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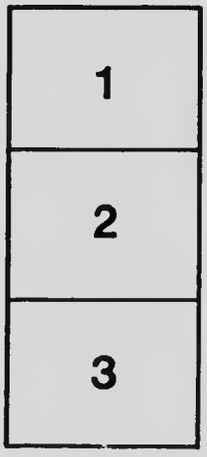

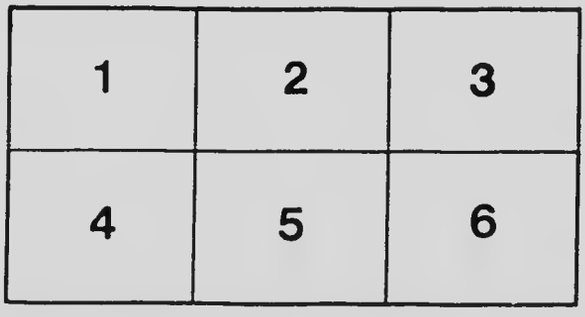

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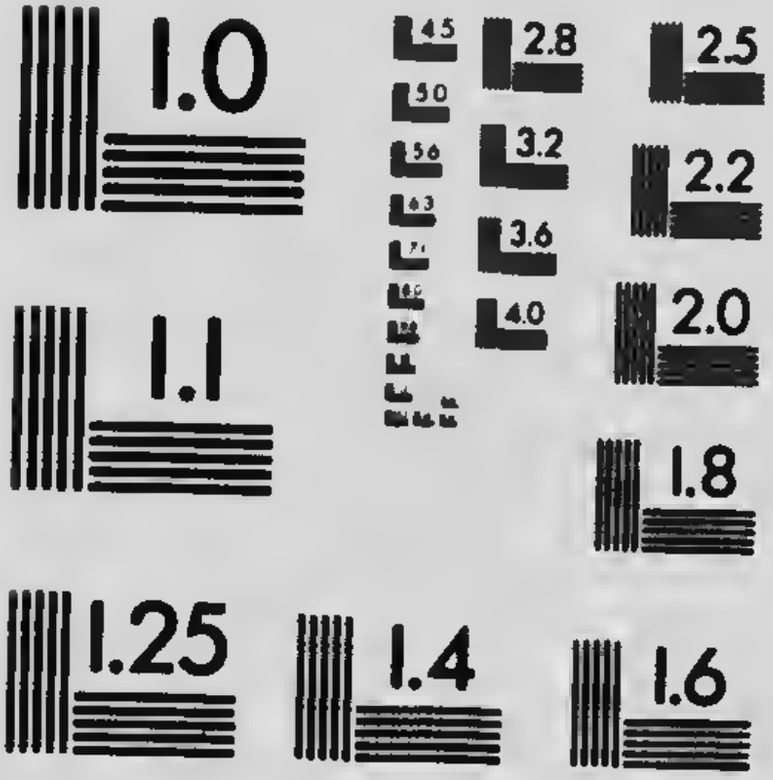

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DOMINION DEPARTMENT OF AGRICULTURE
OTTAWA, CANADA

TOBACCO DIVISION

THE IMPORTANCE OF ROTATIONS IN TOBACCO CULTURE

By

O. CHEVALIER

Bulletin on Tobacco No. A-5

Published by direction of the Hon. SYDNEY A. FISHER, Minister of Agriculture, Ottawa, Ont.

January, 1909

1943—1

OTTAWA, January 6, 1909.

To the Honourable

The Minister of Agriculture.

SIR,—I have the honour to submit herewith Bulletin No. A-5, of the Tobacco Division entitled 'The Importance of Rotations in Tobacco Culture,' and prepared by M. O. Chevalier, assistant agricultural expert in the Tobacco Division.

In this bulletin M. Chevalier demonstrates the absolute necessity for a rotation in order to obtain good yields, and he warns planters to be on their guard against the wasting of their farm manures or the wrong use of industrial fertilizers. They will also find therein the explanation of certain phenomena which perhaps they have not hitherto understood. I recommend that it should be printed for distribution.

