Notes on the use of By-Products of the Sugar Industry as Fertilizers.

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That an enormous quantity of valuable and expensive plant food can be, and is, lost every year, as a result of wasteful methods on the part of the planter and miller, is obvious to everyone who has noted the analyses of these by-products, and these losses were discussed in a paper by Dymond in the Sugar Annual for 1923 and one by the Writer in 1924. For the Natal figures quoted below, the write is indebted to Mr. Dymond's analyses.

The reasons for these losses taking place are probably:—

(1) The value of the plant food lost is not realised.

(2) The difficulties to be overcome in making the most scientific use of the material are considerable.

(3) It has not been demonstrated definitely and finally what return would be obtained by the industry if a better use were made of the By-Products (*i.e.* from the fertilizer standpoint).

By plant foods I mean the Nitrogen, Phosphoric Acid, Potash, etc.,—neglecting for the moment the value of the organic matter as distinct from these essential plant foods.

TOPS AND TRASH:

Assuming a yield of 30 tons of cane per acre, Natal figures showed that the tops and trash contained 49 lbs. Nitrogen, 10 lbs. P_2O_5, 110 lbs. K_2O and 48 lbs. SO_3, and while it may be assumed that a good deal of the mineral in the ash is not lost when burning the trash, this does not apply to the Nitrogen which passes off into the air. The planter, of course, loses all the plant food in any trash or tops left the cane sent to the mill. The loss of Nitrogen alone per acre in Natal if neither trash nor tops are returned to the soil, is equivalent to a dressing of 300 lbs. Nitrate of Soda or 250 lbs. Sulphate of Ammonia, costing over £2. Deerr estimates the value of Nitrogen in the leaves and other waste matter in the total sugar areas of the world at about £20,000,000 per annum, a very large proportion of which is lost by burning trash.

BAGASSE:

The amount of Nitrogen lost by burning bagasse is comparatively small, say 5% of that contained in the trash and tops. A large portion of its potash is lost when using the bagasse as fuel, either as flue dust or in a useless slag, but even then (to quote Dymond again) the ash contains 4½% Potash and 1½% Phosphoric Acid, and should, therefore, be returned to the soil.

FILTER PRESS CAKE FROM THE MILLS:

According to Deerr, the press cake from 30 tons of cane contains 18 lbs. of nitrogen and 23 lbs. P_2O_5, and an average analysis given by Dymond showed 1% nitrogen and 1½% P_2O_5. There is practically no potash in the cake. Figures showing the amount of press-cake produced annually in Natal are given in Mr. Dymond's paper which you have before you.

According to Deerr, of the whole of the plant food removed from the soil, 70% of the nitrogen and 70% of the potash are to be found in the leaves, etc., most of the remaining nitrogen being in the press-cake and most of the remaining potash in the molasses. It has already been pointed out by Mr. Dodds that the plant food in a given tonnage of cane is far higher in other cane areas than in Natal. Recent average figures for 3 varieties of cane in Hawaii show that in 30 tons of cane when cut there are 120 lbs. Nitrogen, 55 lbs. P_2O_5, 380 lbs. K_2O, a total of **555 lbs. of** plant food as against 250 lbs. in Natal. It would be interesting to know to what extent this difference is to be attributed to the poverty of our soils, whether the deficiency is an indication of the amount of available plant food in the soil, or if Uba cane normally requires less plant food.

It should be added that the above figures can be only approximate; analysis of the plant varying according to the age of the cane, the class of soil and the amount of fertilizer used, and also, that there is nothing new in these figures; they are compiled in order to have them in a handy form, and as an introduction to the following remarks. No mention has been made of the lime and sulphur removed in the crop, but the amounts are considerable and the loss of either of these may be of importance in certain soils.

Assuming then that it is agreed that enormous quantities of nitrogen and potash (particularly the former) may be lost or recovered in the above materials, how can these be used to the best advantage ?

TRASH AND TOPS:

In Hawaii and Java, which are perhaps the most efficient cane growing areas in the world, trash is burnt.

In Mauritius and British West Indies, most of the trash is used as bedding or litter for the animals working on the estates, and is then returned to the soil.

In Cuba and Natal the usual custom is to let the trash rot in the fields, where it lies as a blanket.

Although this subject of "trashing" has been so frequently discussed at Sugar Conferences, I hope to be pardoned for referring to each of the above methods in detail.

