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SOIL REJUVENATION WITH CRUSHED BASALT IN MAURITIUS

Part II—The fertility of basalt and its nutritional effects

By O. D'HOTMAN DE VILLIERS

There is, in Mauritius, a striking scenery: "La Selle is distinguished from the neighbouring hills by its bareness; the jungle stops abruptly and the saddle ridge bears only a thin cover of grass. This sudden change in the character of the vegetation is due to a change in the character of the rocks. East and West of La Selle is formed of olivine basalt, which gives a deep rich soil under the influence of tropical rains, but the trachyte of which the saddle itself is composed yields a meagre stony soil in which the palms seem unable to get a footing," says Prof. S. J. SHAND, cited by N. CRAIG[1] who gives an analysis of the trachyte showing percentages of 0·02, 0·01 and trace respectively of oxides of Ca, Mg and P, as against, in basalt, about 10 Ca, 8 Mg, and 0·25 P on average. A comparative example of the fertility and *weatherability* of basalt has thus been powerfully established by Nature.

"On these maps we see how a complex of settlements lies between Soekadana and Boemidjava precisely on an outcrop of basalt, while on the surrounding acid stuffs no population at all has established itself. . . . In such ways, along empirical lines, the native population demonstrates the close connection between parent rock and soil fertility. . . ." says Prof. JULIUS E. MOHR[2].

But perhaps still more demonstrative of all is, in Mauritius and in the sister island Réunion, the establishment of higher natural vegetation in rather fresh crevices of large masses of basaltic rocks, particularly on mountain slopes.

In the previous article were cited the successful growing of tomato plants in pure crushed basalt fertilised with nitrogen, exclusively, together with the significant results of H. EVANS and S. M. FEILLAFÉ, the former using nitrogen alone in one case and the other nitrogen and phosphorus. As to the latter study, the fact that it was found that basalt was effective in the senile yellow soil *but not* in richer soils, is of specific value. Indeed, this fact largely excludes the probability of some physical effect, as recently suggested by PARISH and FEILLAFÉ[3], since it is most unlikely that the rock dust would have produced a very beneficial aeration effect in the senile soil *and not* in the richer soils—especially since the soil, in pots, usually is in the very best state of physical preparation or tilth. In this respect, it is necessary to mention that the senile yellow soils of the super-humid regions, containing 5–7% organic matter and today called "humic latosols," are not very compact and greatly in need of permanent improvement in physical condition. On the contrary, N. CRAIG writes[4]: "These soils are characterized by very good crumb structure . . ." and what follows is the greatest praise of the good physical conditions of these soils composed of very stable aggregates of the clay which contains up to 93% of hydrous oxides of iron, aluminium and titanium and—this is of fundamental importance—as low as 5% silica. So stable is the structure, that it is possible to cultivate the land within a short period after heavy rainfalls without doing any harm to the physical condition.

In addition to the already cited striking results with large doses of crushed basalt with trees on poor forest lands, R. ALBERT[5] found a several-fold increase in available plant foods in the soil of plots treated with basalt, and A. NĚMEC[6] observed increased nutrient uptake by oak and larch under rock dust. Thus, to all these European investigators the emphasis is on the nutritional effects of basalt applied in large doses to poor soils (sands and podzols) and if, under the relatively low rainfall and low temperatures of the Continent, such important results are obtained, it can easily be realised that under 100–175 inches annual rainfall and tropical temperatures, the rock dust will much more readily yield its elements of fertility to the acid (pH 4·7–5·5) senile soil rich in organic matter and to the acid exudate of the roots of cultivated plants—not to forget the action of the micropopulation of the soil fauna and flora, or biological weathering. In that latter connexion, are to be cited the fascinating investigations in Russia and Yugoslavia[7, 8] relating to the breaking down of non-exchangeable potassium and other plant foods into exchangeable forms by specific micro-organisms acting on rock silicates.

Moreover, the basaltic rock, in Mauritius, and probably elsewhere, is not an entirely dry stone and the moisture, slowly acting for very long periods, has rendered already fairly available, through a

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1 *Mauritius Sugar Cane Research Sta. Bull.* (4), 6.
2 "The Soils of the Equatorial Regions with special reference to the Netherlands East Indies", p. 533. (Translation by Prof. ROBERT L. PENDLETON.)
3 *Mauritius Sugar Ind. Research Inst. Ann. Rpt.*, 1958, 81.
4 *Mauritius Sugar Cane Research Sta. Bull.*, (4), 7.
5 *Forstarchie*, 1940, **16**, 231–232.
6 *Soils & Fertilizers* (Imp. Bureau Soil Science), 1953, (215), 49.
7 ALEKSANDROV: *ibid.*, 1950, (904), 171; 1951, (179), 46.
8 TĚSIČ & TUDOROVIČ: *ibid.*, 1953, (564), 116.

process of hydrolysis, quite interesting quantities of plant foods as revealed by laboratory studies. A one per cent. solution of citric acid can extract as much as 1·47% silica; 1·02 magnesia; 0·198 lime and 0·053 potassium oxide from the fine sand of crushed basalt. In another study in which the fine sand was *repeatedly* extracted with a one per thousand solution of nitric acid, it was found that calcium, magnesium, phosphorus and potassium after being notably soluble in the *first* extract, became much less soluble in subsequent extracts. In such a phenomenon is perhaps to be found the reason why large quantities of crushed basalt on very poor soils can give high increases in yield at a *first* crop and then, very sharply, much lower but still very interesting figures in a more or less regular manner for a long series of subsequent crops.

