COFFEE CULTURE IN CEYLON.

MANURING OF ESTATES,

BY

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BEING

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THE MANURING OF COFFEE ESTATES.

INDEX.

The Books consulted in preparing the following Essay were :—

Johnson's Chemical Composition of the Plant.
Fowne's Chemistry.
Dana's Mineralogy.
Page's Geology.
Odling on the Food of Plants.
Chemistry of Soils and Manures.
Liebig's Letters on Chemistry.
,, ,, Modern Agriculture.
,, ,, Natural Laws of Husbandry.
Sabonadiere's Coffee Planter.
Brown's Coffee Planter's Manual.
Ferguson's Directory.
,, Planting Register.
Pogson's Indian Agriculture.

Note.—This Essay was written, and practical experiments conducted on Estates in a low district, with a rainfall of 152 inches. Soil varying from poor gneissic and schistic rock to rich chocolate coloured loam, with loose boulders interspersed.

SECTION I.

MANURING OF COFFEE ESTATES.

Introduction.

The importance of the subject of this Essay is indicated by its selection for the Planters' Association Medal of 1874. Notwithstanding the contributions which have been made to the literature of Manures and Manuring, it is undeniable that ignorance exists among those whose success or failure in life is intimately connected with the processes by which the fertility of the soil is extended and renewed.* The character of the more serious of the writings recently addressed to Planters have either consisted of indignant denunciations of systems other than those advocated by their several authors, or of *rechauffés* of Liebig's works. The latter, however valuable to the Saxon farmer, are only partly applicable to the circumstances of the Ceylon planter. The widely different conditions of rainfall, labour supply, and means of communication shew that the system of cultivating European cereals must be modified before it can be applied to perennial tropical fruit trees. Moreover the semi-scientific verbiage adopted by some recent writers, prevents the diffusion of the really valuable information which is obscured by a classical vocabulary.

In attempting to collate the conclusions of practical planters with the scientific facts of Liebig and Johnson, it is right to acknowledge that I speak with no authority on a single point in either. The utmost I claim is to have diligently searched wherever the truth is to be found. Where difference of opinion exists between planters I have given both sides of the question.

* In the *Ceylon Observer* of 12th September, 1874, a letter appeared signed "Only a Superintendent," in which the writer, after stating that his crop is ripening, says that has a large quantity of manure to be put out, which must be done: failure to do so involving dismissal. He also announces his intention of imputing to leaf disease any deficiency of crop arising from excision of roots; a practice which he alleges to be prevalent among his neighbours. If this letter be not a joke it is a crime.

It would be an idle affectation to ignore the sources from whence I have obtained the most valuable hints. To Mr. Wall, Mr. A. Brown, Mr. Sabonadiere, Mr. Sinclair, and other gentlemen, some of whom are possessed of copious practical acquaintace with agriculture as practised at home, I express the obligations I am under for whatever value this essay may have for my brother planters.

DEFINITION OF MANURE.

The word "Manure" must be read in two senses. *First*, that in which it enriches the soil with additional fertilising substances; *second* that in which without directly contributing additional fertilising elements, it renders available for the formation of fruit, &c., those substances already present in the soil, and is a vehicle for the operation of such substances. The former process may be compared to a gift of money; the latter to the performance of a discount transaction. The first enriches, or at least leaves the soil as it found it, the second has diminished its dormant capital.

It is thus evident that there are two methods of increasing the yield of coffee estates, one of which, if alone followed, implies the inevitable exhaustion of the soil. The high-flown advertisements of manure merchants contain as a rule triumphant testimonials to the efficacy of their wares in producing *crop*, but are silent as to their effect on the *soils* in which they have been tried. I am often reminded when reading the flowery adjectives which sometimes compose the puffs of artificial manures, of those generous offers of cash on *post obits* which money enders place before expectant heirs.

THE FORMATION OF THE COFFEE PLANT.

Most agricultural writers are accustomed to describe the destructible portion of vegetable bodies by the term *organic*, and to designate the ash ingredients, *i.e.*, the residue after combustion, as *inorganic*. The most recent authorities agree in rejecting this use of the words as inaccurate. What is found in the ash of a coffee bean, in so far as it is an essential part of the organism, is as truly organic as the volatile portion; and, in the words of of Professor Johnson of Yale College, "by submitting organic bodies to fire "they may be entirely converted into inorganic matter, the volatile, as well "as the fixed parts."

COMPOSITION OF THE VOLATILE PARTS OF PLANT.

The destructible parts of a plant consist of carbon, oxygen, hydrogen, and nitrogen, and, to a less extent of sulphur and phosphorus. The indestructible parts, or the ash, shew phosphorus, sulphur, silicon, chlorine, potassium, sodium, calcium, magnesium, iron, and manganese, as well as oxygen, carbon, fluorine and nitrogen. These bodies are elements, which signifies in chemical language, that they cannot be resolved into other substances. The combination of these elements in various proportions by the agency of the several physical and chemical forces, constitute the vegetable structure. Almost every plant possesses an organic body peculiar to itself. In coffee the active principle is caffeine, which is almost identical with the theine of tea. In the range tree is found no less than three oils; the leaves, flowers, and rind of she fruit each yielding one. Botanists are unacquainted with all the different substances contained in plants, the number being practically unlimited.

We have seen that there are two divisions in the constitution of a vegetable structure. One part of the plant returns to the atmosphere, in combustion or decay—which is but a slow burning—the other

remaining in the non-volatile form of ash. In its growth the coffee plant absorbs from the soil phosphoric acid, lime, potash, magnesia, soda, iron silica, and sulphuric acid. Of these, the seed requires phosphoric acid, lime, soda, potash, and magnesia with a little iron (oxide) and chloride. The quantities of each in 100 parts of the ash of the coffee bean are given under Liebig's name as follows :—

Phosphoric acid	13·59
Potash	52·94
Magnesia	10·90
Soda	14·76
Lime	4·33
Oxide of Iron	·66
Chlorine	1·22

(This analysis is only strictly correct as regards the particular sample of coffee operated on. Of three different analyses in my possession, no two are alike; the proportion of Potash, for example, ranging from 52 to 55 per cent.)

One portion of the ash ingredients—that occurring in the juice or sap—is soluble in water. Another portion is insoluble and exists in the tissues of the plant in the solid form. After burning, or any process of oxidation (combination with the oxygen of the air) the ash remains as the skeleton of the plant, and at times actually retains and exhibits the microscopic form of the tissues.

NECESSITY FOR ALL THE ELEMENT OF THE ASH TO BE PRESENT IN THE SOIL.

Unless all the above mentioned constituents of the ash be present in the soil, coffee cannot flourish. You may pour out gold like water to increase the potash, and without avail, if phosphoric acid is absent from the soil. The presence of each is indispensible. The absence of one renders the others inoperative. Hence the obvious absurdity of pronouncing any one manure infallible, unless it contains the whole of the elements named.

It is not sufficient that the non-volalite constituents of coffee be present in the soil ; it is necessary that they be available for use, by the plant. A soil may be rich in ash constituents without necessarily yielding heavy crops. The action of solvents—of ammonia (a compound of one part of nitrogen to three parts of hydrogen,) of carbonic acid are needed. Nature accomplishes this task in different ways. Rain contains a trace of ammonia, particularly after a drought. The rainfall of Ceylon, with its 100 to 150 inches per annum is a much more considerable agent than that of England with its 30 inches, as proportionably more ammonia is brought to the soil. The carbonic acid from decaying vegetable matter carried downwards by the rain, also renders more quickly available the undissolved mineral matter in the soil. The reason why heavily-timbered land, on being felled and planted, generally affords fine crops, is because the action of the trees has been long exercised in accumulating available mineral and volatile matter on the surface. A good burn does not affect the quantity of ash constituents, however much of the destructible matter may be dissipated. In the proper section will be discussed the advisability of applying solvent manures where a fierce burn has volatized too much of the vegetable matter on the surface.

CROP DEPENDS ON THE ELEMENTS PRESENT IN LEAST QUANTITY.

No one of the ash constituents of coffee possesses a superior fertilizing power over another. Crop is determined by the elements present in the least

quantity. Were the minimum matter known in each case, its direct application would be sufficient to increase the fertility of the soil. Good farm-yard manure is sure in its action on partially worn-out soils, and on crop, because it is a complex mixture containing all the food elements of plants, and while supplying what is not wanted, also supplies the element of food present in least quantity. To produce the simile of the money lender, it as if the expectant heir were forced to take Brussels gloves and Jersey eau-de-Cologne which he does not require, along with the cash for which he is pining.

ASH SUBSTANCES REMOVED FROM THE SOIL MUST BE REPLACED.

Whatever quantity of the non-volatile constituents of coffee are removed from the soil, either as crop or by burning weeds, must be absolutely replaced or the extinction of that coffee estate is just so much nearer as the difference between what is taken and what is restored is greater or less. Experiment proves that one pound weight avoirdupois of dried coffee yields 500 grains ash From this it will be seen that an export list of a million cwts. of Parchment Coffee involves a loan from Ceylon of 5,580 tons, 7 cwts and 4 lbs. By the immutable laws of Nature this bulk of non-volatile substance must be replaced I have endeavoured, by studying the import statistics for the last six years, to discover if the introduction of artificial manures to the Island is commensurate with what has been removed from it. The result is not satisfactorily accurate, especially as manures produced on the estate are not calculable, but so far as the figures prove anything, they shew that supposing all the imported manure to have been well appiled to coffee properties alone, they are in considerable arrears in their debt to the soil. By the Customs returns the average yearly importations of bones from 1869 to 1873, was 4,000 tons.

THE ORGANS OF NUTRITION.

"Take care of the root and the stem will take of itself," is a motto planters may lay to heart. Injure the root and you will impair the functions of the whole tree. To test the truth of this statement, and to see how manure is absorbed in the life of the tree, is necessary to understand the construction and the offices of the organs of nutrition underground. All plants whose embryos are furnished with two seed leaves and whose stems increase externally by additions of new rings of growth, have at first a single descending axis or tap root, which pierces vertically into the ground. As in the aerial portion of the plant, lateral roots branch out at intervals, and these subterranean secondaries sub-divide with tertiaries, and these in their turn divide again.

TAP ROOT.

In parts of Uva where the dryness of the climate compels the coffee to seek for moisture at considerable depth, the tap root is of great length, and forms the most conspicuous feature in the radication of the plant. In districts where slab rock forbids the tree to descend, lateral roots may be seen as large, or in some instances, larger, than the tap root. The tender roots formed last in order of growth are but an inch or two in length, and correspond to the primary and secondary roots, as twigs correspond to the larger branches of the stem.

ABSORPTION.

The function of absorbing food from the soil is one of the utmost importance, and is one for which the rootlet is marvellously adapted. The extreme delicacy of its structure, its peculiar sensitiveness and absorbent power, particularly in the newest root foundation, fit the machine for its work.

The sensitiveness of fresh root formation may be tested by taking a bean from the vegetable garden, and immersing it in a solution of common black ink and water. The tiny rootlet will almost at once acquire a dark hue, while the stem remains for some time unaffected.

ROOTLETS.

It is not, however, the newest and most sensitive portion of the roots that are alone engaged in absorbing food, but all parts that are still young and delicate, still contribute, in lesser proportion, to the support of the tree. The colour of the recent formation of the coffee root is a creamy white, while the primary and other large root branches become coated with a nearly impervious cuticle, and by them the function of absorption is no longer performed. On estates where iron tools are employed in weeding, the trees, to use the simile of an able planter, are generally like over-grown school-boys, with their legs too far through their trousers. The function of absorption in such a case is entirely transferred to the recent formation. If these bare roots be properly covered to the collar with good soil or suitable manure, hair-like rootlets will branch directly from the larger roots near the tap root, shewing the importance of observing the obvious injunction of Nature—to avoid any practice which exposes the root above the surface.

SIDE ROOTS.

The distance to which side roots occasionally extend is no criterion by which to judge of the efficiency with which the plant is nourished. Two plants may bear equal crops, and be equally nourished, when one of the two may have double the root surface of the other. It is on the *aggregate food-absorbing surface* that the tree depends and to increase this is the effort of the careful planter.

ROOTS ON THE SURFACE.

Wherever the food of coffee is abundant and available there will be found a fleece of stout rootlets. The disc of sensitive rootlets on or near the surface is larger and more important than that on any lower plane. To entice the rootlets beyond the direct influence of the sun is the object of an able school of planters, and deep holes are consequently recommended by them in manurial operations. In good coffee, where the ground is well shaded from the tropical sun, almost any disturbance of the soil is immediately injurious to masses of rootlets.

INSTINCT OF ROOTS IN SEEKING FOOD.

The underground organs of nutrition appear endowed with almost canine agacity in their search for food. All trees are not alike in this respect. The pear-tree of our English orchards is seemingly possessed of suicidal tendencies. It will pierce a sour and poisonous subsoil, and die, unless restrained by tile-paving, the hole in which it is planted, thus forcing it to deflect its roots. The idea of investing the vegetable world with animal qualities is no new one. Although we do not yet speak of the *folly* of the pear-tree, every school-boy remembers how Ovid—who was a close observer of Nature—sang of the *loves* of the poplars. In like manner it is natural to detect in the coffee tree a cheerful pushing disposition, which rises superior to much discomfort. Its roots discover almost inaccessible stores of food. Hence it is that every system of mauuring with good manure applied at the proper time, has been found to benefit the tree. So long as food is chemically available, it will survive a vast amount of neglect and ill-treatment.

It is important to remember that the first formation of rootlet, no matter whether the soil be sterile or rich, is organised and put forth from the plant itself. It must attain a certain developement before it can support itself and assist in feeding the parent tree. Those rootlets which come in contact with food, live, enlarge, and ramify. Those which fail to find nutriment remain undeveloped or perish.

The food of the coffee-tree derived from the soil, enters it in a state of solution, and is absorbed by the rootlets with the water taken up. The plant has, to a certain extent, a selective power which enables it to absorb water without necessarily absorbing the matters dissolved in the water.

STABILITY GIVEN BY ROOT.

On the firmness with which a coffee plant is established in the ground, depends its ability to withstand the violence of furious winds. The provision of substantial tap and lateral roots is only to be attained by exercising foresight in planting ample nurseries sown with chosen seed. The loss and delay arising from the use of village stumps or plants, with their forked, puny, and often black-hearted tap-roots, are never counteracted by the most liberal supplies of manure.

It is not within the scope of this Essay to consider the uses and construction of the stem, leaves, and fruit, with their phenomena of leaf-pores, fibre, pith, and bark, and other contrivances by which the economy of the coffee plant is carried on. An intelligent acquaintance with the facts, is however, most desirable.

SECTION II.

MANURES PRODUCED ON THE ESTATE.

Adam Smith, in the "Wealth of Nations," Vol I., Book I., Ch. XI., writing a century ago, insists that "in all farms too distant from any town to carry "manure from it, that is in the far greater part of those of every extensive "country, the quantity of well cultivated land must be in proportion to the "quantity of manure which the farm itself produces."

