



Lecture on rust in cereals

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ON
RUST IN CEREALS
DELIVERED BY
FERD. MUELLER, PH.D. M.D. F.R.S.
IN THE
TOWN HALL, SANDHURST, 22ND MARCH, 1865.
UNDER THE AUSPICES OF
THE BENDIGO
AGRICULTURAL AND HORTICULTURAL
SOCIETY

SANDHURST :
J. M. HARCOURT, BRITANNIA PRINTING OFFICE, WILLIAMSON STREET.

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RUST IN CEREALS.

IN responding to the request of the Agricultural and Horticultural Society of Sandhurst, to address their members on this occasion on the causes of rust in wheat,—a subject, after what we have experienced of late years, fraught with vital importance,—I can scarcely hope to promulgate new views ; but I may perhaps succeed in directing attention anew to some measures, not yet generally adopted by cultivators, as safeguards against a plague which has of late proved well nigh ruinous to many a farmer in this country. I will attempt, then, to concentrate in a succinct manner, the views which have presented themselves to me on the subject ; though, while my investigations are far from being concluded, I can, suddenly as I am called upon, but inadequately do justice to the task before me. Neither do I so without diffidence, the enquiry having manifold bearings, and standing—especially in this country—in need of more extensive observations than those on which I have been hitherto enabled to generalize. It is therefore scarcely necessary to point to the importance of further data being locally collected, and I shall, in the course of this evening, permit myself to direct the attention of the intelligent cultivators here assembled to the principle points yet requiring observation and elucidation.

During the last summer it fell to the conjoined lot of Mr. A Mackenzie and myself to devote, on behalf of the Board of Agriculture, some special attention to the causes

and effects of the rust-fungus, which, during the last two seasons, has caused such sad ravages on our farms. In this duty we were kindly aided by many communications from Victorian farmers. We endeavored to collate what appeared to us the most eligible means of its mitigation or prevention, and we ventured to offer—divested of a scientific robe—for the consideration and perhaps guidance of the farmers, a few plain and practical suggestions borne out by experience, and, indeed nearly all recommended by our agricultural journalists or their correspondents, to whom much credit for keen observation and thoughtful suggestions is due.

We pointed, in the first instance, to the desirability of effecting the sowing of wheat as early as possible in the season, the main weight of testimony before us having shewn this to be one of the conditions required to guard against rust:—late sown crops suffered wherever the rust made its appearance infinitely more than those of early sowing. Perhaps the propriety of this recommendation, long recognised and advocated, may be explained by the fact that early crops are, at the time when cereals burst into flower, less exposed to those sudden changes in temperature which the increasing summer heat renders extreme, changes which are apt—especially in cereals not fortified by a normal content of mineral substances—to produce minute mechanical ruptures of the epidermal tissues, indeed, vulneration, by alternate contraction and expansion in moist weather, suddenly followed by heat. In the sap oozing out, especially if of too aqueous a nature, the seeds—or, as they are called phytologically, the spores—of the rust-fungus find a ready medium of vegetating, and germinate beneath the cuticle of the cereal. The rapid development of innumerable fungus-plants—though individually most minute, in their aggregate most destructive,—arrest the free flow of the sap, deprive the young fruit-ear of its nutriment, and destroy it more or less, if it has not already imbibed what it mainly needed for its development.

I refrain from entering into a description of the rust-plant itself, its position in the system of nature, and its character and development being over and over again recor-

ded. Those interested in the natural history of the fungus may most easily study it under a microscope of ordinary power.

The second point to which we deemed it desirable to direct attention concerns the selection of the varieties of seed grain. It has thus, for instance, been demonstrated conclusively that the White Tuscan and the Red Spring Wheat,—and indeed all the red varieties,—have much better resisted the attack of rust than the Golden Drop, the White Prolific, the Club-eared, and Winslow's Wheat. All varieties of more rigid growth proved more hardy and better calculated to resist the rust; but as these facts are practically long since appreciated, I regard them beyond the province of a lengthened discussion, yet I did not like to pass them altogether on an occasion like this.

