first costly, it represents a great conservation of organic matter which helps both nutrition and anti-erosion methods.

On jungle the difficulties are still greater, but we recommend that where possible a temporary cover be sown immediately on clearing. We have seen *Vigna sinensis* (Cowpea) growing luxuriously, and note the ease with which it can be removed when necessary. Furthermore, it does not interfere with holing operations. We would urge that some such crop, supplemented by contour hedges, be grown and dug in up to the time when they would endanger young seedlings or stumps. In other words, that every effort be taken to preserve a soil of good tilth and porosity from the very start.

PERMANENCY OF EXISTING METHODS.

If by permanency and non-permanency of existing methods is implied the possibility or necessity of radically altering systems of planting and replanting, it does not appear to us that any sudden change is feasible. New tea can be planted with attention to improved methods, but old tea is another matter. Something in the nature of recutting drains on improved lines might be done, but we refrain from trespassing in a sphere where our experience is necessarily limited.

LEGISLATION.

The same difficulty arises here, that of dealing with existing plantations. Legislation would almost necessarily involve a criterion of neglect, and with the very varied situations and local problems, the assessment of neglect would be a very difficult, not to say invidious, task. Efforts for prevention of soil erosion successful in one locality might prove ineffective in another.

Apart from stipulating enlightened drainage systems when new leases are granted, it is difficult to see any effective method of legislation. The problem is really one of education, and in this matter the co-operation of the Tea Research Institute in experiment and propaganda will be most whole-heartedly given.

We cannot, at the moment, table schemes for checking soil erosion on St. Coombs, but we can give the assurance that these will be a matter of early discussion, and that they will take the form indicated by our visits to existing systems, and by the fundamental soil properties here outlined.

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