For the word "farm" substitute "Coffee Estate," and the remark of the old Glasgow Professor is justly applicable to much of the coffee cultivation in Ceylon in the present day. The maintenance of fertility in the soil is a problem which has occupied the attention of all nations since history was recorded. It has been successfully solved by two Empires in the far East, until recently rigidly exclusive. Vessels of Chinese porcelain were found in the Pyramids of the same shape and with the same characters as are made in the present day. Since the ultimate wealth of a nation consists in the fertility of its soil, it is clear that the fields of the Chinese cultivator have retained their fertility unimpaired since the plans and elevation of the great pyramid of Ghizeh were first laid down on papyrus. This result has been attained by the simple rule of returning to the soil what is taken away, and as increased population made greater demands upon the soil, the ash constituents were faithfully restored. In his three principal works Baron Liebig dwells, with the utmost stress, on the advantage and necessity of this system. In England, as in Germany, ignorance and fear have combined until late years to prevent the minerals taken by man from the soil being devoted to any other purpose than polluting the atmosphere or the rivers. Here in Ceylon we are met by caste prejudices in our attempts to utilise human excreta. The subject is truly nauseous but the example of the Japanese and Chinese is so instructive I shall proceed to discuss the properties of the most valuable manure produced on the estate.

Human fæces.—In burning 1,000 parts of this substance we obtain 150 parts of Ash which consist of

Phosphates of Lime and Magnesia	100	parts.
Sulphates of Soda and Potass	8	do.
Carbonate of Soda	8	do.
Silica	16	do.
Charcoal and Loss	18	do.

Human Urine is shown by quantitative analysis to contain (after deducting common salt) :—

Phosphoric Acid	34·24	
Alkalies (Soda and Potass)	47·76	
Alkaline Earths	7·62	
Sulphuric Acid, Silicic Acid	10·38	
	——	100

On comparing those figures and elements with the components of the non-volatile portions of coffee (see page) the value of human excreta as a manure is obvious. It supplies precisely what coffee most requires, alkalies and phosphates.

The offensive odour which is one of the chief impediments to the employment of sewage in its original form, is simply the smoke and soot of imperfect combustion. Mixed with dry and sifted earth, as in Moules' system, deodorization is complete. Of this fact the Japanese in their use of human manure are either ignorant, or are indifferent to the effects of imperfect sanitary arrangements. Beneath an oblong square hole the Japanese agriculturalist places a basket or tub, with projecting ears, through which a pole can be passed to carry the vessel. A large earthen pot with handles is also sometimes used. As soon as the vessel is full it is taken out and emptied into a larger receptacle. This is a large cask or jar, with a capacity of from 8 to 12 cubic feet, let into the ground nearly to the brim. The contents are diluted with water, no other addition being made to them, and stirred until they are entirely intermixed. In rainy weather the vessel is covered; in sunny weather it is exposed to the air. The solid ingredients soon subside, fermentation sets in, and the water evaporates. By this time the vessel in the privy is again ready for use. More water is added, the mass is again stirred and the water again evaporates. This process is repeated until the cask or jar is full. After the last supply of excrement and thorough mixing, the mass is left a few weeks longer, according to weather. Under no circumstances is it ever employed in a fresh state. This course of proceeding shews that the Japanese are indifferent to the ammoniacal ingredients, which are decomposed by the sun and dissipated by the wind. But they take the greatest care to shield the solid matters from waste by wind or rain. The manure thus obtained is applied in a liquid form, and as a top dressing. The Japanese are surface manurers.

Ceylon Planters meet and discuss manures, and display preferences for his or that fertilizer, because its action is "more lasting." To the Japanese such an expression has no meaning, and the term fallow" is also strange to them. There are no Japanese Agricultural Associations. The son knows no more than the father. It is, therefore, the more remarkable that, while the area in Japan available for cultivation is not so large as that of Great Britain, while the population is denser, England imports food to the extent of many millions sterling per annum, but Japan maintains its own population. Moreover, since the opening of the ports Nagasaki, Osaka, and Hiogo, no inconsiderable quantities of food are exported.

True culture, then, is educating the soil to give permanently high produce by way of real interest on the capital of the land. The system which urges large crops by an incessant drain on the entire stock of available minerals, is one which inevitably ends in total exhaustion. The real produce of land can only be calculated by the average crops of a long number of years.

The application of human excrement to coffee estates has been more than once systematically attempted. One gentleman built substantial accommodation, divided the buildings in proportion to his coolies' castes, and did all in his power to make the plan succeed. But the Pariah coolies would persist in polluting the accommodation provided for the higher castes who, in consequence, betook themselves to their ancient ways.

IMPRACTICABILITY OF UTILISING LINE ORDURE.

There are many difficulties in the way of introducing the system on estates. Among 403 coolies on this estate at the time of writing, there are but 22 who can boast of Pariah extraction. The difficulties in dealing with the manure when obtained, and the danger of typhoid fever, seem to have prevented a single estate from adopting the Japanese plan of husbandry.

NATIVE MANURE.

The manufacture of poudrette is, however, quite feasible in the towns, and arrangements have already been made for utilising excreta wherever the dry earth system is in force, in Colombo. The introduction of *Native Manure* to the island by Mr. Brown, is also a valuable service to the planting community. The analysis given of the manure shews its fertilizing qualities and eminent fitness for coffee.

POUDRETTE AT OOTACAMUND.

At Ootacamund, the Sanatarium in the Neilgherries, the Jail administration manufacture poudrette, both with earth and wood ash. With the latter it was found too stimulating, but simply deodorized with earth, it was used with marked advantage on coffee. In 1873, attempts were made to improve the quality of poudrette by the admixture of blood and crushed bones. So far as experiment had gone, blood and bone poudrette had proved valuable on coffee and tea plantations.

POUDRETTE.

111 tons were manufactured last year, all of which was sold at prices ranging from Rs. 7 to Rs. 10 per ton according to the quantity taken. Manure such as this and for such a price would be a great boon to this island.

CATTLE MANURE

Is an irregular mixture of decaying vegetable substances combined with solid animal excrement. It is soaked with fluid which holds ammonia and potash in solution. The value of animal manure being in exact proportion to the richness of its food in mineral constituents, no two analyses will shew the same proportions. In the "Handbook of Practical Agriculture for British India," by Lieut. Pogson, an analysis is given of cattle manure which excludes magnesia, which forms at least 4 per cent. of the bulk of a stall-fed beast's droppings.

A standard analysis—that given in the "Encyclopedia Britannica"—of cow-dung, is :—

Phosphates	20	(10 magnesia).
Peroxide of Iron	8	
Lime	1	
Gypsum (sulphate of lime)	3	
Silica	63	
Loss	2	

As an example of another, and to shew the difference between different samples, I subjoin the analyses of cow dung and urine by Arzbacliners and Buchan, quoted in "Liebig's Letters on Chemistry," page 423 :—

Potash...	17·15	56·74
Soda	6·30	1·31
Carbonic Acid	—	31·04
Lime	7·31	1·74
Magnesia	4·50	4·09
Peroxide of Iron	3·34	0·31
Sulphuric Acid	3·23	4·63
Silicic Acid	41·00	—
Phosphoric Acid	17·05	—

FOOD ELEMENTS REJECTED BY THE BODY.

If we deprive an animal of food it diminishes in size. The fat disappears, the muscles decrease, and if the animal is allowed to perish, hardly anything remains but hair, skin, and bone. This emaciation clearly shows that during the life of an animal a process of change is always present. This process of change is intimately connected with the phenomenon of breathing, for, it is accomplished by the oxygen of the air combining with all the matters within the body. At every inspiration a quantity of oxygen passes into the blood, and unites with its elements. As much oxygen as is imbibed in inspiration passes off in expiration in the form of carbonic acid and water, so that at every breath the weights of carbon and hydrogen in the body are diminished. But the loss of weight by starvation does not alone depend on the disunion of the hydrogen and carbon. All the other substances which are in combination with those elements in the living tissues, also pass off in the secretions. The nitrogen is altered and thrown out by the kidneys. Urine contains not only nitrogen, but the sulphur of the tissues in the form of a sulphate, all the soluble salts of the blood, the phosphates (lime and magnesia), soda, and potash. The carbon and hydrogen of the blood, &c., go to the atmosphere; the nitrogen, and all the soluble non-volatile elements to the earth as urine, and the non-soluble elements as fæces.

YOUNG CATTLE.

In youth a portion of the food is required for loss of substance, and a portion for growth. Thus, as young cattle require a supply of food greater than they waste in tissue, it is more economical when cattle are maintained for the purpose of fertilization to have as many full-grown, and as few steers and heifers as possible.

The ashes of an animal's food and drink are identical with the ashes of his secretions. Hence it follows that the richer the food the better the manure, and high cultivation of grass designed for the consumption of cattle is one method of highly cultivating coffee.

The Sub-Committee of our Association, appointed in October, 1868, to consider the Manure Question reported as follows :—"The cattle manure is "par excellence, the best and most lasting, the effects remaining over two "and three years."

Eleven years previously, Mr. Wall, with the exceptional advantages he enjoyed for experiment, expressed his opinion thus succinctly :—

"It would be mere waste of time to descant on the virtue of this "manure; its value being universally acknowledged.

"I believe that a cooly load, that is an ordinary basket full of cattle

'manure applied to each tree in the usual way gives an increase of crop "varying from two to five hundredweights per acre, according to the soil and "climate, and its effect lasts from two to four years."

The lapse of years since Mr. Wall's Essay appeared, has added little or nothing to our knowledge of the subject, except that the "usual way" may, perhaps, no longer mean hole cutting.

The effect on the tree of cattle manure is not only lasting, but when the tree relapses into its original state, there is none of that violent reaction to be remarked after the temporary influence of certain artificial manures has passed away. In low districts, to discontinue artificial manure when it is once applied, is assuredly to maim the tree for life, if not to kill it outright. The case is otherwise with cattle manure, which is in itself a soil.

VALUE IN THE GROUND.

The value of cattle manure in the ground with coffee over 100s. may be taken at £13 per acre. Under most unfavourable circumstances it is singular if it cannot be produced for less than this. The cost on different estates rangess from Rs. 45 to Rs. 100 per acre including application.

GUINEA GRASS.

In organising a cattle establishment, as in everything else, forethought and tact may work wonders when a hand-to-mouth shiftless system will only plunge the estate into debt. Guinea grass should be planted above the coffee, and thus admit of the use of labour-saving appliances. If an estate were intelligently planned from the first, with the view not only of economical but of permanent, cultivation fields of grass would alternate with fields of coffee. Cattle sheds with from nine to fifteen beasts placed in convenient situations, will almost invariably be found more economical in the long run than a central establishment. The value of jungle fit for coffee, however, renders planters very loth to plant grass on any but waste or inferior land.

In the appendix I submit plan of cattle shed, which has been found suitable for its purpose.

If the absence of patenas or other circumstances render it necessary to plant Guinea grass, as much attention to roading, draining and weeding should be given as to coffee. In point of fact the cultivation of grass is but the cultivation of coffee in another form. Paths cut two feet in the solid at Rs. 80 per mile signally economize the time of the grass coolies. In planting the grass it is well to have two lining ropes, with knots or divisions two feet apart. Four boys hold these, while twelve others are cutting small holes, each taking a section of one of the lines. Six coolies follow with the grass to be planted. It is a good plan to place three root slips in each hole in an upright position, and well stamped down. The tendency of Guinea grass is to spread in every direction, so that the three roots quickly unite and form a compact mass. Grass planted in May should be fit to cut in November. At five years old the grass field should be renovated by dividing the roots, and filling the cavity with manure.

GUINEA GRASS.

Another plan of planting grass is to place two stones in the hole in the form of a cross. The supposition is that if the weather be too dry the upper root fades and decays, but preserves the lower: while if excessive rain prevails the under root rots, and the upper survives. The idea is plausible,

but in practice it is impossible to make coolies adhere to the pattern, and the simpler plan I, for one, have found to be the most effective.

MAURITIUS GRASS.

Mauritius grass flourishes in wet and shady ravines, but care must be taken to prevent it from spreading into the coffee. The rapid growth of this grass is amazing, and cattle eat it greedily, but it is not alone a safe food for cattle, on account of the large quantity of moisture it contains, and the liability of cattle to griping pains after eating largely of it.

PATENAS.

Those who are so fortunate as to have patenas have a large item in their expenses reduced to a considerable extent. By arrangement tavelam and other native cattle can often be stalled in estate sheds, and supplement the desired manure heap.

BEDDING.

Bedding for cattle should be dried for three days before use. In this state it absorbs those substances to obtain which cattle are maintained more readily than when full of their own sap. Beneath the bedding a layer of hard-wood twigs should be placed. The urine does not then unduly saturate the animals' standing ground: a very fruitful source of disease is obviated, and the urine flows along the covered drain into the tub in the manure pit prepared to receive it.

COMPOSTS.

On such estates as produce cattle manure at great cost it will be easie to supplement it at the time of application by phosphates or poonac. The estate produce will thus go much—probably 200 per cent—farther than if used alone.

SULPHURIC ACID AND URINE.

The probability of obtaining sulphuric acid of local manufacture, and its known value in manurial processes, render it advisable to describe the manner in which it is applied.

In the first place care must be taken to protect the secretions from the sun and rain. With the volatilization of the ammonia a considerable loss of effective fertilizing power accrues. Experiment has proved beyond a doubt the superior value of farm-yard manure which has been sheltered from the rain, &c.

URINE AND SULPHURIC ACID.

It is calculated that the value of one cow's urine per annum amounts to Rs. 20. The wisdom of draining it into properly fixed tubs is, therefore, apparent. As soon as possible after the liquid is collected in a receptacle, the capacity of which is known, acid should be added in the following manner. Taking each gallon to weigh 10 lbs., 6½ % by weight of oil of vitriol, or an equivalent quantity of brown commercial acid, should be added. The liquid may then be evaporated by sun heat or otherwise, or dry earth may be added, and the compost put on the manure heap. The reason for adding Sulphuric acid so soon is that generally within a day or two Carbonate of Ammonia is found in the urine. This carbonate is a volatile salt, and if not fixed at once soon flies off in vapour, and leaves no trace in the tanks or manure heap except when fixed by acids, sulphate of lime, or earth; or mechanically held by pressure.

As recommended by Mr. Wall, a regular Debtor and Creditor account should be kept of the financial part of cattle manuring. A *pro forma* account is included in Mr. Wall's Essay, on which it is impossible to improve.

DISEASES.

Neither space nor the scope of this paper allow me to dwell on the ills to which cattle are heir, but I append one recipe for the cure of sore-foot and mouth disease.

As soon as the disease is observed, squeeze the juice of two limes on to a handful of salt. Rub the half limes well in this, and then rub the animal's mouth and throat as far as the hand will reach.

For the feet, anoint them with Stockholm tar, especially in the division of the hoof. This can be done with coir rope dipped in the tar and drawn backwards and forwards. In extreme cases a dose of Epsom salts may be given. For food give rice conjee, with salt and tender grass.