I have the honour to be, Sir,

Your obedient servant,

F. CHARLAN,

Chief of the Tobacco Division.

THE IMPORTANCE OF ROTATIONS IN TOBACCO CULTURE.

When we consider the present position of tobacco culture in Canada, one fact immediately strikes us. How is it that in spite of the judicious selection of varieties and of careful attention to details of cultivation, planters are unable to exceed certain yields greatly below those which they are entitled to expect. It appears to me that it will be interesting and useful to look into the reasons for this state of things, and, if possible, to ascertain the practical remedies.

In the first place, notwithstanding the improvements lately effected in tobacco culture, we find that the yields are diminishing every year. This is easily explained by the fact that the majority of planters grow tobacco regularly every year on the same land. It is this successive cultivation of the same plant on the same soil that is one of the reasons for the constantly decreasing yield.

We are aware that tobacco, owing to its short season of growth, is one of those plants that require the greatest amount of fertilizing elements. Indeed a tobacco plant in full growth removes daily from the soil:—

Nitrogen	0·287
Potash	0·289
Phosphoric acid	0·601
Carbon	2·513

Considering also how slow planters have been to make use of manures, whether farm yard or chemical, and that the waste products of tobacco, stalks and stemmed fibres,were frequently thrown away, we see that with a plant which consumes everything and when practically nothing is returned to the soil, the land will speedily become impoverished.

Hardly more than two kinds of soil were chosen for tobacco culture: Virgin soil and alluvial soil, both exceedingly rich in humus.

A tobacco plantation will never succeed without humus. The absence of a rotation and the failure to restore ingredients removed, are the principal causes of diminished yields.

It will not be amiss perhaps if we dwell for a few moments upon the important rôle which humus plays in vegetation. This rôle is in agriculture a leading one. We can discuss it from two points of view: (1) as a means of disaggregation, and (2) as an agent of mechanical change. These two special properties are due to the considerable quantities which it contains of nitrogen and carbonic acid. Moreover, these two processes go on simultaneously. Two alternatives may present themselves: (1) Where the soil is rendered sterile from the lack of humus, and the consequent absence of nitrogen and carbonic acid. (2) Where a small quantity of humus produces disaggregation but causes no mechanical improvement; so that

mutritive elements escape the action of the roots because these soluble materials will be partly drained away by the waters of filtration and partly arrested by clay which as we know possesses considerable powers of absorption. Doubtless the humus itself also possesses a great power of absorption, but we may observe that humus has a tendency to disappear owing to incessant microbic reactions to which it is liable. The result of this disappearance, due to microbic influence, is a production of nitrogen.

The mineral substances, potash and phosphoric acid, are yielded slowly by the humus which recharges itself gradually with those elements which it has furnished to the plants as and where required. We may therefore look upon humus as an indispensable intermediary between the nutritive material prepared by the mineral elements and the organs of growth. Humus is therefore necessary for the absorption of nutritive materials, and we may say that a soil without humus is a body without a soul.

One might conclude that heavy applications of farmyard manure might serve to make good this lack of humus. Possibly it would, but in all cases this practice would only be imperfect, for where the soil lacks humus it lacks also mineral elements, and the soil being poor, the manure will itself be poor, because it is so to speak, the reflection thereof. Never with such a manure can we hope to correct the defects of the soil.

Again, farmyard manure, whatever its state of decomposition, takes a considerable time before it can be transformed into humus.

And then a heavy application of farmyard manure, pure and simple, may have serious disadvantages. In particular it may bring about reversion, that is to say, transition from a soluble to an insoluble condition of the sulphate of ammonia, for instance, which is much used in tobacco culture. The resulting humus forms with the sulphate of ammonia a humate of ammonia which by chemical reaction and also by microbic action may cause reversion, probably by dehydratation, and end in the formation of an insoluble composite amide from which consequently the plant will be unable to derive food.