1. BURNING TRASH AS IN HAWAII AND JAVA:

The most recent Hawaii report I have seen, in which the effects of burning trash are discussed, was presented to the Association of Sugar Technologists, Hawaii, in 1923 by McGeorge. There, it is stated that this practice does not deplete the soil of its organic content "the roots and stubble presumably being sufficient to keep it up." It is claimed that repeated experiments showed little or no advantage from burying the trash, and it is suggested that this may be due to the unrotted nature of the substance. The report applies apparently to the irrigated areas and Deerr states that on the rainfall estates, marked improvement (about 25%) has resulted from burying or partly burying the trash, the decay of which is hastened thereby. It is unfortunate that the cause of such contradictory results has not been fully investigated so as to reconcile the apparent contradications.

Java conditions are totally different from those in Natal owing to the rotation of crops and non-ratooning of cane, so no comparisons should be made.

2. USING TRASH AS BEDDING IN THE STABLES:

If this method is carried out correctly, *i.e.*, if the rotting product is not left too long exposed to air and rain, it is by far the most scientific way of dealing with trash. Most of the plant food is recovered (although there is some loss of nitrogen) and the product is in the right form to become thoroughly incorporated in the soil, and so form humus.. A similar method is adopted on at least one estate in Natal, the urine from the mule stables being pumped over heaps of waste vegetation, such as grass and reeds, but I know of no case where trash is treated in this manner.

That there are practical difficulties in the way of so treating all the trash of our cane fields I fully realise, but before we can discuss difficulties, we must first determine what benefit would be obtained by adopting this, or any other method.

3. The Cuban and Natal method is recommended by Deerr, who says "not only is it (trash) returned to the soil, but it acts as a mulch, preventing surface evaporation, and to this custom the long continued fertility of much of the Cuban cane lands is to be attributed."

I do not agree with this statement, judging from observation in Natal, and I doubt very much whether any large portion of the valuable nitrogen and organic matter in the trash is returned to the soil at all by adopting this method. What takes place generally (thanks perhaps to our comparatively dry climate and winds) is that the trash undergoes a slow combustion, resulting in a loss similar to that obtained when trash is burnt. Certainly there is a gain owing to the trash mulch reducing the evaporation of soil moisture and weeds are kept down, but that is all. Experiments are now being carried out in order to study what does happen when trash is treated in various ways, but only careful experimental field work for some years will determine what is the best method to adopt.

General experience would lead one to recommend that trash near a mill should be collected, mixed with bagasse ash (or failing that a little lime) press cake and any waste liquors, etc., from the mill, water added, and the whole allowed to rot, stable drainage being added where possible. A very valuable compost is thus formed, which, when well rotted, is the ideal material to return to the soil. If heavy dressings are used per acre (say 15 to 20 tons) they should be applied and ploughed in a couple of months before planting, as nitrification is reduced, or even stopped, for some time after the application.

At greater distances from the mill, artificial methods of rotting the trash should be tried. This is being investigated by Mr. Dodds at the Experiment Station, and also at Umbogintwini. Knowing the analyses of the waste materials that are available, it is possible now-a-days to state what additions of lime, phosphate or nitrogen are necessary to bring about the most complete and quickest rotting.

Until a great deal more investigation work is done, it will be impossible to compare the relative values of the organic matter (in the by-products of the planter and miller) and the plant foods therein. Neither can be overlooked. It is certainly not correct to assume that any method of returning organic matter to the soil is necessarily beneficial or that it will ensure the full benefit of the nitrogen present being obtained. That the problem is somewhat complicated can be shown by discussing the results of using molasses as a fertilizer.

MOLASSES:

In Java, some 90,000 tons of molasses are returned to the soil every year, and it is stated to have a particularly favourable effect on certain heavy clay soils of poor water-holding capacity.

In Mauritius, too, it is now standard practice to use molasses as a fertilizer, and the most complete investigation of the effects of using molasses in this way, has been carried out in Mauritius, where 4 tons up to 15 tons per acre are used, chiefly with plant cane. It is placed in the holes some weeks before the canes are planted, or is used between the rows after planting. On a cycle of one crop of plant cane and 5 ratoons, a total increase of up to 20 tons per acre is obtained as a result of the one application of molasses. From the agricultural standpoint, the explanations given of the action of the molasses are most interesting. It has been shown:—

(1) That the good effects of molasses are not chiefly due to the plant food present, though 4 tons contain from 160 to 320 lbs. of potash and 16 to 50 lbs. of nitrogen (the lower figure being for Natal in each case). Results using pure sugar containing no potash or nitrogen give good increases of cane, though not quite so large as with molasses.

(2) That the sugars rapidly disappear—practically none being present three weeks after adding to the soil.

(3) That the molasses profoundly affects the micro-organisms of the soil, destroying temporarily those organisms which predominate in soils (including nitrifying organisms) and increasing the number of fungi, moulds, etc.

The final result is greatly enhanced nitrification, but the intermediate processes are still unexplained, and it is still not clear how one application of molasses to a soil rich in nitrogen and organic matter and not lacking in potash, such as in Mauritius, can affect the growth of cane over several years.