LIQUID MANURE.

One part by weight of cow dung, with eight parts water, is the portion used in applying liquid manure.

One acre of guinea grass will feed two cattle for a year. The secretions from three cattle will manure two acres, or mixed with bone dust, &c., six acres.

PIG MANURE.

The offal of pigs is far more stimulating than that of horned cattle, and a smaller quantity is more effective. Pig manure is eminently suitable for composts. Pigs are eclectic in their tastes, and will thrive on jungle stuff, or coarse reedy grass that cattle hardly touch. But their favourite provender is the fruit of the jack. On many estates in low districts jacks have been planted in great numbers to serve both as shade for coffee and as food for cattle. One motive for the selection of this tree as suitable for a coffee estate was the supposed fact that it is almost entirely a subsoil feeder. It was widely held that the jack not only did not rob the coffee, but actually contributed to its support by the falling of the leaves, which constantly renewed the surface soil by nutriment drawn from below. As food for pigs jack is admirably adapted, and it forms a pleasant shade for estate paths. When this is said all that is adduced in its favour is known. After considerable enquiry and observation I have no hesitation in saying that the advantages of planting jack thickly among coffee are more than annulled by the drawbacks. Coffee will not bear heavily beneath it. The same coffee at once responds to the change on the removal of the jack. It is but partially true that jack is a subsoil feeder. Like coffee itself, it seeks for food wherever it is available. Long scarlet roots branch out in every direction to great distances from the stem, and secure the valuable fertilizing ingredients of the surface soil. Any experience I have gained on this matter is born out by the action of five of my neighbours, all of whom had large numbers of jack on their estates. One of these gentlemen to whom I applied for statistics on the subject writes me as follows:—

"With reference to jack trees it is now a well-known fact that every "one has deeply regretted planting them as thick coffee shade in this district. "Much money is now spent in either lopping, thinning, or cutting them out "altogether, and I certainly think that coffee does much better without them."

If pigs are to be fed on jack leaves and fruit it is well, therefore, to

confine the cultivation to the road sides, and even then the drains are incessantly choked with their substantial leaves. Perhaps a better plan still is to plant a small clearing of jack by itself.

STOCK PIGS.

In providing stock a pair of well-bred animals should be obtained. Good boars are sometimes to be procured from the Masters or Stewards of Canal steamers calling at Colombo and Galle, at prices ranging from Rs. 60 to Rs. 200 each. On every account it is truer economy to breed from good stock. Apart from the bacon and pork which are to be obtained, the fertility of a well-bred sow is far superior to that of the long-legged native swine. If boars of the Berkshire or other good English strain cannot be obtained, the China breed is a good substitute. They fatten readily on comparatively little food, and give but little trouble.

One of the chief uses of pigs in connection with manure, apart from their own direct contributions, is the manner in which they work up and thoroughly mix whatever bedding as litter is given them. Cattle manure, pulp, and jungle stuff are vastly improved by forming pig litter for a time. In crop time a roof over the pulp pit, and an arrangement by which the water does not flood the whole enclosure, forms a capital sty for half-a-dozen pigs. Much of the pulp passes through the animals, and the remainder is so trodden down and saturated with the valuable animal secretions, that is worth almost as much to the planter as the excrement itself.

Good sows will breed twice a year, giving sometimes sixteen or even more at a time. The average number of survivors cannot, however, be taken at more than ten in a litter, and one farrow per annum is as much as is good for a stock sow.

With Guinea grass and a little poonac, the cost of pig manure in the ground should not exceed Rs 70 per acre, and the value Rs 110. The effect, however, is not so lasting as cattle manure, and owing to its stimulating properties, it is better suited for compost than for direct application.

The establishment of pigs at Kolapatna was, I believe, known as a partial uccess.

PULP.

As a vehicle for more active manures, as an ingredient in composts, as a harmless and efficacious manure for supplies, pulp is invaluable. Alone, when applied to coffee it is not found especially useful, and it is hardly worthwhile using it unaccompanied by some mineral substance. The cost of applying pulp ranges from Rs 10 to Rs 20 per acre, according to distance of transport, and nature of the soil.

Mr. Wall considers "pulp to be neither very valuable nor very effective," and when used alone the general opinion, with a few exceptions, endorses that judgment.

ALKALIES.

Wood Ash or potash is a useful alkaline fertilizer, and according to analyses by Lehmann, Liebig, and others, forms more than half the substance of the ash of the coffee bean. Potash must, therefore, always be an important ingredient in manure applied to coffee. Potash is the most powerful of the alkalies, and is that obtained from *land* plants, just as soda is the alkali obtained from *sea* plants. Potash combines eagerly with acids, and mixes with oils and fats form-

ing soap. It is well known that the green leaves and twigs of trees contain more of the potash salt than the hard, matured wood, or the branches.

The use of wood ashes as a manure is attended with signal advantage when judiciously applied. When lime is not obtainable, wood ashes form a partial substitute. In a compost heap where swamp soil is present they form a valuable constituent and when dug into the soil with a fork their effect is marked. On a stiff clay soil their use, in conjunction with the tillage of the fork, will be amply repaid.

It is usual to contract for sifted ashes to be employed as estate manure. The cost ranges from fourpence to sevenpence a bushel. If the ashes are prepared on estate account, the planter must be careful to employ no large branches or logs for combustion. As already stated in small twigs and leaves the sap resides, and it is from these potash is to be extracted. A smouldering fire protected from wind is in every way preferable to a smart strong blaze which only dissipates a proportion of the ash.

KILN FOR WOOD ASHES.

A simple kiln may be made of four mud walls, three feet high, with air holes at the sides, and open at the top. It should be carefully protected from the weather and erected in a swamp, adjacent to jungle; it forms the nucleus of compost heaps.

LIME.

Lime is a very valuable fertilizer in such soils as are of gneissic and quartzy formation. The resonableness of this will appear when we reflect on the necessity for lime in the composition of the coffee bean, and the want of it in gneissic soils. Gneiss is composed of quartz, feldspar, and mica. These are resolved into silica, alumina, potash with a little iron and fluoric acid. In almost all Ceylon soils, therefore, lime is needed. Coffee grown in quartzy soil and lime bottoms contains double the quantity of Caffeine to what coffee grown in gneissic soils does. This fact shews that the use of time in soils deficent in it is likely to be followed by an improvement in the medicinal quality of the bean. The existence of accessible limestone on an estate largely enhances its value. When lime is present in quantities which repay extraction, it is usual to contract for its production at rates varying from five-pence to one shilling a bushel. If manufactured on estate account the best kiln is one of a circular form, fed with fuel from the top, and so built into a bank or diff that one half of the expense of construction is saved. The fuel, &c., rest on iron cross bars, and the prepared lime falls into, and is raked out of, a lower chamber. With this kiln the firing is continual, and to long as fuel is supplied the kiln is in operation. The cost of producing the sime, added to the cost of transport and application must be considered in relation to the value of the lime, for there are as many qualities of lime as difference in coffee.

The effect of burnt lime in a soil is to decompose organic substances, and by its presence converts the process of putrefaction—which is hurtful to coffee —into one of decay, which is beneficial to it.

The presence of vegetable matter in a soil rich in silicates, such as gneiss formations, enables water in percolating through the soil to dissolve a larger quantity of a certain acid than is good for the development of the tree. Lime not only destroys this quality, but by its action on the silicate, potash

—which forms so large a proportion of the components of the coffee bean—is set free, and rendered fit for distribution in the soil.

GENERATION OF FUNGOID SPORES.

Organic matters such as the web of jungle roots left decaying in the subsoil after a burn, act injuriously, more especially in clay. The process of decay is communicated to the delicate rootlets of coffee, and the spores of fungi find ample field for their developement ready at hand. How far this fact is connected with the origin and spread leaf of disease it is imposible to say. Mysterious as is the result of noxious putrefaction in the generation of fungoid spores, these obscure processes are effectually stopped by the judicious application of lime.

When a proper dressing of lime has diminished the excess of the acid above alluded to, a second application will not accomplish a similar result, because the hurtful property of the soil once removed will not return. On stiff clay however, the application may be repeatedly unsuccessful, for, by the action of lime, such soils are made more friable and richer in available potash.

GYPSUM.

I have not heard of gypsum or sulphate of lime being employed in Ceylon, but its success as a fertilizer in European agriculture has not been very marked. It possesses the power of effecting the distribution of magnesia as well as potash in soils. Mr. O'Halloran claims for Sulphate of Lime a very high position as a manure. His reasoning is entirely *a priori*, unsupported by experiment. He dwells on the fact of sulphur and lime being deficient in most Ceylon soils as the approximate cause of leaf disease. The ventilation of this theory would have been more remarkable had Mr. O'Halloran given some authentic results of experiments by which *Hemileia Vastatrix* had actually quitted an estate as the direct and indisputable consequence of the application of Sulphate of Lime. (See also Gas Lime.)

MAANA GRASS.

The neighbourhood of a patena is of great value to a Coffee Estate. Besides the cheap and efficacious bedding it furnishes for cattle, when properly dried, it forms an excellent thatch or mulch for the ground. Properly speaking it can hardly be termed a manure in either of the senses spoken of in the Introduction, but the conditions of the loss of the coffee-plant are, under some circumstances, much improved by its use, either as a litter or covering for the ground, or worked into the soil by the fork.

As a mulch when applied to loose, free soils abounding in vegetable matter, it is of little use but to keep down weeds. On a wet, cold soil such as Amabagamuwa, its effect has been known to exceed that of Cattle Manure. Mr. Wall writes, in that essay to which I am already so-largely indebted:—"I have applied it to a cold, heavy, yellow soil, in which "coffee bushes could scarcely exist, and where their scraggy branches had only "a few small yellow leaves on them, and the effect was most surprising. Not "only were the trees soon clothed with fine dark green foliage but even the "soil appeared to be changed, and to the depth of three or four inches be-"came pliable and dry."

This extract is a valuable gloss on the following paragraph from Liebig:—"By the digging into the land of plants and their remains a tenacious soil "loses its cohesion, it becomes more brittle and more readily pulverised than "by the most careful ploughing. Each stem of the green manure plants . . .

"opens up by its decay a road by which the delicate rootlets . . . . . "ramify in all directions to seek their food."

By littering the ground four or five inches deep with maana grass much superfluous rain is carried off, and in extraordinarily wet seasons the ill effects of overabundant moisture is, to a great extent obviated. On the other hand in times of great heat, the fierce rays of the sun which wither the tender rootlets, and bind the earth with an iron band, are averted. and an equable temperature is maintained.

COST OF MULCHING.

A third and more obvious advantage of mulching the ground with manna grass is the suppression of weeds. On a property saturated with weeds this aim should be borne in mind when laying a field of coffee under a litter of grass. Many planters restrict the use of a mulch to coffee within 200 or 300 yards of the point of supply. If the estate be a stiff clay soil, and the ground penetrated with weed seed, an expenditure of Rs 40 per acre would be remunerative. Where patenas are adjacent, and the means of transport convenient, the cost of cutting, carriage, and application of a heavy bundle of the grass to each coffee tree should not exceed Rs 20 per acre. Three litterings per annum are sufficient, if the system be maintained, against the cost of which the economy in weeding must be placed.

MULCHING IN CONNEXION WITH SURFACE MANURING.

A fourth method of utilizing manna grass is to cover cattle or other manure previously scattered round the tree. In the event of the season for disturbing the roots being over, or the objection at any time to cutting a hole and amputating any portion of root surface, being entertained, as in the case of fine coffee, where the surface rootlets form a thick web which are inevitably disturbed and injured even by the fork, the application of maana is consonant with Nature's own teachings by the falling leaf. Moreover the waste by wash and evaporation is thus completely removed. When using it in this way some planters peg down the grass, placing a stick or wattle between each pair of forked pegs.

It is needless to point out the objection to maana grass on account of the liability to fire. In dry hot districts it is hardly to be recommended. But in the rainy half of the year on most estates its judicious use cannot but be productive of the happiest consequences.

SUBSTITUTES FOR MAANA GRASS.

In the foregoing uses of maana grass, its qualities being mechanical rather than chemical, jungle branches and plants, if equally available, are equally efficient. A jungle shrub called Hapatiya, prevalent in the valleys near Kandy, is well adapted for littering the ground. and has been so employed with advantage in Matale.

So great and conspicuous are the virtues attached to maana grass by some planters, that those who have cattle but no patena are recommended to plant maana on any available jungle or chena land. It is grown readily from seed. In May last a plot of ground was sown with maana grass from seed obtained from Haldummulla. The plants were ready for division in four months.

ANALYSIS OF MAANA GRASS.

The trifling value of maana as a direct contributor to the non-volatile elements of the food of the coffee plant, is apparent from the following analysis;

It contains

Silica	...	81½ per cent.
Chloride Potassa		2 do.
Potash	...	3 do.

and other immaterial substances. We see, then, that flint is the main component in maana, and is the cause of that knife edge which has drawn blood from many a heedless tyro.

PRACTICAL EXAMPLE OF THE BENEFIT OF MULCHING.

The effects of maana grass are enhanced when the soil, if it be stiff and clayey, is previously loosened and delved with a three- or four-pronged fork. Under such conditions the mulching acts under the most favourable conditions, as the following example will attest. A patch of "shuck" wind-blown coffee, was selected, suffering and exhausted with the disease, almost devoid of leaves, or at best with one or two yellow leaves, fluttering at the end of the scanty primaries. After forking in June to the depth of ten inches, the ground was mulched with a litter four inches deep. In four months the coffee had taken a new lease of life, threw out strong and healthy wood free of leaf disease, and in fact exhibited every sign of a prolonged and profitable existence. A certain number of similar trees adjacent were simply mulched. In these the improvement was conspicuous, but by no means either so obvious or so rapid as those which had had oxygen admitted to the soil in which they grew.

FROST.

As the range of cultivation of coffee ascends, frost will form, indeed already has formed, one of the "Enemies of the Coffee Tree" not considered by the late Mr. Nietner. The example of the Chelsea Market Gardeners, the comparison of whom with our body afforded food for the wit and rhetoric of His Excellency the Governor, is not without its value. As winter approaches our Chelsea colleagues cover the roots of their apples and currants with straw or matting. Delicate fruit-trees are thus aided through the rigours of a long frost.

MR. SABONADIERE'S OPINION.

Mr. Sabonadiere in his work on coffee planting remarks:—"Maana grass "must be buried in trenches cut longitudinally across the face of the hill . . . . . "and all patena lands planted with coffee should be treated in this manner."

Mr. Sabonadiere does not state that maana grass so applied acts as manure in the sense of contributing or preparing the food of the coffee, but it is difficult to understand why the maana should be buried in trenches but for the purpose of manure. A substance so miserably poor in the requirements of the coffee tree can hardly be worth applying, while the sandy and porous nature of most patena soils would hardly be rendered cohesive and adherent by cutting trenches filled with maana. The reason of Mr. Sabonadiere's advice is not, therefore, so clear to me as generally throughout the other portions of his admirably written work.