It must be constantly kept in mind that, as in two of the previous field trials, heavy fertilizer treatment was applied to all plots at Rose Belle. Now, as is well known, the results of application of increasing doses of plant foods should follow, and often do so, the classic law of diminishing return. It is therefore suggestive that the yield figures for plant cane at Rose Belle set a most regular diminishing return curve from the application of increasing doses of crushed basalt; even more remarkable than the one obtained by the writer[9].

Except quite significantly for silica as observed by the writer, no percentage increases in major plant foods have been found in cane leaves from basalted plots as compared with control. We should however not lose sight of the fact that the *total* weight of leaves on basalted plots was probably notably higher at time of sampling so that notably more plant foods were, in reality, contained, *in total*, within all the leaves on basalted plots, in correct book-keeping.

Anyway, at crop time, for plant cane, we remember that the increase in yield of millable cane reached the impressive 100% mark. The increase in entire plant weight—not forgetting the roots and the dead leaves fallen down during the growth cycle—must have been even higher. Consequently, the weight of all essential and useful elements *other than N.P.K.*, like Si, Ca, Mg, Na and the numerous micro-nutrients, on the syn-tonic interactions of all of which, concurrently with N.P.K., the obtaining of the *highest possible yield* depends, the weight of these elements, it is to be emphasized, within the plants on the 180 tons/acre basalted plots, must have been at least double the weight within the cane on control plots.

In view of the fact that the soil under experiment is among the poorest known, and in the light of accumulated evidence regarding the nutritional effects of basalt, it seems practically certain that it was mainly the already slightly weathered silicates of the rock dust which have supplied the plant with this 100% increase in weight of all these mineral elements, and were indispensable for the production of the 100% increase in yield of millable cane on the most heavily basalted plots.

Indeed, as exhaustively established, the senile yellow soils in Mauritius and elsewhere in the tropics where the rainfall exceeds 90–100 inches a year, are not only devoid of exchangeable bases the sum of which may be as low as 2·3 meq % dry soil, but are also nearly devoid of primary and/or secondary rock minerals. The absence of the latter is shown by a fine sand content in silica as low as 3·7%, as against 35–37% for the very rich soils of the sub-humid regions, which dryer soils, therefore, contain large reserves of primary and/or secondary rock particles ("juvenile weatherable material")—the *silicates* which are the very backbone of complete soil fertility, of particular importance in tropical conditions, as emphasized by the eminent tropical soil scientists Prof. JULIUS E. MOHR and P. VAGELER. To complete the picture, the subsoil which usually goes very deep underneath the senile yellow soils, is even poorer, if one can say so, than the artificially maintained arable layer less than a foot in depth.

Of all the elements suppliable by large doses of crushed basalt, especially to a first crop of plants grown on senile soils under 100–175 inches annual rainfall, magnesium, calcium and silicon, together with not negligible amounts of potassium and phosphorus are, naturally, those the plant would use the most. It is suggested that such elements, as well as the micronutrients which are also contained in basalt, will, owing to their rather low water solubility as silicates, come gradually at the disposal of the plant throughout its entire growth cycle. This is very different from the application of concentrated or soluble fertilizers in one or two doses under the heavy tropical rains. It is even very probable that heavy fertilization with one or two doses of potassium and ammonium salts will increase the detrimental deficiency effects of calcium and magnesium in the soil and plant.

Although the ash of many plants, including sugar cane, contains up to 50% silica, little is yet known as to the function of silicon in the plant metabolic processes—except that it is called the skeletal element and that it affects the mobilization of phosphorus in the soil. Moreover, cases exist of increases in yield due to the use of soluble silicates, including growth results of sugar cane obtained by the University of Hawaii. But what is a most interesting and specific study is the one made by E. M. BASTISSE[10] of Versailles, in which plants were grown in culture solutions at pH 5·0–5·5 containing increasing quantities of silica and, except for the control series, either freshly precipitated iron and aluminium hydroxides or lateritic soil (like the senile yellow soils). The higher the silica the greater were both *yield* and (with some exceptions) the phosphorus content of the plants. Irrespective of the final pH, phosphorus in the solution was increased by the presence of silica. Increased use of silica in phosphatic fertilizers is advocated; thus confirming similar findings and recommendations by other investigators.