It has been shown in various parts of the world, *e.g.*, England and Natal, that the ratio of organic matter to nitrogen in any one area is remarkably constant. Materials such as cellulose, starch, sugars, kraal manure, added to the soil, given favourable conditions, rapidly decompose in such a way that the ratio is unaffected. Further, additions of such materials may bring about an increase of nitrogen in the soil in a form which is readily available to plants.

That excellent results are to be obtained by using molasses as a fertilizer was shown with barley at Rothamsted, England, where 30% increased yield was obtained if the application was in the previous autumn, equally large decreases being obtained if applied in the Spring just before sowing.

The bearing of all this on the problem how best to make use of organic waste materials in Natal, will be at once seen. It would seem that a carefully planned series of experiments should be carried out with a view to isolating the various factors involved, so that the true value of waste organic materials as a source or humus as well as of plant foods can be determined. Not till then can the best use be made of the waste products or by-products of the cane.

ANALYSES OF MOLASSES:

	% Nitrogen.	% Potash.
Beet	1.5	5.0
Hawaii Cane	0.6	4.0
Argentine Cane	0.7	4.2
Natal Cane	0.29	2.1

Again the Natal figures are very low.

CHEMICAL PRODUCTS FROM MOLASSES:

It is obvious from the above that it is wrong to assume that the full fertilizer value of molasses can be obtained by first fermenting the latter and then recovering the nitrogen and potash from the lees or dunder. While a certain amount of solid matter can readily be separated from the dunder, most of the nitrogen and potash remains in the liquid, and can only be recovered at considerable expense, as there are many difficulties in evaporating the dunder and obtaining a saleable product. Potash was recovered in this way during the potash shortage caused by the war, the product of the evaporation being calcined, or ignited, and the residue being leached to extract the potash which is then converted into sulphate by means of sulphuric acid.

Evaporation, without calcining, is the only way in which all the nitrogen can be recovered, and this is as valuable at to-day's prices as the potash. The latter has been recovered from beet molasses by means of hydrofluosilicic acid which may be added either to the molasses or the dunder, thus precipitating the potash.

Potash from molasses can also be obtained by using the latter as fuel, where it is not economically possible to make it all into alcohol. An Hawaiian report (Sugar Technologist's Report 1922) gives an account of three months working with preheated molasses sprayed into a furnace of special construction. The ash contained an average of 28% pure potash with 2% phosphoric acid. A large amount of chloride of potash was volatilised, but it was shown to be possible to recover 90% of the potash under correct conditions.

Dunder from cane molasses can readily be concentrated until it contains 2 to 3% of nitrogen, concentration entailing considerable difficulties. The nitrogen in similarly concentrated liquors from beet molasses is largely converted into cyanides, and many thousand of tons of cyanide are made annually in Germany in this way, but I know of no similar recovery of cyanide or other valuable nitrogenous products from the dunder of cane molasses.

In the case of beet molasses, the waste water is subjected to dry distillation—the amines evolved are heated to 800°C. and so converted into hydrocyanic acid (see Tech. Methods for the Utilization of Molasses, Circular No. 145 of the U.S.A. Bureau of Standards 1924).

None of the methods referred to above for the recovery of potash or nitrogen from cane molasses seem attractive under normal market conditions, but they are worth investigation by your committee. It is difficult to get the full benefit of the plant foods in dunder by applying direct to the soil without an expensive system of irrigation, as the liquor cannot be run on to the same land again and again, at short intervals, while crops are being grown.

GLYCERINE FROM MOLASSES:

During the war, Germany needed all the glycerine obtainable from all sources, for the manufacture of explosives, and a method of obtaining glycerine from beet molasses was worked out, which is also applicable to cane molasses. A small amount of glycerine is always produced during sugar fermentation, but it was not until 1917 that glycerine was successfully manufactured in this way. It was found that in the presence of alkalies (notably sodium carbonate and sodium sulphite) increased amounts of aldehyde, acetic acid and glycerine were produced. The fermentation must be started in the usual manner, and when well established the alkali is added. The yield of glycerine was 15 to 20% of the sugar fermented.

The aldehyde first produced combines with the sulphite to form a stable compound, instead of being reduced to alcohol, and instead some unknown intermediate compound is reduced to glycerine. By increasing the amount of sodium sulphite, the percentage of glycerine produced increases up to the point when the sulphite interferes with the action of the yeast. Correct temperatures and concentrations have to be maintained to give good results, and it is difficult to obtain a good recovery of glycerine from the fermented liquors. A good recovery of glycerine and a utilization of the other products of the alkaline fermentation are essential to success, but the chief factor is of course the market value of glycerine relatively to molasses and alcohol.