I trust that enough has been said to demonstrate the great value of a fertilizer, lying close at hand in many cases, but which has been too often discarded for artificial manures of great reputation but of small inherent worth.

JUNGLE SOIL: COST OF APPLICATION.

Jungle Soil or Humus is a manure available for almost all, and has been found most efficacious by some, planters. By others it has been applied without success. The conditions under which the employment of this sub-

stance is likely to be profitable is when coffee in the vicinity of jungle has been washed and scraped until it is bare of top soil, when the roots are exposed, and the coffee is high out of the ground. Under these circumstances, conditions of transport being favourable, the application of precisely those substances which Nature has provided as the food of plants, and which are not only rich in potash, but friable from the presence of vegetable matter is of infallible advantage. Under such conditions the cost of application is considerable. At least five baskets to a tree are required to create a new soil, the cost of which, with a task of a hundred baskets, wages at tenpence, and twelve hundred trees to the acre amounts to Rs. 25. The application of jungle soil is hardly worth attempting, unless the tree be liberally dealt with, and it is open to question whether ten baskets per tree will not in the long run pay better than the number on which the above calculation is based.

In the replies to the series of questions propounded by the "Sub-Committee to Consider the Manure Question," appointed in October, 1868, it is somewhat remarkable that not a single planter admitted that he had applied jungle soil. In most cases, this substance must have lain within six feet of their coffee, and yet remote islands in the South Pacific were ransacked to sustain the vigour of their property, and after great expense, the barren results of Peruvian, Bolivian, and Bird Island Guano, were in a number of instances such as—especially when employed in a liquid form—"to preclude," as Mr. Wall remarks, "The possibility of adopting that method otherwise than for experiment." The truth of Adam Smith's words at the beginning of this section, was never more strikingly illustrated.

FERN.

Fern, or the common bracken *(pteris aquilina)* when present in abundance, may be advantageously utilized in sustaining the coffee tree. When cut and dried this fern is also valuable as a litter for cattle. The ash contains salt, (culinary) and potash, and forms a good top dressing. The plants should be applied or dug in when green, as the alkali escapes in every shower that falls. When divided into lengths by a straw cutting machine, the reduction of the tough fibrous texture is much faalitated. Any estimate of cost would be unreliable; the conditions under which bracken flourishes vary too much for satisfactory calculation. A table of application cost will be found in the appendix.

STAGNANT SOIL.

Swamp or *Ravine Soil* is a valuable fertilizer under proper treatment, and under certain conditions. The mud or soil from stagnant places is saturated in the minutest particles with the elements of plant food. Dead generations of plants have flourished and faded, the roots of which have drawn a quantity of mineral matter from a certain depth of soil. These remains are decomposed, in other words undergo a slow combustion, and their non-volatile elements or ash constituents are dissolved by the action of carbonic acid. The presence of potash, phosphoric acid, iron, and sulphuric acid in the soil and water of stagnant places is thus easily explained. But decaying substances in excess, by generating too much carbonic acid, injure even those plants which thrive particularly well in a soil containing a modee

rate quantity of humus. The application of swamp soil to the roots of coffee, unmixed with any other manuring agent, is, therefore, dangerous. The poisonous and active acid is neutralised by lime, while the valuable minerals remain intact. For a compost partially constructed with swamp soil, lime should also form one of the ingredients.

When it is impossible to obtain lime at a reasonable cost, the use of swamp soil as a fertilizer need not necessarily be sacrificed. The swamps or ravines must, however, be heaped, for the double purpose of draining off surplus moisture and ærating the vegetable remains.

Fresh wood ashes, containing a powerful alkali, potash, will eagerly unite with the acid of the soil forming a neutral base.

The cost of swamp soil consists, of course, in its preparation and application, the proper place for compost heaps being in or near a ravine or marsh. The great specific gravity of soil charged with moisture, imposes on the planter the necessity of diminishing the charges for carriage as much as possible.

It is seldom that any operation on a well-organized estate cannot be made to pave the way for another, accomplished at less cost and with more success than were the latter operation undertaken alone. Thus the heaping of swamps and ravines for manuring operations, is naturally followed by the planting of grass. Mauritius grass will grow more readily on the clean and newly prepared surface, and soon eliminates the weeds which probably flourished undisturbed before.

Charcoal is mainly valuable on account of its absorbent properties. It is a great economizer of manure, and like gypsum fixes ammonia very readily in a compost heap, therefore, it is a useful ingredient, whenever sulphate, or any other form of ammonia, or Cattle urine, forms a part.

From a recently burned-off clearing charcoal may readily be collected. The gathering and pounding of charred wood give employment to children and women unavailable for heavier work. The task should be three bushels each cooly per diem. Pioneers on the road receive fourpence per bushel for making it, including the cutting of the timber. The cost, however, on estates with jungle adjacent, or with the dead trunks of hard wood trees still sound should not exceed threepence per bushel.

In burning wood for charcoal it must be borne in mind that the charring process does not take place where the wood itself or the partly burnt wood comes with contact with the air, but that it happens wherever the wood is separated from the air by burning gases. Manufacturers at home prepar charcoal by heating the wood to redness in an iron box or oven, entirely excluded from the air, with the exception of a pipe allowing the gases to escape. After those gases have been driven off nothing is found in the box or oven, but a quantity of charcoal.

MODE OF PREPARING CHARCOAL ON ESTATES.

A simpler way of making charcoal, and one better adapted to the circumstances of a coffee estate consists in piling the wood in a large stock, and setting fire to it. By this means the outside wood in contact with the air gets burned away to a greater or less extent, and the inside wood being simply heated by the burning which is taking place upon the outside of the heap, is not consumed, but gives off its gases which ignite on the

outside. What is left on the inside is charcoal produced by the action of heat upon wood without the access of air.

From its purifying and absorbent qualities Charcoal deserves more attention than has apparently been accorded to it.

BURNT CLAY.

Clay is a plastic earth consisting mainly of pulverised feldspar and quartz. It owes its plasticity to the alumina, and ceases to be called clay when the proportion of silica is too great for plasticity. Oxyde of iron, carbonate of lime and magnesia are often present in clay. The application of heat in excess often pulverises the stones in clay, which sets free a quantity of silica, available for the stem of the coffee plant.

PROPERTIES OF BURNT CLAY.

The value of burnt clays consists in their tendency to sink down into the subsoil, thus amalgamating with, and aerating it. Mr. Mechi, of Tiptree Hall, one of the London *Times'* most constant agricultural correspondents, and enjoying an European reputation as a scientific farmer of arable land (his experience in grass farming is disputed) thus writes in his book "How to Farm Profitably" :—

"Burnt clay ..... causes heavy lands to work easier and in every way is "a most cheap and effective way of permanently increasing the fertility of "the soil. I believe the advantage arises principally from the improved "mechanical condition of the soil, which admits a more free circulation of "air and water. ..... We are too apt to forget that for thousands of years "millions of reptiles, worms, and insects, have lived and died and decom-"posed in our soils; for thousands of years the feathered tribe, carnivorous and "omnivorous, have used our earth as their feeding ground, their dung heap, "and their grave. Time has dissolved their elements and the elements of "their food, and the inorganics have been washed deep into the subsoil.

"The same may be said of our primeval vegetation. There is someting "very encouraging in the durability of burnt clay brick dust. It sinks gra-"dually down into the obstinate subsoil, and mixed with it in minute gra-"nules rendering it more permeable and more accessible to the roots of our "crops. Fifteen years of practical experience have enabled me to come to "these conclusions."

PREPARATION OF BURNT CLAY.

The kiln, as described under the subject of "Lime," is available for the calcination of clay. The plan usual in Europe is to burn immense fires all over the ground the subsoil of which is amiss. In Ceylon, where subsoils are rarely good, and are sometimes almost poisonous, anything that improves them deserves our careful attention. The impossibility of burning clay in the English method, without consuming coffee and topsoil together, renders it a simple matter for calculation whether kiln-burnt clay is financially practicable; and for experience whether attention to the subsoil had not better be postponed until the top soil is all that labour can make it.

It is probable that the fierce burns of felled jungle, so deprecated by one school of planters, exercise a most beneficial effect on the subsoil.

PRUNINGS.

Prunings are alleged by many to be a useful manure. It is natural to

expect that coffee itself is its own best manure. I have, however, arrived at a different conclusion as regards buried prunings. After carefully examining their condition at stated intervals, it is difficult to say how far the slight improvement noticeable in the Coffee was the result of the disturbance of the soil, and how far owing to the restoration of the leaves and branches of the coffee itself to the soil. A hole cut between each group of four trees, the prunings being covered with six inches of soil, was opened and examined ten months after it was made. The branchlets were undecayed, and the roots from the surrounding coffee, which was somewhat finer than the average, derived but very partial benefit from the mass, judging from the number of rootlets found in the neighbourhood.

Where labour is a subject of difficulty—and where is it not?—the most intelligent disposition of the force at command distinguishes the practical from the theoretical planter. The burial of prunings appears to me precisely one of those operations which can only be done with advantage when work is well in hand, and no more remunerative employment of hands is feasible.

COST.

The cost for one year on this estate was Rs. 2·75 per acre. The following season the pruning being heavier, the cost was slightly more.

Mr. Wall thinks that "it would be found convenient to have the holes "opened before crop time when labour is abundant." Experience so prolonged and wide as Mr. Wall's is probably sufficient warrant for the practice of cutting holes before crop to obviate the choking of drains and to gain other collateral advantages. It is with diffidence I urge that any practice involving the excision of root surface at the time when immature crop is straining the powers of the tree to the utmost, is strongly to be deprecated. Spare labour before crop would surely be more wisely employed in almost any work other than the disturbance of the root system.

Ash of weeds contains, if applied in a bulky vehicle, everything that coffee requires. The process of cleaning a weedy estate is a heart-breaking task unless the weeds are systematically burned or buried. I incline to the former method, both because the destruction of seed is immediate, and the partial restitution of abstracted crop elements, is more easily accomplished.

AGERATUM.

The ash of flowering weeds obtained fresh and applied with pulp is very useful. With cattle manure in the proportion of a measure to a basket, they have been found as successful as the most costly manure applied. Coolies may be usefully engaged in sprinkling the fresh ash of extinct fires over the ground and lightly covering it with the soil, or else in conveying the ash to the pulp pit. By these means the valuable property of the ash will be fixed and retained in the soil, instead of being dissipated in the atmosphere. The cost of weed ash is, of course, equivalent to the cost of application.

COMPOSTS.

Having given a brief account of the principal manures produced on Estates, which in many instances must necessarily form the chief if not the whole extirneous assistance rendered to the coffee, it is necessary to consider the methods in which they can most cheaply and efficiently applied, alone, or in conjunction with other substances.

The blending of bulky manure ingredients is attended with the obvious disadvantage of the double operation of carrying the various substances first to the compost heaps, and secondly to the point of application unless the advantage accruing to the planter by mixing his bulky manures prior to application, exceeds the cost of the extra transport, common sense will suggest the discontinuance of this process. In England, composts are held in little favour by practical farmers, as it is held that the several manures can be applied more conveniently in separate form. The circumstances of our estates are however far removed from those of English farms, where steam tillage and cereal cultivation close the door to arguments grounded on similarity in facts. Bulky manures are held by the ablest planters to be absolutely necessary for the due maintenance of the fertility of an estate. Coffee which is worn, and prematurely old,—coffee whose roots are exposed to the blaze of an equatorial sun by the incessant use of iron tools, will never be renewed by a dose of phosphate, or any other food constituent measured in ounces. Or, if a temporary improvement takes place, a reaction comes, and the last state of that tree is worse than the first.

USES IN MIXING INGREDIENTS.

The objects to be attained in employing composts are three fold :

(1.) The restoration of nutritric substances to the exposed root surface, to replace soil lost by wash and scraper.

(2.) To obtain the fertilizing power produced by the union of two or more substances, which, in certain cases, is greater than when the ingredients are applied separately.

(3.) To increase the surface extent of the particles of the more costly artificial manures, since the increase of surface extent is to enhance the effect —to lesen the surface extent is to diminish the effect.

HUMUS.

When under high cultivation as regards draining, terracing. and digging, a certain appreciable waste of soil is inevitable, the use of well and cheaply prepared compost will be beneficial. How much more then does coffee, which, properly speaking, no longer has any top soil, demand the restoration of the compost which has been taken away, for what else is humus, which at best we can but poorly imitate, but a perfect compost ?

MR. WALTER CROSS BUCHANAN'S EXPERIENCE.

Bulky vegetable matter decomposed when mixed with well rotted cattle manure and pulp, gives to coffee as robust and vigorous an appearance as if Cattle Manure alone had been applied. Mr. W. C. Buchanan has written as follows, and his remarks meet with the concurrence of those who have actually tested the fact stated :—

"If an Estate," writes Mr. Buchanan, "be capable of manuring say "thirty acres annually with cattle manure and pulp, the quantity so used "if mixed with a combination of artificial manure and any vegetable matter, "should be sufficient to manure, in my opinion, ninety acres, at no increase "in the relative cost per acre, while compost would not be in any way "inferior to the cattle manure and pulp by themselves."

INSTANCES OF INGREDIENTS MIXED MORE VALUABLE THAN WHEN APPLIED ALONE.

Liebig writes,—(Natural Laws of Husbandry, page 28) : "With wood ashes

"that part readily with their potash to water, it will be found useful to "mix the ash before applying it, with an earth that absorbs potash, adding "so much of the latter that water poured upon the mixture will no longer "turn litmus paper blue."

Another instance of the increased value of mixed manures is found in the case of animal charcoal. To effect the speedy distribution of this substance through the soil, it is necessary to blend it with a decaying vegetable substance, to supply the carbonic acid required for its solution in rain water. (See Liebig as supra, pp. 277-8.)

The increased value of lime and ravine soil, when mixed, has already been described.

The most ignorant peasant should ever have before his mind's eye the following fact; "The effect of a manure in a stated time is in exact pro- "portion to its surface." This axiom is true whether the manure acts as a solvent, or directly as nutriment. Of course the best way of increasing the surface of a manure is to till it into the ground. Tillage in Ceylon is only feasible by the fork, and then only when the circumstances of labour, &c., allow of its use. The particular effect of tillage is nearly imitated by the separation of the particles in four or six ounces of bone-dust in a basket full of decayed jungle stiff swamp soil, &c. So far as this isolation of each particle is attained, it is an approach to the ideal increase of superficies impressed on us by agricultural chemists. If the compost be worked into the soil, by so much the more will the desired increase of surface be accomplished.

Having noticed the prominent advantages inherent to manures applied as composts, the mode of constructing them must be next considered.

WHERE TO BUILD COMPOST HEAPS.

In the immense variety of features marking the Coffee Estates of Ceylon, it is as a rule impossible to have compost heaps for every field as is desirable. To high and inaccessible coffee the application of bulky manure is generally out of the question. The principal compost should therefore be prepared on a flat, or where it commands on a level lower than itself the largest possible extent of coffee. The vicinity of water, a swamp, jungle, and a kiln such as was described under the head of "Lime" are needful if not indispensable. Neglect in the selection of the spot offering the greatest natural advantages *must* be always attended by increased expense, and *may* entirely neutralise the benefit looked for by the mixture of the ingredients. The principles for constructing a compost heap may be gathered from the following example; the details can be varied at pleasure.