[9] *Rev. Agric.* (Mauritius), 1947, **26**, 170a.
[10] *Soil & Fertilizers*, (Imp. Bureau Soil Science), 1952, (1699), 335.

One hundred-and-fifty tons of crushed basalt per acre will bring, in the senile lateritic yellow soils, over 70 tons of silica of which about two tons will be soluble either in a one per cent solution of citric acid or in a one per thousand solution of nitric acid.

And as it is well established that P_2O_5 anions are energetically fixed, immobilized in lateritic soils of very low silica content, *one* of the beneficial aspects of the addition of large quantities of crushed basalt to these soils can thus be understood.

THE SUGAR CANE IN INDIA

Proceedings of the Conventions of the Sugar Technologists' Association of India, 1959 and 1960.

1959

A BRIEF note is given by M. V. DIVEKAR of the change of variety effected in the Bombay State since the early fifties when the standard cane, Co 475, succumbed to rust. The new variety is Co 775, a cross between POJ 2878 and Co 351. Comparative data of yield, fibre and juice quality factors for Co 775, Co 419 and Co 475 are given. It produces the golden yellow juice of Co 475 apparently as a result of the low content of K_2O and CaO and the high content of P_2O_5 and N.

The three systems of irrigation, flood, furrow and overhead, with their costs, are compared by B. K. S. JAIN; and S. C. SEN and RAJENDRA PRASAD record the effect of spraying gibberellic acid up to 4 times on small plots of wheat and sugar cane, and on wheat in pots. The increased yield of grain found in wheat is not repeated in the case of sugar cane.

A record is given by B. N. PRAMANIK *et al.*, of the Shahjahanpur station, of combinations of groundnut cake and ammonium sulphate in various combinations, the latter broadcast, along the line and in pellets. Groundnut cake at 60 lb/acre N was superior to all other treatments in yield of sugar/acre.

In view of the fact that the lower Gangetic plains are frequently flooded, S. C. SEN and M. FAROOQUE subjected canes in drums to varying degrees of flooding after complete submergence for a week. The respective damage to tissues and juice quality are recorded. In contrast, A. N. KAPOOR gives an analysis of the effect of the Bihar drought of 1957-58 (25 inches of rain against a normal 40–45 inches) by comparison with 1956-57 both as regards yield of cane and quality of juice.

Different responses are found according to the nature of the soil and, under normal cultivators' conditions, the responses reflect these differences. Figures were collected during a village soil survey on two types of soil, one underlain by a hard pan and subject to waterlogging. Differences of yield and juice quality are presented by B. N. PRAMANIK *et al.*

A practical application of harvesting on the basis of maturity as determined by hand refractometer readings and the issue of "challans" based thereon, is described by S. C. SEN *et al.* The area concerned is that of the Neoli Sugar Factory situated in the Etah district, U.P.

G. R. ATHAVALE and S. L. PHANSALKAR comment on the difficulties, including cultivators' suspicions, accompanying the decision of Government to adopt the metric system, and give conversion tables for maunds and cwt to kg.

1960

Ratooning in the Gangetic plains is a fairly recent introduction and D. C. AGARWAL and R. A. GUPTA discuss, for the Western U.P., the effect of date of harvesting plant cane on the subsequent ratoon crop. In the 3 varieties considered there are characteristic variations both in number of shoots and yield of sugar per acre. With Co 313 mid-November harvesting gave the best results followed by mid-February. Both in Co 421 and Co 453 a steady rise in yield occurred with a delayed harvest from mid-November to mid-April.

In a comparison between ammonium sulphate and chloride fertilizers, H. SINGH and S. C. SEN show, by leaf, juice and bagasse analysis, the relative adverse effect of the latter. S. C. SEN and A. P. GUPTA, by means of moist sand to which superphosphate and Fe_2O_3 were added, measured the large fixation of P in the presence of Fe. S. C. SEN *et al.* also compared single and double precipitation methods as $Mg_2P_2O_7$, and as quinolinate $Mg(C_9H_6ON)_2$ with the volumetric method for estimating Mg.

A comparison of plots under different degrees of irrigation, subsequent to the monsoon, up to continuous submergence under 6–9 in water is made by S. C. SEN and HARPAL SINGH. The results, confirmed in a repeated trial the following year, indicate a distinct improvement in juice quality from submergence. Rapid deterioration takes place after the land dries and submerged cane should be cut at once or kept submerged by irrigation.

In the Northern (Gangetic) sugar belt, cane planted in February or March is subjected to intense drought until mid-June. An irrigation, where water is available, is beneficial. H. P. VARMA *et al.* describe trials with both trash and paddy husk as a protective cover in addition to 2 or 4 irrigations and find a lower production of shoots, counterbalanced by a lower mortality, better control of weeds and increased yield.