We were further able to bear out the observations promulgated by Sir Joseph Banks in the beginning of this century (Koenig and Sim's journal 1806,) that seeds of wheat, in which, through the attack of rust, the albuminous portion was only scantily developed, might still serve the purpose of seed grain as long as the embryo remained materially uninjured. But, it is a startling fact,—we believe, not clearly enunciated before our enquiry,—that, in numerous instances traced by Mr Mackenzie, the plants from such affected grains produced a much more abundant and healthy crop than those raised from imported grain of plants free of rust. It is not easy to account for a fact so singular, but it has inspired new hopes to many a farmer who harvested a diseased wheat, and who may thus feel encouraged to trust to similar favorable results in availing himself of any damaged seed within his reach. The fact itself calls for theoretic explanation. It seems, indeed, that a luxuriant plant, produced from a rich seed, is more liable to the attack of the rust-fungus than a less vigorous plant emanating from a poorer seed. Whether—in the basaltic soil from which the rusted wheat often emanated, the seed grain brought from a different geological formation finds not the elements best adapted to the innate individual constitution of the variety, and hence, perhaps degenerates or passes into over-luxuriance, and thus

becomes readily affected by extraneous influences,—is a question reserved for future investigation and solution.

Inasmuch however, as, varieties of wheat particularly subject to rust, should, after seasons in which the fungus prevailed, be as much as possible excluded from our fields, we recommended the use of seeds of rusty wheat for sowing, only in cases of emergency when no more eligible seed may be within reach.

One of the most important facts, to which, in the progress of our investigation, our attention was drawn, revealed itself by the chemical analyses entrusted, on behalf of the Board of Agriculture, to Mr W. Johnson of St. Kilda. This talented gentleman proves by his assays that the surface soils, as well as the subsoils, from fields which produced rusted crops, contained phosphates and lime in quantities either scanty in the extreme, or at least below the proportion regarded normal to wheat soil. This proves again how needful it is in husbandry to subject the arable soil to a chemical test,—an operation involving a most trifling expense when it is merely an object to ascertain the proportionate contents of those mineral substances which are mainly required for the assimilation of plants;—for, be it understood, soil, notwithstanding its apparent richness, may be devoid of some particular ingredient essential for the cultivation of the intended crop, and, if a single one of those should be wanting the others will remain inactive; hence, the choice of the latter should be ruled by the former, or by the kind of tested manure available. On this deficiency of phosphates and lime in many of our soils we have the concurrent testimony of Dr. Macadam, in a record appended to the Report of the Board of Agriculture, issued last year. It is scarcely necessary to point out, that, by the application of crushed bones to such soils as came under our investigation, the substances wanted for wheat cultivation would be directly offered:—One pound weight of bones contains phosphates nearly enough for three bushels of wheat.—It is equally known, that, by the action of sulphuric acid on bones the assimilation of their elements is much more accelerated, and of bones so prepared a lesser quantity at a time is

needed.

Lime, even if contained in sufficiency in the land for the cereals, if added, breaks up, chemically, the clay, liberates from it the alkalies, and gelatinizes the silicates and aluminates, whereby the mineral substances are presented for more ready assimilation. If the soil is wanting in the needful quantity of silicates of lime and potash, the straw will not attain the necessary firmness. If alkaline and earthy phosphates are not in sufficiency available, the seed of the cereal cannot be formed. The eight substances required in all soils for food of plants are—phosphoric acid, silicic acid, sulphuric acid, potash, soda, lime, magnesia, and iron ; of these—potash, phosphoric acid, ammonia, and lime, are not unfrequently absent, or but scantily present.

A most interesting fact, bearing on the nutrition of plants, and hence on the whole investigation before us,—comparatively, of late years, only established by the progress of science in Britain, and, perhaps, not generally known among our rural population,—leads us to many reflections in our arrangements for husbandry operation. Allow me briefly to refer to it.—Not a vestige of potash, ammonia, or phosphoric acid, is by exfiltration through rain removed from the soil ; these, indeed, by the ordaining wisdom of the Creator, are, through attractive force, retained in the soil when offered to it, and stored up, in the most subtile distribution, as the indispensable mineral food of vegetation. Until the soil, according to its capacity, is saturated with these important substances, none are withdrawn by rain-water, drainage, or other action of water. This gives a conception of the powerful absorbing action of soil on these three mineral nourishers of plants, otherwise easily held in solution. But this power of the soil for absorbing these substances is not always alike. Saturation takes place with less in sandy soil ; more is fixed by marly soil, and still more by clay soil. The latter withdraws from solutions also, silica ;—humus soil not unless lime be added.