HOW TO MAKE A COMPOST HEAP.

On some such spot as described above, near jungle, and commanding an expanse of coffee, cut a level foundation thirty feet long, ten feet wide and eighteen inches deep. Puddle the sides and bottom with clay to retain the liquid. Till the trench then made with one foot of top soil and a six-inch layer of jungle stuff. The object of placing earth at the bottom is to absorb the ammoniacal liquids, which percolate downwards, and are wasted unless retained. A layer of lime, wood ashes, and ravine soil, may now be added. The acidity of the earth will be neutralised by the lime, and the alkali of the potash will at the same time be fixed. The rich vegetable remains will be left unimpaired. The proportion of unslaked lime to ravine soil should be about one to four in weight. A layer of maana grass or jungle stuff

sprinkled with sal-ammoniac, or ammoniacal liquor, will soon decay. When ammonia in any form is present earth should be added to fix the ammonia, which otherwise will evaporate. Bone dust macerated in potash and lime will remove the oil which prevents bone from speedily decomposing. The phosphate of lime is thus left free for assimilation by the soil. A tar barrel with

1 Bushel bone-dust
1 Do. wood ashes
½ Do. unslaked lime

should be filled with water and allowed to stand for a fortnight before sprinkling it over the compost. The gelatine of the bone eagerly united with the alkali of the potash, contained in the wood ashes, and forms soap. If the bone-dust is in the form of superphosphate, this process is unnecessary.

In sprinkling ammoniacal liquor over compost heaps, the proportion of water is seven parts to one.

The object of fermentation is to accelerate decay and the chemical changes dependent upon that action. The whole mass is thus brought into the condition most suitable for assimilation, and will be ready for application a month or six weeks from date of construction.

Cattle manure, jungle stuff, with sal-ammoniac or sulphuric acid to promote decay, lime and ravine soil, urine and jungle soil, pulp, bone dust, guano, wood ashes, charcoal, and water, or some of them, must form the base of all compost on coffee estates—the problem being to form them with a minimum expenditure under the head of transport. When completed the heap must be thatched securely.

Compost heaps should not only be as numerous as possible, but should vary in size and quality in accordance with their position. Thus, near the kiln, lime made from coral, or indigenous lime stone—wood ash, jungle stuff, and ravine soil would naturally form the staple ingredients. Near the pulping house, with the pulp properly decayed, bone dust, pulp, and poonac form an excellent manure, in these proportions:—

Pulp	...	1 basket
Poonac	...	8 oz.
Bone Dust	...	4 oz.

Near the cattle sheds, dung—earth saturated with urine, in various forms will, with jungle stuff well decayed, be found the most convenient. The one desideratum is, the avoidance of needless transport. An excellent compost may be made at too great a cost. I have known a compost costing £6 per acre increase crop by about one cwt. per acre. Four years ago a compost was made and applied at the cost of £3 per acre which placed and matured a magnificent crop upon the trees.

SOIL SUITABLE FOR COMPOST.

As a general rule composts are best suited to land which is not too stiff and clayey. Liebig states that compost is not well suited for compact soil. He means cattle manure and earth, and suggests that turf dust be mixed with the cattle dung in lieu of earth.

Subjoined are some recipes for compost heaps which have been found useful.

	Of eight parts	
1.—	Poonac 5 Bones 2 Guano 1	well mixed with fine earth.
2.—	Cattle Manure 1 Basket Bones 4 oz. Coffee Husk ½ basket	
3.—Of twelve parts	Maana Grass Lime 1 Ravine soil 7 Pulp 4	

If sulphuric acid diluted be added to composts to accelerate decay it is considered that 5 o/o of acid diluted with three times its bulk, (about six times by weight) of water is the proper proportion for decomposing weeds, prunings, and jungle stuff.

SULPHURIC ACID.

When sulphuric acid is added to compost heaps both for fixing the ammonia and decomposing vegetable refuse, about 1½ cwt. of acid is desirable for the quantity of manure intended for an acre. This is considered a fair general average, but experience may modify the quantity recommended.

Intelligent consideration of what is required, and available methods of accomplishing it will teach each separate planter to make a better and a cheaper compost, than by blindly following the example of others. From the foregoing pages it is hoped that some information may be gathered as to how to set to work.

This is not the time or place to dilate on labour-saving appliances. But on no operation connected with coffee planting is the saving of labour more directly remunerative than in the collection and distribution of bulky manures.

SECTION III.

ARTIFICIAL OR MANUFACTURED MANURE.

The use of manures procurable only at great cost, and after removal from the sea-coast, is only warranted by advantages so marked that no room is left for doubt that the outlay inurred is recouped. Capital has been wasted in purchasing useless, and even deleterious, manurial agents. Money is, in many instances, invested by A. in a specific manure for no better reason than that B. under other conditions of soil or climate, has reaped benefit from it. If a man suffering from cholera were to wildly spend his all in buying the remedies which had saved his friend from consumption, his disappointment would meet with little sympathy. The planter who acts similarly to his land deserves no lighter censure.

ADULTERATION.

Supposing, however, that the planter has hit on the right manure, he is still exposed to danger from the atrocious system of adulteration so largely prevalent. "For the Colonial market" is significant of an inferior class of goods. Artificial manures offer a rich field of imposture to the unscrupulous trader. He sands his superphospates and dilutes his guano secure from discovery. Since the main body of planters are *employes* liable at any time to be transferred from estate to estate, it is not remarkable that the clamour for an analytical chemist is neither loud nor deep. Few, however, of those who have given their consideration to the subject, are not found to concur with the reasons given for the employment of a chemist by the colony capable of accurate quantitative analysis. Among other reasons set forth for the creation of such an appointment, there is none more telling than the just claim of Society for protection against adultrated imports. This principle already partially obtains in England. Tobacco below a given standard is destroyed by the Inland Revenue. It is sought to apply this principle to tea, which arrives from China "faced" and adulterated.

Ceylon receives manure to the value of £20,000 per annum. I say nothing against any of it, but as a simple matter of business the buyer ought know whether he obtains the article he wants. This can only be obtained by independent analysis. The machinery for doing this should be provided by Government. The holder of such an office would find plenty to do outside his more immediate duty, in the collection of trustworthy information regarding the soil,

and in advising planters as to the treatment of their several estates. Merchants and manufacturers of good name would be glad that the true character of their wares should be known, and dishonest dealers would be driven from competition.

BONE DUST.

Among the first of artificial manures is *Bone Dust* or Phosphate of Lime. Years of experience have confirmed the high position this form of manure has attained. It consists of phosphorus and lime, and either by steam or sulphuric acid it is mechanically adapted for application by division and sub-division into the smallest possible atoms. A given weight of superphosphate of lime possesses the maximum superficies possible to that weight of Bone. It is, therefore, for this reason, well adapted for blending with other manures. Bone earth, as distinguished from superphosphate, spreads rapidly through the soil and is slightly soluble in water. The small but perceptible portion which does dissolve is a combination of Phosphate of Lime and Gelatine, which is not, according to Liebig, "decomposed by the arable earth, and therefore penetrates deep into "the ground, a property wanting in the superphosphate." Bone Dust is consequently well fitted to supply Phosphate of Lime to the subsoil roots of coffee. *Bone Earth* is the name applied to bones separated by calcination from the glue or gelatine.

As carbonic acid is needed to effect a speedy distribution through the soil, mixture with a bulky decaying substance, such as pulp or any vegetable compost, largely enhances the manurial value of bones. For this reason, mixture with a small quantity of poonac alone does not prove so successful as when bone-dust is blended with other and more bulky manures, producible on most estates.

BONE DUST.

An excellent mixture is

Bone Dust 6 oz.
Cattle Manure 1 basketful.

A field of coffee manured thus in December last displayed as marked an improvement, and matured its crop as successfully as could be desired. The increase in crop was about four cwts. per acre and the cost Rs. 93·40. The sample of bean was regular and full, and the line of demarcation where the application ceased was so pronounced that the most superficial observer could not but remark the contrast.

ABUSE OF BONE DUST.

Although the value of good Bone Dust judiciously applied is beyond question there is considerable danger, particularly in low districts, in the application of phosphates or superphosphates otherwise than through the vehicle of well-rotted and bulky compost. Cold, wet, and elevated soils where bulky manures are inapplicable from the cost of transport are the sole conditions under which unassisted Bone Dust should be administered. Even in such cases it is questionable whether labour and capital might not be more profitably concentrated on accessible portions of the estate. I know of five instances in which bone dust has been applied and discontinued. Shuck coffee was the result in four cases, and one field so assisted, relapsed into jungle.

The reason of this is not far to seek. Coffee is ever prone to bear more fruit than it can mature. The mechanical admixture and disturbance of the soil, whether from hole cutting or surface manuring in no way checks this

productivity. Nutriment in a quickly available form being placed near a certain proportion of root surface, the supply is no sooner absorbed than exhausted. The tree manifests a temporary artificial vitality. Not only is the manure itself consumed, but a certain proportion of the mineral constituents of the soil is abstracted, and the only result is an obvious diminution in the power and productiveness of the tree.

To a soil rich in decaying vegetable matter the danger of applying simple Bone Dust is, of course, reduced to a minimum.

COST.

Good Bone Dust is obtainable in Colombo for Rs. 75 per ton. The costs of transport and application are comparatively small. A table of application will be found in the appendix.

The immense numbers of cattle contained in the island, particularly traversing the cart roads and coffee estates or patenas adjacent, suggests the practicability of utilizing the skeletons that might be collected. By simple calcination these skeletons would easily be prepared for manure.

Another plan of preparing bone dust on the estate is to fill a brandy case with broken bones, add half the quantity of sand, toss the mass into a small pit and so proceed until the bones are used up. Then moisten the contents of the pit with water, turn the whole well over, and cover the pit with a mat. In a short time the bones will ferment, heat, and crumble down to powder which may be stored for use.

With sulphuric acid Superphosphate of Lime may be readily prepared for use on the estate. Sink a hole in the ground as before (ten feet in diameter and two feet deep will hold a ton of bones) and puddle the sides and bottom as in the compost heap. Next sift your broken bones through a quarter-inch sieve, and cover the bottom of the pit with the fine bone dust heaping it also as thickly as possibly round the sides. If you have ashes or can get them, it will be better to line the sides and bottom with ashes, and over and inside them with the fine dust. Having done this put all the rough powdered bone inside the ring, keeping the coarsest pieces in the centre. Now take from 40 to 60 per cent of water (by weight) and moisten thoroughly the rough bone dust, and then sprinkle the heap with 20 to 30 per cent of sulphuric acid, or its eqivalent of unconcentrated acid. In six hours mix the coarse bones well together and cover with the fine dust, and ashes, if they have been used. Leave the heap to stand a few days and afterwards mix the whole thoroughly several times daily, and in a week or less the bones will be found converted into an excellent and *unadulterated* superphosphate. The process must be carried on under cover. Rain falling on the mass would neutralise the action of the acid before it had time to act. *

A soil that has suffered from the injudicious application of bone dust requires the prompt application of bulky decaying matter, worked into the ground. As a rule all the neutral phosphates must be reduced to atoms of great fineness, and the presence in the soil of available soda and potash, and soluble silicic acid is indispensable.

* I am indebted to the courtesy of Mr. C. O'Halloran for the particulars of this recipe.

POONAC.

Poonac (cocoa and castor) is to the Ceylon planter what rape cake is to the English farmer. There is a great difference in the Poonac supplied by various Colombo firms. The improved hydraulic machinery of some mills express more oil than the antiquated appliances of others. It is from the owners of the latter that planters should purchase their Poonac. The natives are said to bring the chief portion of their copperah to market in wet weather, and profit in most cases to the extent of 25 per cent by the article absorbing damp and weighing more. In the wet months immense pressure is require to extract the oil, while in dry weather the oil flows readily. In unfavourable weather the oil turned out is apt to be muddy and rancid, and the Poonac, besides being bad for cattle is generally infested with insects.

Poonac contains a large proportion of a matter abounding in nitrogen as well as the non-volatile constituents of the ash of the nut. Its effect on coffee is rapid owing to its decomposition in the soil, by which the nitrogen is set free to form ammonin. Poonac is seldom applied alone, except to supplies. Its value for this purpose is proverbial.

POONAC AND BONES.

Where circumstances call for *much* rather than *thorough* manuring, a union of one part Bones with two of Poonac is a fashionable dose. Benefit undoubtedly results to the crop, but whether the soil is not impoverished is another question. So far as I have seen it is impossible to cease manuring coffee to which this mixture has been applied without marked degradation in the character of the tree. I speak with more absolute conviction with regard to low districts, for there all experience tends to shew that 4 oz. bones and 8 oz. poonac applied to 100 acres per annum, will not in five years' time place so much money to the proprietor's credit as 20 acres per annum manured with more consideration for the soil and loss for crop.

Poonac is readily portable and easily applied.

Castor Poonac has been used the last two years. with surprising results. One objection to Cocoa Poonac, viz., the depredations of wild pigs is here a positive advantage, should they swallow the castor poonac, the medicinal value of the plant so speedily asserts itself that the undigested elements of the animal's food for that day, are hardly removed from the spot. A planter writes me: "I applied castor poonac with fine bone dust at the beginning of May to "good and bad coffee with very good result so far that the bad coffee which "had small yellow leaves in the beginning of August had fresh large dark "coloured leaves, and besides had thrown out abundance of young wood, and "will no doubt force out a good blossom in the good coffee."

The method of applying was in a semi-circular hole 9 in. ⋈ 9 in., about 15 in. from the stem of the tree. One pound of the Poonac and Bone Dust was well mixed with the soil and covered up.

Poonac is supplied from Colombo mills ground or in broken cakes. If prepared on the estate water is sprinkled on the cake, it is left for 24 hours, and then pounded with wooden mallets by women and boys.

Passed through cattle Cocoa Poonac is increased in value. The excrement of the animals so fed contains the principal bulk of the elements to which its fertilizing properties are due.

Castor Seed is more costly than Cocoa Poonac, but the increased certainty and good effects of its action counterbalance the extra expense.

SALT.

Salts are employed with marked success in some cases. Their efficacy does not alone depend upon their containing the good elements of coffee, but by the possession of certain qualities which affect the influence of the atmosphere upon the condition of the soil, and aid and promote mechanical tillage. The nature of these peculiarities is not yet thoroughly understood, but the facts are not less certain.

In Ceylon, where tillage of the land planted with coffee is all but impossible, the value of common salt as a fertilizer is conspicuous. Its power in effecting a distribution in the soil of other elements of food, renders it in some sort a substitute for the plough and the harrow. Liebig says: "If "all other circumstances are the same, their (*i.e* salts) effect will be much "less marked on a well-tilled field than upon one not in the same condi- "tion."