We must remember also that a soil too rich in humus will, owing to its excessive acidity, delay considerably the process of nitrification, and may even arrest it altogether. And if virgin soils very rich in humus have at first given good yields it was doubtless because the alkaline element had neutralized the injurious excess of acidity. Certain growers, those of Lake St. Jean, for instance, who had omitted to burn the stumps after the felling of their trees, only obtained poor harvests because of the acidity of the humus, which acidity the carbonate of potash resulting from the burning of the vegetable matters could have neutralized.

The application of lime, the use of which seems thus indicated, would, however, only partially solve the problem, for in addition to the difficulties met with in procuring lime and the risks incident to its excessive use it takes a long time to make its influence felt. In fact the nitrification of humus differs greatly from that of minerals incorporated directly with the soil. Salts of ammonia, for instance, as well as those which originate during the development of ammonia generally, nitrify very quickly, these being nitrogenous substances directly nitrifiable. But it is not so with humus, the nitrification of which is very slow, and there are even cases

where the nitrification does not take place at all. It begins only where decomposition has considerably advanced, and it requires the presence of alkaline salts, the function of which is to ensure disaggregation and mineralization of the humic substance. In order perfectly to effect nitrification, nitrogenous materials should be applied in the form of humates. We may observe in passing that the ammoniacal humate is that which contains the largest proportion of nitric nitrogen, whilst potassic and sodic humates will be much less rich. The nitrogenous element in the latter comes entirely from the transformed humus.

We cannot expect therefore to correct the want of humus quickly by heavy applications of farmyard manure. And besides soils naturally fertile are always much superior to others. In the first place they obviate expensive operations necessitated by the maintenance of the productiveness of the soil. Also this natural fertility is characterized by abundant food reserves which give to plants slowly, economically and with precision, the nutritive principles they need. In this remarkable way 'nature truly shows its genius' and justifies the terms 'fat land' or 'land of pristine vigour,' that is applied to soils of natural fertility which it is so important to preserve. It is incontestable that planters, although it was a long time ago, found themselves in possession of soils of this kind. Yet this natural fertility tends inevitably to disappear or at least to decrease rapidly. Removal of the crops, feeding of farm animals, losses of nitrogen at the stable and in the yard by ammoniacal fermentation, all result in rapid exhaustion of soil reserves.

We no longer believe in the possibility of supplying the want of mineral substances by strong applications of chemical manures; in fact these by their nature are very soluble and consequently are apt largely to disappear, especially in tobacco culture which requires a light deep soil that lends itself easily to losses by drainage. The dissolving action of water is not the same on all the mineral constituents of the soil. Potash and phosphoric acid, for instance, do not disappear readily. Sulphuric acid and nitric acid are easily lost. Chlorine also drains away easily, and this in tobacco culture is an advantage, because chlorine has an unfavourable effect upon the combustibility of tobacco. Of all the constituent elements of the soil, it is the lime which disappears with greatest facility. On this point there is an important remark to be made. Tobacco needs a great deal of potash, and in soils poor in lime potassic salts are with difficulty changed into carbonates when they are very soluble; their tendency to drain away is thus considerably reduced. For tobacco it is necessary therefore to choose a soil that is not too rich in lime, and especially because when the snows are melting the excessive washing of the soil renders the draining away of the potash particularly easy. Once they have disappeared many years will be required for the restoration of these valuable nutritive reserves. Doubtless these substances are not lost since they accumulate and will become operative some day; but this is not the object aimed at by the use of chemical fertilizers, the action of which is expected to be rapid.

The lack of humus and of mineral substances indispensable for plant growth, though a main cause of soil exhaustion, is not the only one.