The objections to the use of common salt as a manure for coffee arise from its great cost, at least in the Central Province; its great affinity for water; and the fact of its being a common article of food with coolies, which exposes those who adopt it as manure to a multitude of petty thefts.

The application of salt in the form of strong brine kills vegetation. Gardeners at home extixpate the weeds on garden walks by its use.

The application of salt in a liquid form best elicits its peculiar distributive qualities. One part by weight of dried salt to seven parts of water is the proper proportion. The brine thus prepared from 7 cwts., will be sufficient for an acre. Good roads, serviceable carts with water tight barrels, mounted, and fitted with lengths of hose and a nozzle are necessary. What is known in Englad as a "garden engine" would be well adapted for the distribution of brine (or other liquid manure), and by falling on the leaves and stem, insects lurking thereon would be removed. A preparation strong enough to destroy grub or insect life *in the soil* would be hurtful to coffee, but falling directly in the form of spray on the leaves, larvæ, and grub are attacked successfully.

Salt is also sprinkled by hand in the solid form; it may be advantageously mixed with earth or lime, and it is a valuable ingredient in a compost heap.

Salt is sold from the Government Stores for home consumption at Rs. 2·36 per cwt., or 2⅜ cents per lb. The Renter purchases the salt at 40 cents per cwt., and retails it at Rs. 2·24, leaving a profit of Rs. 1·54 per cwt. When salt can be spared for export, it is sold at Rs. 4·25 *per ton*. The wastage allowed on the removal of salt from one store to another is two per cent., but there is no fixed principle to regulate the wastage in store. The practice has been to allow 3 or 3½ per cent. in cases of deficiency, arising from natural or atmospherical causes.—(See Ferguson's Directory, 1874, pp. 290-291.)

The road from Hambantota to Wellaway is yet unbridged, and can only be used in the dry—the S. W.—Monsoon. Loads could be got up by tavelams to Laymas, and thence by cart.

My object in recording the above particulars, is to suggest that Government be moved to supply salt required for agricultural purposes at the same rate as is paid by the Renters,—40 cents per cwt.

SALTS OF SODA AND POTASH.

Soda and Potash are chemically related, and their salts have many common properties. Chloride of Potassium has the same crystalline form as Chloride of Sodium. Their taste is similar, and in solubility they differ but little. To the unpractised eye they are hardly distinguishable, but the soil distinguishes between them by withdrawing from two solutions of chloride of sodium and chloride of potassium, each containing an equal amount of chlorine, *half* the sodium and *all* the potassium.

Those who have been so unfortunate as to apply bone dust in small holes, would increase the activity of the phosphates by applying either common or ammoniacal salts. Their remarkable digesting power renders them most valuable, independently of the action which is due to their own proper elements.

An old planter who carries salt on coolies' heads 25 miles, writes as follows :—

"I apply from one to one-and-a-half ounces to a tree. I have it pow-
"dered fine and mixed with the other manure if I apply Cattle Manure and
"Bone Dust. I mix the salt with the bone dust and put them on top of
"the Cattle Manure. I apply

"Bone dust ... 4 oz.
"Salt... ... ... 1½ ,,
"Cattle Manure ... half a basket.

"With Castor Poonac 8 oz. I put 4 oz. of Superphosphate of Lime or Bone
"Dust 1½ oz. of and Salt."

VALUE PLACED ON SALT BY SOME PEOPLE.

In the recent Ashantee War, one of the Special Correspondents related how, among the Gallas tribe, the husband sold the wife, and the father his daughter, for salt.

The value of common salt is not yet rated so highly in Ceylon as among the Gallas, but it is a question whether it is rated high enough. For those who wish to learn more about common salt than the limits of space admit here, an essay by a Belgian physician, Dr. de Sawe, (quoted from the Journal de Chimie Medecale. p. 127, by Liebig, Letters on Chemistry, p, 434) will contain all they require.

CHILI SALTPETRE.

The action of Saltpetre is generally similar to that of common Salt, but its use, owing to its great cost, being impracticable in Ceylon, the characteristics need not be discussed.

SAL-AMMONIAC

Is known as a solvent manure of rapid action. As a salt it has the power of distributing the food elements of plants throughout the soil, and as a form of ammonia it dissolves earthy phosphates far more quickly than common salt.

Mr. Wall writes with regard to these salts, "The strong affinity for
"water, they as well as common salt, possess, make them particularly liable
"to be carried down below the reach of the roots or swept over the soil
"before they have had time to be absorbed." Mr. Wall's remarks are naturally accepted as just, but are they correct? Liebig says, "The salts of

"Ammonia are decomposed by the soil much more speedily (*i.e.* than other "salts) *and often even immediately*, so that as a general rule no solution of "such a salt can be said to be actually moving about in the soil. . . . "While, then, the action of salts of Ammonia is barely perceptible. "in the somewhat deeper layers of the arable surface soil, that which they "exercise on the uppermost largers is so much stronger." (Nat. Laws. p. 79.)

SAL AMMONIAC AND SULPHATE OF AMMONIA.

The use of sal ammoniac instead of sulphate of ammonia gives rise to chloride of magnesium and chloride of calcium which act rather unfavourably than otherwise on vegetation.

Ammoniacal salts should never be applied alone, but always in conjunction with other manures containing the elements which are to be assimilated by the Ammonia. The presence of Ammonia in a compost heap, "fixed" by jungle or ravine soil is the condition in which it is to be applied with the most unexceptionable results. Ammonia alone is dram-drinking for the tree. True Ammonia, of course, is death. But in conjunction with the earthy phosphates, cattle manure, and vegetable compost, ammonia digests and prepares those substances in the fittest condition for consumption by the rootlets.

For the cost of Sal Ammoniac must be comprised the variable loss of bulk owing to its extreme volatility. There is no quotation for Sal Ammoniac in Colombo at the time of writing.

Recent action which has been taken by an enterprising tradesman of Colombo renders it probably that sulphuric acid will be manufactured in the Colony, at a fraction of its present cost. Should this be so, Sulphate of Ammonia can be prepared on the estate in the manuer described under the head of "Cattle Manure." The sulphate is far less volatile than Sal Ammoniac and is said to be a better distributor of food elements.

AMMONIACAL SALT OR SULPHATE.

A dressing of from three to five cwts per acre is the proportion recommended, according to the nature of the soil.

AMMONIACAL LIQUOR.

Ammoniacal liquor is best applied to compost heaps, &c., in the following proportions:—

Ammoniacal Liquor		1 part.
Water	... ...	7 do.

GAS LIME.

Gas Lime (see Gypsum and Sulphate of Lime) used alone is injurious, if applied within 18 inches of the plant. If used generally over the soil it should be sprinkled thinly and dug in. The proper place for Gas Lime is in a compost heap where, with the usual vegetable matter, it is known as a successful manure. Gas lime or Ammoniacal Liquor are effectual in removing insects of all kinds.

The cost in Colombo of Gas and Coral Lime are about the same. Particulars can be obtained from the Gas Works.

Sulphate of Lime is made by adding Oil of Vitriol to Lime, weight for weight. It is used as a manure in the proportion of 5 cwts. per acre. It assists in the decomposition of vegetable compost and is capable of absorbing half its own weight of Ammonia.

GUANO.

Guano is the excrement of fish-eating birds, and contains, of course, the non-volatile constituents of the flesh of fish, together with a certain quantity of ammonia salts.

Its use in Ceylon does not hitherto appear to have been followed with such advantage as has been found to be the case in England. Beyond a temporary freshening of the foliage little result is known to have accrued here. Whether this barrenness of fertilizing power is due to the employment of a stale and adulterated sample, to errors in the mode of application, or to the nature of the soil, cannot be said, but it is certain that the properties of pure Peruvian Guano are adapted to stimulate coffee into heavy bearing.

Mr. Mcbi of Tiptree Hall, Elvedon, Sussex, states that Guano is one of the manures he never uses without advantage.

The cause of the difference between the action of Guano in England and in the tropics appears explicable. The fields of the wealthy English farmer are already saturated with the decaying matter of plants and cattle manure. They have as well a rich store of the minerals required as plant food both available and unavailable, and beyond all comparison their soil excels in porosity the hard iron-bound soil of the tropics, if from no other cause, by the periodical action of frost alone.

The ammoniac of the Guano has, therefore, a larger scope in English farms than on Ceylon plantations. Tillage, as European cultivators understand it, being unknown, Guano has not the same surface to act on, while the soil itself is generally poor in one, if not in both, classes of plant food. To apply Guano to worn-out coffee is to flog a dead horse.

EFFECT OF AMMONIA IN GUANO.

It is important to remember, however, an indisputable fact, that a given quantity of Ammonia in the form of Guano, produces a far greater effect than the same quantity of ammoniacal salts. At the Rothampstead experimental farm Mr. Lawes established this proportion as 1 to 5. The same experiment, with a similar result, has been performed by Kuhlmaun and others It is, therefore, clear that the value of Guano by no means alone consists in its Ammonia, but in the presence of other matters. It is, therefore, wise in using Ammonia to place those matters in relation with it.

Analysis.

In 100 parts Guano contains

Potash	1·56
Lime	34·00
Magnesia	2·56
Phosphoric acid	41·00

and other matters.

The deficiency in Potash is marked—another reason for the application of Guano in a bulky vegetable compost.

The compositions of human excrement and guano are somewhat *similar*.

In a letter to Mr. Cruwell, Liebig expresses an opinion that ammoniacal salts for perennial plants should be avoided, using *phosphorites* to a large extent. As the object of coffee planting is not to grow coffee, but to make growing coffee pay, Ammonia, as one of the most crop-compelling fertilizers known to science, has its advantages. If a given piece of land will *only* yield a certain weight of parchment coffee, whether concentrated into ten, or

spread over forty years, common sense would crowd the crops into the smaller period. to reduce the cost of gathering, weeding, &c. Although nutmeg trees may have failed at Singapore from the injudicious use of Ammonia in some of its forms, the fact will not serve to deter Ceylon planters from cautious use of the same fertilizer.

VARIETIES OF GUANO.

Guano is of many varieties—viz, Peruvian, Bolivian, and Bird Island. The produce of Baker and Jarvis Islands are esteemed more highly than the others on account of their acid reaction and greater solubility. The Baker Guano contains as much as 80 her cent of Phosphate of Lime.

Dr. Voelcker writes to the *Ceylon Observer*, that the present shipments are all made from the Guanape and Macabi Islands on the North Coast of Peru. These samples contain 12 to 13 per cent of ammonia, and are not subject to the great variations which are known to occur in some of the deposits in South Peru.

Both Liebig and Voelcker advocate the propriety of treating Peruvian Guano with Sulphuric acid, and offering it for sale in a finely prepared and dry condition of uniform strength. If to this is added a guarantee by independent analysis, nothing is left to be desired. The addition of Sulphuric acid to Guano, not only renders its phosphatic constituents more soluble and in consequence more efficacious and valuable, but the volatile Carbonate of Ammonia is also fixed.

Guano, when equally finely powdered, is nearly of equal diffusible power with Bone Dust. One hundred parts by weight of Guano require 20 to 25 per cent. of concentrated Sulphuric Acid, or 30 to 40 per cent of the lead chamber acid.

APPLICATION OF GUANO.

A legitimate occasion for the use of Guano or other ammoniacal manures, is after a burn so fierce that the humus and decaying vegetable matter required for the assimilation of plant food being dissipated, the non volatile contituents remain almost alone. A vehicle for the conveyance to the rootlets of the young coffee of the ash constituents will, in such a case. be indispensible, and the application of ammoniacal manure, especially in a bulky compost, would employ the idle phosphates, and assimilate them for consumption by the plant.

The addition of Wood Ashes to Guano, in land poor in potash, would probably be found most beneficial. The carbonate of potash decomposes with the phosphate of ammonia into carbonate of ammonia and phosphate of potash and the potash does not interfere with the phosphoric acid penetrating the soil.

Mr. Grinlinton states that he has applied Dissolved Peruvian Guano as follows :—

"I made a compost on the Estate of all decayed vegetable matter, wood "ashes, stable and cow manure, loamy earth, with about one sixth of gas- "lime or ordinary coral lime (both being about the same cost) and a hogs- "head of ammoniacal liquor. When this compost is fit to apply as manure— "in from three to four months,—I remove the earth from the base of each tree "for about a foot or so all round, with a four-pronged rake the teeth being "about 4 inches in length, then lay in a small basket, or half a large basket,

"or half a large basket of compost, sprinkle 6 oz. or nearly half a cocoa-"nut shell full of Dissolved Peruvian Guano, or about 12 oz. of Native Guano. "I then lay on such dead leaves, &c., as may be near at hand, and cover "up the manure with the earth which has been raked away, and put about "three or four mamoties of earth from the drains or from the ground be-"tween the trees on the top, covering all with a few stones, or with dead "grass to protect the manure from the heat of the sun and from heavy rain.

"The compost manure heaps being placed at convenient distances, the "the labour costs me on an average 30s. per acre, employing four coolies "trained to the work in each gang of manurers.

"One ton of Peruvian Guano, or two tons of Native Guano will manure "4½ acres."

Fish Guano is manufactured from the bones and skulls of cod-fish. Formerly these were thrown away, but now they have become an important source of wealth to Norwegian fishermen. Cargoes of dried skulls are sent from Norway to Leith where there is a prosperous manufactory of fish guano This guano is, of course, rich in phosphate of lime.

CAUTION AGAINST ABUSE OF AMMONIACAL MANURE.

In closing the remarks to be made on Ammoniacal Manures, I venture, at the risk of wearisome repetition, to urge on planters the fact that Ammonia in any of its forms, unless supplemented by other matters, does not contribute to the nourishment of the *soil*. A heavy crop is never put on by Ammonia alone, although it may persuade the soil to part with enough capital to place a heavy crop on the trees. Remembering this, Ammonia is one of the most valuable fertilizing agents we have.

COMPOUND ARTIFICIAL MANURES.

The use of manufactured manures, of the ingredients of which the planter is ignorant, cannot be recommended except after comparison with successful experiments upon soil of the same nature, and bearing coffee under the same conditions, of climate and elevation. How far a single artificial manure can allay all the ills to which coffee, in all its varieties, is heir, remains an unsettled question. We know that the pill, advertised as a sovereign cure for all human diseases, in all climates, at all ages, and of either sex, is but commercial practice upon the frank intelligence of the public. That the complex deficiencies of the soil, and the varied requirements of coffee should meet with a single panacea, is most improbable. Until that desirable compost be discovered I prefer to pin my faith on those simpler fertilizers, whose virtues and defects were known to practical planters before I was born.

SOMBREORUM.

Among the chief of these compound manures to which attention has been attracted, is Mr. Tytler's Sombreorum. It is known to contain bone dust, chloride of potassium, sulphate of potash, and nitrate of soda. These

ingredients comprise the chief requirements of coffee, and, if applied *in an available form*, must be attended with good results. Remembering Mr. Corbet's fate in 1871, when he ventured to question the title of Sombreorum to confidence and respect, I shall not myself say one word for or against the manure. Liebig writes: "I am an enemy to mixed manures, and think "it better to manure with artificial manures singly. Soils rich in alkaline "salts want phosphates; others in which lime or quartz predominates, chiefly "potassa. Since soils vary *ad infinitum*, one and the same mixture for "all does not suit."