In fact in certain cases phenomena of a purely chemical nature may result in the insolubility of a fertilizing ingredient of the first importance, or may produce a substance injurious to the quality of the tobacco. In ground that is rich in lime and in

ferric salts humates and alkaline silicates are particularly liable to such a transformation. Thus silicate of potash, for instance, by the action of any calcareous salt, amongst other chloride, may be precipitated under the form of an insoluble silicate of lime by causing the formation of chloride of potash. Here we find ourselves confronted with the type of reversion by precipitation. Salts of iron would produce a similar reaction, the silicates of soda and potash alone being soluble. As we have seen this precipitation induces the formation of chloride of potassium, a salt that is injurious to tobacco, because of the nature of its acid which acts very unfavourably upon combustibility. This last consideration furnishes us with another reason why for tobacco we should seek a soil that does not contain too large a proportion of lime and salts of iron. Now certain soils of Canada are rich in lime and in ferric oxide; this last salt, in particular, shows its presence by the special colour it imparts to the soil which one meets with everywhere. The almost total incombustibility of the tobacco of St. Damase (Rouville Co.) is probably due to the excess of lime to which we refer, for the soils of that country exhibit a sufficient richness in potash from which we infer that potash is there present in the form of chloride.

Another important retrogression relates to the phosphates and determines the fixation of a notable quantity of phosphoric acid. The mono-calcic phosphate reacting on calcium carbonate, gives either bi-calcic phosphate or tri-calcic phosphate, or generally a mixture of the two. The salts of iron and of alumina may produce the same phenomena by determining insoluble sesquioxyde phosphates. This reversion of the phosphates is a serious drawback in agriculture, and so we perceive all the danger of the use of the superphosphates in the soils where salts of iron and of alumina and lime are in excess.

An excess of lime and of iron may also determine the precipitation of soluble humates, especially if the soil is deprived of phosphoric acid. This soluble humate, potassic humate for example, changes rapidly into insoluble humate precipitated by the salts of iron and of lime.

We should therefore be fortunate if we could make use of a soil rich in phosphoric acid, which allows of the formation of humo-phosphates and does not let the humates remain susceptible of becoming insoluble. Further it is not a matter of indifference as to whether we obtain one or other of these last. The humates which relate to agriculture are very soluble, whilst humo-phosphates being much less so will present greater resistance to the draining away of the water. The dissolvants are the solution of alkaline carbonates.

In conclusion we see that soluble phosphoric acid may be absorbed by humic matter or may be precipitated by alkaline humates, this precipitation being accompanied by the formation of humo-phosphates.

These then are the various considerations which should be of assistance to us in explaining the exhaustion of the soil and the inability of planters to increase their yields of tobacco at will.

Unfortunately we are obliged to follow general considerations arising from the great known laws. Is there really a lack of humus in our tobacco soils? Are there defective conditions of nitrification? Is there a lack of nutritive mineral elements? Is there in a word a due combination of the constituent mineral principles? We

have here a sufficiently difficult problem to solve, and we trust that soon a laboratory attached to the tobacco division will enable us to arrive at definite conclusions.

Besides the chemical theories that we have just received, we should also take into consideration reasons connected with the climate and agricultural conditions generally. With regard to the climate it is clear that Canada, owing to the length of its winter, and tho almost complete absence of any between season, is not particularly favoured. Autumn cultivation is sometimes difficult, and one is often obliged to wait long before entering upon the spring cultivation, for the melting of the snow and the rainy season which follows, render the fields unworkable. But up to a certain point the activity and zeal of the planters as well as the beautiful summer compensate for the unfavourable climatic conditions, and therefore we are not really faced with any very serious difficulty. From the agricultural point of view, arable cultivation and especially ploughing is of the first importance. Thus if the arable bed is not thick enough it causes sterility of the soil. In fact it is the deep soil that best secures the great reserve of humidity which is essential to tobacco. This humidity, so preserved, rises by capillarity to the surface. Thin layers on the contrary soon dry and are subjected to quick alterations of temperature. For soils that are not deep the carting of earth to increase the thickness of the arable bed is recommended as also is subsoil ploughing when the nature of the subsoil allows it. In the event of this last operation the deepest ploughing must be commenced before the winter, and the depth of the subsequent ploughings must be gradually lessened in order to render the soil sufficiently light for tobacco. When possible one may utilize the proximity of a stream in order to increase the thickness of the arable bed by temporary irrigation. Unfortunately the operations of warping are rarely possible in our country, and moreover they would hardly be practicable for the plant with which we are concerned.

An excess of water is also a cause of sterility. In this case indeed nitrifying bacteria deprived of oxygen, die asphyxiated and cannot consequently fulfil their important function of nitrification, so that the nitrogenous material remains inert.

Lastly, if an excess of limo is frequently detrimental, the absence of this substance is always a cause of sterility. A considerable accumulation of humus indicates the absence of lime. We have already seen the important rôle that lime plays not only as an agent of saturation and assimilation of potash, but also as a cause of reversion. It will therefore be unnecessary to dwell any longer upon its action.

Here we leave our study of the causes which we believe explain partly the stationary condition and even the diminution of yield. For every defect the remedies proposed, and which at first sight seem to be the right ones, have appeared to us to be either inefficacious or impracticable. Does this mean that such a state of things cannot be remedied? Really the problem may be stated thus: How to obtain good yields of tobacco by a powerful yet gradual enrichment of the soil by humus, and to re-establish a due proportion of nutritive constituents whilst obtaining from the soil meanwhile all that it can give. Possibly the study of a rational system of rotation will furnish the solution of the problem.

The rotation we recommend is a triennial one as follows:—

(1) Tobacco.

(2) A cereal.

(3) Clover.

We require an appropriate and economical rotation that shall enable us to draw the greatest possible profit from the soil, whilst at the same time the formation of humus is being produced by considerable but not too heavy applications of farm yard manure: First, in order to avoid the disadvantages enumerated above, and next because we have not at our disposal any very great quantity of manure.

We apply the manure after breaking up the clover and we plough before the winter. We apply chemical manure in the spring at the time of the last ploughing, before the planting of the tobacco. An autumn ploughing follows the gathering of the tobacco, and the cereal and the clover will be sown together in the spring.

Tobacco being a plant that requires hoeing, is placed first in the rotation. By this means we get rid of noxious weeds which spring up from seeds contained in the manure, and we can with no risk of infesting our soil apply at least 15 to 20 tons of farmyard manure to the acre. It is essential to perform this operation before winter and to plough in the manure as deeply as possible. In this way frost will destroy a large proportion of injurious seeds and insects; the other seeds will germinate rapidly enough, once the fine days of spring set in, and it will be easy by one or more light ploughings, to destroy these weeds, thus perfectly cleaning the land besides increasing by so much our stock of fermenting organic substances, and returning completely to the soil all the nutritive elements which have served to build up the noxious plants.

By the application of dung upon the breaking up of the clover, we allow of the fermentation of the humus whilst supplementing the immediate requirements of nitrogen, since as a matter of fact the nodules of this leguminous plant rapidly yield assimilable nitrogen, and the soil will thus be able to await the time necessary for the dung to decompose sufficiently to allow of its nitrification.

There still remains the question of the choice of the cereal. And first, why do we choose a cereal at all? Because owing to its fasciculated root system, the cereal only exhausts the surface of the soil and therefore conveniently succeeds a plant like tobacco whose powerful roots deeply penetrate the ground.

We have the choice between wheat, oats, rye and barley.

Although coming well enough after tobacco, we can at once dispense with wheat, for after heavy nitrogenous manuring we should risk failure. Wheat too requires a great deal of phosphoric acid, especially when earing, and moreover it succeeds best in free soils of due consistency, such as sandy loams or chalky clays, not too wet. In other words the soil suitable for wheat would be too compact for tobacco, which needs a light and sandy soil. Rye would suit better, for it is really the cereal for sandy soils, and after tobacco would find its place in the rotation, since above all it needs a sandy soil well worked and autumn ploughed. The success of the rye crop depends essentially upon the thoroughness with which the soil has been worked. An ancient proverb thus expresses the agricultural law: 'Sow thy rye in powdered soil.'