To this paragraph, Mr. Tytler rejoins, "Liebig's objection to mixed "elements forming a compound manure, I do not understand. The chief "merit of sombreorum in my estimation consists in its being a mixture of "the elements, and in their due proportion, which analyses and experiments "prove to be required for the best development of coffee-bearing wood and "fruit. There is no more 'mixed manure' used than cattle dung, the ash "of which is so nearly identical with sombreorum."

To this the question may be asked "Then why not use Cattle Manure?"

Mr. Tytler's experience, his signal services to the knowledge of coffee culture, and his well-known energy of character, require any opinion deliberately expressed by him to be discussed with diffidence. When Mr. Tytler writes, "My own belief in sombreorum continues unbounded. In "cases wherever it may have been used without effect, I cannot think other-"wise than that it is a question solely of the mode of application," an unbiassed observer may recognize the partiality of a parent. No qualification whatever is admitted by Mr. Tytler, and he forgets that the repetition of a previous statement is not considered, by expert logicians, to add to the inherent strength of a case.

Mr. Sabonadiere considers that frequent application of sombreorum is required to afford lasting and remunerative results.

By common consent planters of culture and experience have abandoned the hope that by a pinch of some chemical ingredient or ingredients of coffee it will be possible to produce a magnificent crop. "As thy manure so shal, "thy crop be," is what Nature is teaching us. Sooner or later, bulk as well as quality, is imperatively asked for.

In his opening speech to the Legislative Council in October, His Excellency remarked *a propos* of the Railway:—"The expediency,—indeed, the "absolute necessity—of getting up manures from Colombo to the coffee dis-"tricts, has always weighed more on my mind than the getting down the "produce of these districts to Colombo."

It is not necessary for His Excellency the Governor to await the completion of Railway Extension, in order to promote the consumption of artificial manure. The appointment of an analytical chemist; abolition of the royalty on salt when used as manure; suspension of the import duty on artificial manure; specially favourable rates of freight on the existing Railway; and the abolition of toll on *all* manures, whether in the schedule or not, are a few of the measures which might accelerate the object His Excellency has so deeply at heart.

SECTION IV.

METHOD AND TIME OF APPLICATION.

In the mode of applying manure, the Planting community, like Gaul in the time of Julius Cæsar, is divided into three parts. One party holds that the proper method of applying manure is to place it in a hole cut above the tree, or in the centre of each square of four trees.

The second, regarding this method as an old wife's fable, insists on surface manuring as the natural, profitable, and scientific system.

The third party attempts to profit by the advantages inherent to either system.

During the discussions which have raged from time to time so much loose and in accurate language has been used, it is well to understand what it is we mean by cutting holes, and what by surface manuring.

By surface manuring some wish to imply the simple etymological sense —laying the manure *on* the surface. Whether they cover over the manure with maana or other grass, whether they first dig or till the ground, is immaterial to the sense in which they wish to be understood—*i.e.*, placing the manure not *under* or *near* but *on* the surface.

Others, again, hold themselves justified as describing as surface manuring, cases in which the fertilising ingredients are placed within a few inches of the surface with only just so much earth as shall, in Mr. Corbet's words, "shade "it from the sun, and prevent the escape of the ammonia or other nutritious "gasses* evolved during the decomposition of the manure."

The holing party, represented by Mr. W. Sabonadiere, state that:— "The usual mode of applying manure is to dig a hole on the slope of the "hill above the tree at least eighteen inches from the stem. The hole should "be two feet long, eighteen inches wide and one foot deep, when cattle man- "ure or pulp are to be applied. Great care should be taken not to injure the

* I do not understand clearly whether Mr. Corbet wishes it to be understood that ammonia is a "nutritious gas."

"large roots. The cutting of the fibrous roots on the other hand, acts beneficially, "as it is a species of pruning, and causes them to shoot with a renewed "vigour. Other manures being more connected, do not require such large "or deep holes, and are usually applied by weight."

"When the land is flat, and the trees are regularly and closely planted, "a square hole may be cut between four trees to receive the manure; but "on steep land it is always best to cut the hole above the tree, that the "manure may percolate down to the roots, and benefit the entire tree. Another "advantage of this plan is that the manure is under the shade and shelter "of the branches; whereas if put out in the middle of the rows, it is ex "posed to the exhaustive heat of the sun and atmosphere and is more likely to "generate weeds, which, unless quicktly pulled up, will absorb the manure "before the trees have been permanently benefited."

In another communication Mr. Sabonadiere says :—"I have always thought that "holes for cattle manure or pulp should be cut one foot deep, and "artificial manure holes six inches deep, and care must be taken not to injure "the large roots. I contend that such holes are not too deep for the gene- "rality of our estates, where the land is more or less steep, as the manure "when thus applied does get to the feeding roots."

HOLES.

Mr. John Ward, a planter of many years standing, not only supports Mr. Sabonadiere but outherods Herod. "Theoretically"—he writes, "I would advocate two feet deep." He claims for his "scheme" a strict compliance with the action of Nature, arguing very pointedly that tap roots will thrust out rootlets and avail themselves of nutriment conveniently placed at almost any depth, and that beyond the reach of wash and the rays of the sun, the action of manure would be more stable and effective.

Planters, with experience it is impossible to gainsay, support the hole system for some or all of the following reasons :—

1. The manure is preserved from wash, and

2. From the effects of the sun in volatilizing unfixed Ammonia, &c.,

3. Slight root pruning, if confined to small roots is beneficial to the tree, and is in accordance with the principles of fruit cultivation practised at home.

4. Holing is easily performed by unskilled labourers and with *proper supervision* the large lateral roots need not be cut.

5. The system has been in force for many years. It has been practised on most valuable and still flourishing estates, and has been advocated by such men as Mr. Wall, and others among the very ablest members of the planting community

6. The disturbance of the earth about its roots has been found most beneficial to coffee, and cases are on record where the mere hole produced an effect as marked as by those filled with manure.

To these statements the other party demur, and allege that

1. Preservation from wash is better attained by thorough draining than by burying the manure. Manure that is not washed *off* the land must be washed *into* it.

2. The loss by evaporation is obviated by mixing the manure. whatever it be, thoroughly with the soil, and by selecting showery or cloudy days for the time of application.

3. Root pruning in English orchards bears no analogy to the same practice with tropical perennial fruit-bearing trees. The pruning of root surface must necessarily diminish the vital force of the tree for the time being. For as much root surface as is excised, an equivalent of plant food is rendered unavailable. Vitality too exuberant is rare, but when it exists heavy pruning, and allowing one vertical sucker to mature a single crop, will check lateral extension, and lower the superfluous force of the tree.

4. However simple holing may be, roots are, as a matter of fact, incessantly cut, and there is nothing in the other system advocated which unskilled labour cannot easily perform.

3. That estates are flourishing under the hole-cutting system, is testimony to the great vitality of coffee, rather than proof of the theory adopted.

6. Disturbance of the earth is better accomplished with the fork than with the mamoty, and can be performed equally well and cheaply in conjunction with the operation of manuring.

Thus far the Surface Manurers in reply to the Holers. They proceed to advance for their theory that

1. Nature's method, of renewing the fertility of the soil is to spread a carpet of leaves, the inferior layer of which continually decaying restores to the soil that which has been taken from it and in addition, that which the trees have inspired from the atmosphere.

2. That since the value of a manure is in proportion to its surface, in other woods, according to the perfection with which it is blended with the soil, this mixing process is best accomplished at the surface.

3. That the most accessible roots of coffee are at the surface, whether rightly so or not, is immaterial; but finding them there it is the simplest matter to convey nourishment to them in the first place, and to leave gravitation and the porosity of the soil to do the rest.

4. That soil is not washed away, as in the case of the loose earth taken from holes.

Rejoinders to these statements are made as follows :—

1. Any argument based on Nature is a *petitio principia.* Nature does not cut the top off her trees. Nature does not prune and handle thrice a year; nor does she annually carry off huge stores of potash and phoshpates from the soil.

2. The mixture of manure with the soil is equally insisted on by the advocates of the hole system. but since in the majority of cases the frequent application of manure is impraeticable, holes or trenches are necessary. By surface manuring rootlets are attracted upwards. The litter decays and the tender rootlets are withered by the sun unless the littering process be efficiently maintained.

3. It is undersirable that the coffee tree should be mainly dependent on a plexus of roots at the collar It is better to promote root formation lower down away from the influence of sun and wash.

Having summarised as brsefly as possible the contention of either party, taken from the lips or writings of a multitude of the exponents themselves. I have endeavoured to frame for the third, or neutral, party a set of rules as a guide to the circumstances under which either system should be used.

These rules have been drawn only after practical trial and long enquiry.

CASES IN WHICH THE SYSTEM OF SURFACE MANURING IS BETTER ADOPTED FOR USE THAN CUTTING HOLES.

Rules for Surface Manures.

1. In any drained land with a slope so moderate that displaced earth or stones remain as they lie and do not roll down hill.

2. In any land, or under any circumstances, when the use of the digging fork is possible and expedient.

3. Whenever, with due regard to the preceding rules, the manure is quickly soluble, or speedily fixed by the earth, as Salt, Sulphate of Ammonia, or Guano.

4. When the soil is light and porous, and naturally adapted to pass, the elements of plant food rapidly through the earth.

5. Whenever the supply of maana grass available enables one cooly to litter 30 trees per diem with four inches of the grass.

6. Generally in districts with extreme climate *in conjunction with maana grass.* If the climate be very hot and dry the litter keeps off the sun's rays from manure and rootlets. If the climate be cold and wet, heat is retained by the litter, and the soil rendered porous and friable.

CASES IN WHICH HOLING IS THE PREFERABLE SYSTEM FOR THE RECEPTION OF MANURE.

1. In steep land, (especially if undrained. Although I must not be held to countenance the application of manure until a perfect drainage system is introduced. There have been cases in which manuring has preceded draining against all theoretical propriety, and good crops have resulted.)

2. When neither labour for working bulky composts into the soil, nor maana grass for littering, are available, it is better to bury them in holes than to spread them to bleach and shrivel in the sun.

With regard to the manner of application, one favourite plan is to scrape the earth away from the tree without injury to the root, to mix the manure well with the soil so scraped away, and to return it to the tree, covering the mass with soil taken from the drains or from the centre of four trees.

Another method is to manure only in showery weather, using a fork bent like a mamotie, digging the manure well into the soil round the tree. This plan is followed on some of the very finest coffee in Ceylon.

The system of manuring with maana grass has been described.

Digging the manure into the soil with a fork is perhaps the most thorough and beneficial plan of all.

In cutting holes—a semi-circular form from six to eighteen inches deep, and nine to eighteen inches from the stem is a common type. By using the mamoty care fully and *parallel* with the large roots they need not be much injured. Occasional injury is inevitable.

In the centre of four trees large holes two feet square, and from nine to eighteen inches deep, are prepared by some. This type of hole

attracts all roots equally, and if root surface be excised, the injury is confined to the extremity.

When cut between each alternate row of four trees, the unmanured portion still receives nourishment from one side. The succeeding year holes in the intervening rows can be cut in a similar manner.

In very steep land it is well to cut oblong holes above and in a line with the stem. Gravitation and the porosity of the soil then make the most of the manure.

ROTATION IN POSITION OF HOLES.

If the hole system be adopted it is well to vary the position of holes in successive years. Much of the benefit claimed for surface manuring is thus unquestionably attained, and every part of the soil fortified in turn.

Renovation of the land by systematical variation in the position of the hole, when circumstances do not permit of surface manuring, appears to embrace more valuable characteristics of surface manuring.

By manuring on this plan for a term of years the soil can be fertilised twice throughout in a decade.

TIME OF APPLICATION.

The question as to the right time to manure, depends to a certain extent on what is required, whether support under a heavy crop, the maturing of berry, or the production of healthy wood.

When coffee displays symptoms of over-bearing, it is evident that the time for manuring has been unduly postponed. The setting of a heavy blossom is the signal for prompt assistance, and to wait for the yellowing leaf and the blackening berry is suicidal. At once on such signs, apply a bulky well-made compost, with an earthy phosphate. Take anxious care that the mode of application dispenses with the necessity of cutting a single rootlet. Mouths are needed. As a rule, when matters are suffered to reach this stage, all that can be expected is to ward off, and support the tree under, subsequent exhaustion. The same manure applied earlier would probably have matured the crop without impoverishing the tree.

APPLICATION OF MANURE DURING GENTLE RAIN.

To bring crop to maturity with such success that no demand is made on the strength of the tree beyond its power, bulky composts and manure should be applied as soon after crop as possible. Poonac and phosphates, if administered alone, may be applied later on. The latter are most advantageously applied during gentle rain. Manures, particularly of Ammoniacal descriptions, or preparations of Guano, applied during the gentle showers, have a pronounced and more speedy effect then when applied in a dry weather.

Except for over-bearing trees, and in the manner spoken of, a period of *at least* two months should elapse between any disturbance of roots and crop time. Amputation of root surface is best accomplished during the period of partial rest, viz., immediately after crop than at any other time in the year. Of two portions of an estate, one of which is to be manured on the holing system, and the other by some adaptation of the surface plan, it is better

to cut the holes as early in the year as possible, and to leave until later the portion which will receive disturbance of root surface.

The planter, with a little foresight, can easily judge for himself when and how a manure should be applied. The proportion of Ammonia in the manure, the slope of the land, and the condition of the trees, will always form the elements for a decision.

TERRACING, DRAINING, AND DIGGING.

TERRACING.

Terracing is an operation, which, carried on in conjunction with manuring, is perhaps adapted to secure the permanence of coffee better than any other method of retaining the soil. Where suitable stones are close at hand, the expense is not excessive. This, however, is rarely the case. In few instances is the systematic terracing of a whole Estate possible—while the plan is feasible on parts of almost all. Where stones are at hand, and on the surface, a cooly can terrace forty trees per diem at a cost of Rs. 12·50 per acre. When stones are scarcer it is a good plan to place a man and a boy in the same time; the man to collect, and the boy to build the stones in position. Flat, heavy stones should be placed as the lower layer, in a perfectly horizontal position, at a foot from the stem. Manure well mixed with the earth should then be filled in up to the collar of the roots. Logs or trunks of trees may be utilised in a similar manner when they lie across the face of the hill.

Terracing, accompanied by draining and hand weeding, reduce to a minimum if they do not absolutely remove, the danger of wash. Whenever it is feasible, the rows of coffee immediately above the estate paths should be terraced. A signal improvement in the appearance of the property is hereby produced, and an impulse given to its permanent productive powers.

DIGGING.

The aeration of the soil by digging is the only method of tillage possible on coffee estates. Its effects are various as they are beneficial. Stiff soil is rendered friable; rootlets work their way in search of food with comparative ease; the land absorbs all but the very heaviest rains, and wash is almost entirely prevented. Coffee that had not responded to two successive applications of manure, has been known to yield a heavy crop after being dug to the depth of ten inches.

The best time for digging is as soon after crop as possible. Some planters maintain that it is possible to dig the soil thoroughly without injury to the roots. It seems to me that the two are incompatible. Roots which already penetrate the soil in all directions are necessarily displaced when the soil is thoroughly turned. Careful supervision will reduce this disturbance of roots as much as possible. Care should be taken that the fork is used in a vertical position, so that it enters the soil to its true depth, and that every root is covered. Two or three forkings of earth should be placed round each tree.

DIGGING IN MANURE.

Digging can always be undertaken in conjunction with manuring operations. It is little or no more work for a cooly to dig in a bulky manure already spread on the ground, than to dig the soil only. Manures in a powdered form can be sprinkled before the labourer, and the very most is made of manures that are well dug into the soil. The largest possible surface is brought into contact with the soil, and the certainty of the roots making a successful search is thereby much increased.

Some writers claim for digging almost incredible virtues. There is no doubt, however, that on flat or moderately sloping ground, especially in stiff soil, that digging is a remunerative operation. It is a sign that vegetable composts are needed when land cakes and dries after digging.

THE FORK.

The tool which causes the least injury to coffee, and at the same time most thoroughly penetrates the soil, is the ten-inch four-pronged fork. Coolies quickly learn how to use it.

COST.

The cost of digging should not exceed Rs. 12·50 per acre.

DRAINING.

Manuring is an operation which can only be profitably carried out after steps have been taken to preserve the soil from waste by flood. To renew soil which every shower dissolves is the act of a man with too much capital. To insist on a thoroughly methodical plan for the drains of an estate, and to see them maintained in good order and condition is the act of every planter who contemplates manuring.

Draining equalises temperature, removes superabundant moisture, warms the subsoil. Stiff land is rendered friable and mellow, and carbonic acid is produced in greater abundance.

A well cut drain should carry off wash, never silt up, overflow, burst or wear a ragged and irregular channel. Too light a gradient will choke a drain; with one too severe, it will tear in a few years a water course of great size, much soil will be brought away in masses, and irreparable injury be inflicted on coffee and its neighbourhood. Heavy gradients in soft and porous soil always tend to an undue increase in the size of the drain.

GRADIENT.

The medium between these opposite evils is hit by a gradient varying, according to the length of the drain and the nature of the soil, from 1 in 13 to 1 in 20. Short drains may have heavier gradients than long; and porous, light soil should always be cut with gentler slopes than hard, impenetrable soil. For general purposes 1 in 17 is found to answer well. A clearing drained on this gradient in May last has needed no attention since. None of the drains are less efficient than when they were opened.

SIZE.

Drains should be at least 18 inches wide and deep, and if more than forty feet apart should be two feet deep. Drains have to carry off not only soft showers but furious storms of rain. It may assist the imagination to picture what an inch of rain falling over a square mile is when we remember that it is equal to 14,500,000 gallons; or, in other words, sufficient to supply a town of 33,000 inhabitants with 20 gallons each daily for a month. Two, three, and even four inches of rain in 24 hours are by no means unusual at the bursting of the monsoons. The damage done on these days of exceptional rainfall, unless ample drainage is provided, must convince the sceptical that large drains are, in the end, the truest economy.

VERTICAL DRAINS.

Drains should deliver themselves into the natural ravines. Exception is taken by many planters to the cutting of vertical channels. In the absence, however, of natural gullies, it is necessary to have recourse to artificial substitutes. On a hill-side, between two ravines a point midway should be marked from which a drain should be traced downwards in either direction. At a distance of seven trees below, another pair of drains should be traced. A symmetrical and efficient system is thus maintained. Drains meeting a road should approach from the same quarter as the road; otherwise the first flood destroys the road at the point where the conflicting currents meet.

Some planters, disliking side drains to the estate paths, cut a drain a few feet above the road on a similar gradient. The road is maintained in an efficient condition with greater ease, and the drain is not exposed to chance obstructions from traffic, &c.

A radically bad system prevails on some estates, by which side drains are delivered into the coffee. Road drains should have a proper outlet every three chains by a drain cut below the road to the nearest ravine. Drains crossing estate paths should be either substantially covered in with flat stones, or made with wide bottoms and gently sloping sides.

Incomplete and slovenly draining is money wasted. A choked or broken channel concentrates injury, which, diluted over a large area, might possibly do no harm.

COST.

The cost of draining varies. In light and friable soil the task is a chain of 18 inches per diem per man. In heavy land half the task may be good work and cheap.

SILT.

The silt from road drains should be thrown *above* the road. Coolies, to save themselves trouble of course prefer the lazier method.

With ordinary intelligence and care, land of almost any feature can be drained. It is rarely that drains cannot be cut even in very rocky land.

SECTION V.

MANURING AS AFFECTING LEAF DISEASE.

As elsewhere, the estates with which I am connected have been affected with leaf disease. Trees of every ages, condition, and elevation, have been alike infected. The only difference observable has been on the recurrence of an attack, after a temporary immunity from the pest. In this case well-pruned and cultivated coffee has borne the attack when shuck trees have succumbed. When the disease quitted the estates in October, the coffee of a vigorous type—vigorous from cultivation, renewed itself with marked rapidity. New wood formed, and the fresh flushes of leaves were untainted with a spot. Not so the unmanured coffee. Apparently exhausted rather than poisoned, it improved but slowly. Coffee manured with Cattle Manure ... ... ½ basket.
Pulp ... ... ½ do.
Steamed Bone Dust ... ... 4 oz.
recovered its normal appearance more speedily and more thoroughly than coffee treated with artificial manures exclusively. In connection with this fact, I find some of my neighbours have remarked a similar difference.

From these observations I cannot but support the theory which places exhaustion as the effect of leaf desease upon coffee, and not poisoning of the sap. Blossom appears to be unaffected, large Blossoms appear again and again, only to excite hopes not distined to be fulfilled. Attenuated crops and light beans in large proportions point to exhaustion as the effect, not to poison as the cause.

That the disease is eminently contagious I found by attaching diseased leave to a healthy tree. In four instances out of five the spores so communicated were visible within twenty days.

I have seen trees die from no cause that I could assign other than leaf disease. On the other hand I have seen an almost leafless field mature a heavy crop. This was, however, the first year of its attack.

Deprivation of its lungs must necessarily lower the vilality of the tree, and, as in the case of overbearing, assistance from without is imperatively

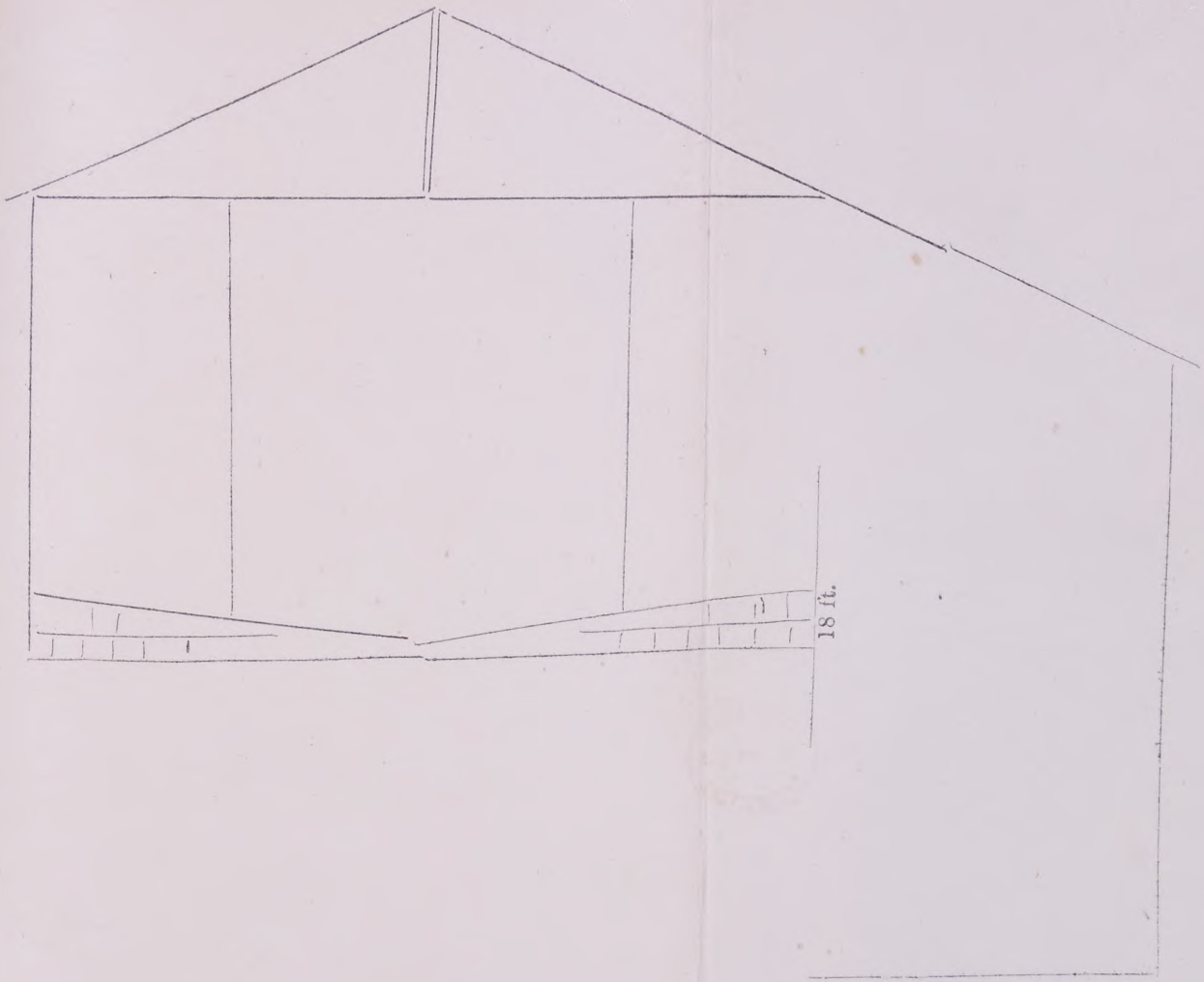
called for. The action of manure should therefore be recuperative, not stimulating. Food, not medicine is, required. Artificial and ammoniacal manurers seem less suited for diseased trees than nutritive and bulky composts.

Cultivation more diligent and more attentive is needed when coffee is infected with *H. Vastatrix*, than when it is in health. Excessive moisture, drought, shade or wind, appear to do more injury to the tree than when in its normal state. Unless this increased diligence in cultivation be given, the Colony and the planting community are threatened with graver ills than we as yet have known. A relapse of the island from its present position to that of a costly military station, retained in the Empire for strategic reasons alone, is a result by no means impossible if the warnings of leaf disease are neglected.

May God avert this blow! May the planter say with truth, as did that other planter in the "days of old" "If my land cry out against me, or "the several furrows thereof likewise complain, let thistle, grow instead of "wheat and noisome weeds instead of barley."

"PALMAM PERSEVERANDO."

FINIS.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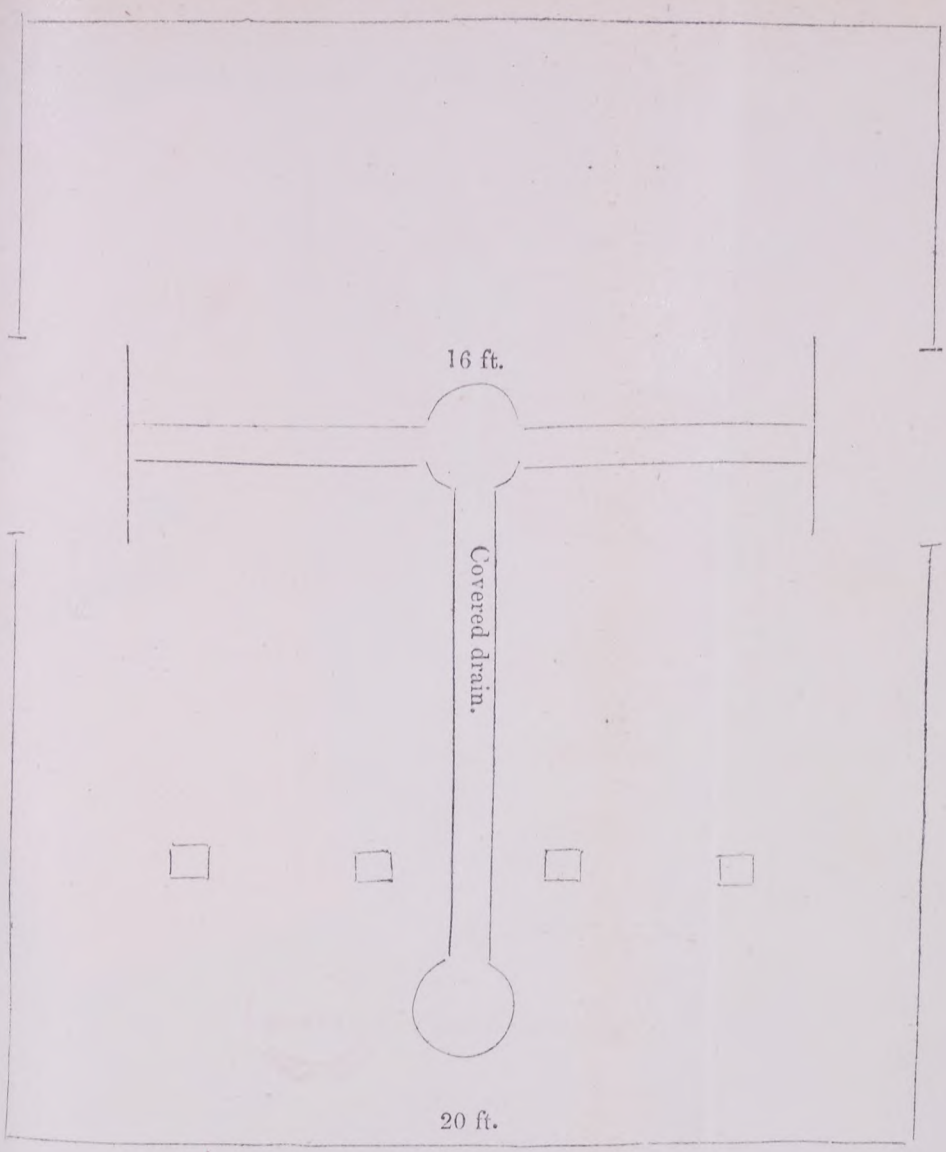

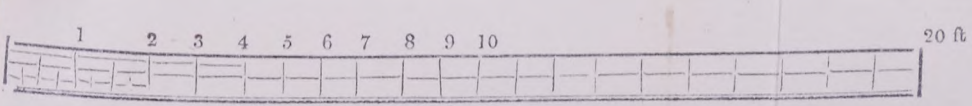

Plan of Cattle Shed for Eight Beasts.