It will not be altogether out of place to state here exactly what is meant by light tobacco sandy soil. Fine sand alone is of no use. From the physical point of view, coarse sand is exceedingly permeable, whilst fine sand is a settling element, although its containing power may, so to speak, be nil. In sandy soils which necessarily contain an insufficient quantity of coagulative elements, the formation of agglomerates

is extremely difficult. If fine soil is the dominating element the penetration of water is difficult and the soil may be considered as essentially resistant, since the permeability of a soil depends upon the quantity of coarse sand that it contains. But we know that the greater the fineness of the soil the less active are the disintegrating agents; consequently fine sand from the point of view of the constitution of the reserves of nutritive elements, is preferable to coarse sand. It follows that a soil suited to tobacco culture must contain in due proportions a mixture of fine and coarse sand; the fine sand is useful for the maintenance of reserves, the coarse as a means of permeability. It is the admixture of these two almost contradictory characteristics which constitutes a good tobacco soil.

Oats are less exacting than any of the cereals, and practically they succeed everywhere. By this crop one can increase the depth of ploughing for it likes a deeply-stirred soil. This would not suit wheat which requires a firmer soil in order to avoid exposing the roots. Lastly, oats better than any other cereal, stands an insufficient preparation of the soil which is a valuable property in Canada where climatic conditions are not always favourable to farm work.

There remains barley. Barley is like tobacco, a plant of rapid growth; it requires therefore a rich and well worked soil. Of all cereals it requires the greatest stirring of the soil, and if it were not also so exacting it would do admirably for a crop succeeding tobacco in the rotation, because a hoed plant on account of the numerous workings that the soil receives leaves the land clear and well stirred.

Amongst these four cereals we are inclined to prefer oats, believing that this cereal best fulfils the purpose we desire it to accomplish. Owing to their small requirements, oats will give a yield without manure and will utilize the phosphoric acid produced, phosphoric acid being doubtless of little use to the tobacco, but being indispensable to growth as we have already seen.

Rye is not much grown in Canada, especially in the province of Quebec, and it is hardly grown in Ontario, except for the distillery. As to barley, it is too exhausting.

We sow clover with the oats in the spring. We recommend a mixture of red with white clover. This last is common enough and succeeds in almost any soil. It is also strongly resistant to drouth and grows well in silicious soils, in fact it is in these soils that it gives the finest yields.

Red clover requirese a soil rich in clay; yet it will succeed in tobacco soils, since the last named plant also requires a subsoil which ensures the necessary moisture. Lastly, red clover being finer than white, will improve the quality of the fodder. If one is careful not to abandon the clover to pasture after the harvest, it will have every chance of giving a good crop. I have several times noticed that in many places farmers put their cattle into the young clover. One sees the defects of this practice from the trampling of the animals. Nevertheless and in the special case we are now considering pasturage owing to the excrements of the animals could be practiced and would be a fairly good operation. We may choose between the two practices according as to whether our object be to enrich the soil with humus or to obtain a good crop of fodder. The latter plan seems to me to be preferred, it being understood that the farm has enough meadows to supply the food requirements of the stock.

It is scarcely necessary to justify the inclusion of a leguminous crop in the rotation which we recommend. The strong radicular system of clover, penetrates the soil deeply, but the chief part it plays is the enrichment of the soil through the fixation of nitrogen by its roots.

We would draw attention to the breaking up of the clover which is a delicate operation, for the roots of the leguminous tend to raise the earth and to produce what is called a hollow soil. This disadvantage must be avoided by strong and repeated spring rolling.

A large part of the manure buried with the first crop of the rotation will now be transformed into humus, and if we take account of the quantity of nitrogen fixed by the root nodules, we perceive that at the completion of the rotation the returning tobacco will begin to find ready for it an abundance of nitrogenous material.

Finally, from the tobacco point of view alone, an alternate system of culture is preferable, for this method contributes powerfully to the destruction of insects injurious to tobacco and especially of cut worms and flies, in fact for many insects no other means of destruction are available.

OTTAWA, January, 1909.