Further, by this beneficent action of the soil, potash and ammonia are separated from their acids ; the latter enter into combination with lime, magnesia, and other bases,

rendering them more readily assimilated. Common salt and Chili saltpetre are in the same manner decomposed, These salts contribute not directly to nutrition, but indirectly, by rendering the mineral food widely diffused. Phosphates are, by their action, converted into superphosphates. Hence, in applying ammonia combinations through manure and other substances to the soil, it is not its nitrogen, as an isolated element, to which we owe fertility of the soil, for this is abundantly available as atmospheric food, but its base and acids, separately as such, facilitating the widest distribution of the mineral food through the soil in the minutest division. But, while thus, by the additional action of ammonia, fertility is accelerated, the total of the mineral bases serving as food of plants is not increased; they are, in a corresponding ratio, sooner exhausted; merely the quantity is increased within a given time. This is a significant fact, on which the prosperity of many a farm depends.

We next dwelt on the likelihood that the effect of rust on wheat crops would be mitigated whenever the phosphoric acid, alkalies, and alkaline earths, necessary for the healthy growth of this cereal, were abundantly offered.

I am induced to think that a too aqueous sap,—pervaded therefore with less than the normal proportion of mineral ingredients—renders the plant flaccid and liable to suffer in unfavorable weather more than a healthy plant, and that, in its abnormal juices, the fungus is most particularly prone to vegetate. If diseases of the human body are often connected with the abnormal state of the blood, we may safely assume that inadequate nutrition, and other causes affecting the formation and constitution of the sap, would induce also so sickly a state of a plant as to render it susceptible to all those extraneous influences which it otherwise might have resisted. It was not our idea to contend that rust would be created by the abnormality of the plant indicated, but merely that the fungus, when once established, would find ready means of spreading, and, by continually increasing extension finally also ruin the healthy and normal crops,

In the Geelong districts, over which our observations mainly extended, we noticed the rust more or less in all

positions and aspects, in apparently rich as well as in sterile soil, in land with surface drains as well as in land undrained ; but the ravages of the fungus were most extensive on new lands which had been sown immediately after ploughing :—nor has the rust been found confined to any geological formation. Nevertheless, it cannot be shewn with absolute certainty by these facts that all endeavors, so far, to guard against the plague are hopeless, inasmuch as, in a variety of soils, apparently rich, the phosphatic and alkaline ingredients may be deficient. It becomes, also, a grave consideration whether or not, perhaps, the myriads of spores of the *Uredo*, when wafted through the air from a badly cultivated field on which they were generated, may not finally affect the healthy crops in so dangerous a vicinity. Observations are,—at least as yet,—not in sufficiency extant to prove or disprove whether the rust, in the first instance, always arises on fields on which a highly unhealthy crop favors the prodigious growth of the fungus, and whether or not, from thence under certain climatic conditions, the evil spreads over fields which otherwise would have remained free from infection. It is a question of deep interest, on which ample and undeniable testimony should be brought to bear. If the *Uredo* thus originates on ill cultivated ground, all the requisites for a normal growth of our crops may elsewhere be contained in the soil, and all conditions for the proper cultivation of the cereal be fulfilled ; yet, under the incessant prey of the spores on the stomata of the plant, it may, at the least unfavorable weather, succumb under their attack. Let me remind you, how, in many other instances parasitic organisms generated in unhealthy bodies, are transferred, not merely to others in a diseased state, but also to those in perfect health. Thus the diseased crop of one farm may injure those of a whole district.

In newly ploughed land, neither that disintegration of its mineral substances, which renders them so much more readily available as food for the plant, nor the decomposing and stimulating influence of the atmosphere, can be attained to its full extent.

Next, therefore, we alluded specially to the necessity of

effecting the breaking up of the ground at so early a period as to admit of a fair interval during which the air and water could exercise their disintegrating effect on the soil. It has certainly been found that crops sown immediately after ploughing succumbed much more readily than others. Probably in these cases, the seed, transferred to a soil not genial for the nutrition of the young plant, produced from the very beginning an abnormal organization never fully able to establish the chemical and physiological equilibrium in all its parts, and therefore, not calculated to cope so well with noxious extraneous influences as healthful plants.

Among the combined causes inducing the development of the rust-fungus in our cereal crops some are within others beyond our control. A moist season, in which, during spring and summer, the temperature frequently sinks below those degrees of heat under which a vigorous ripening process of the wheat plant only can take place, will favor the growth of the fungus, especially if the cereal by other abnormal conditions of its youth should be predisposed to disease. When the corn is sown so thickly that a free current of air cannot have access to the soil to expel super-abundant humidity, one of the conditions is established favorable to the development of the fungus, while, on the other hand, the best crops of wheat are produced on land subject to free aeration. The effect of stagnant humidity on the plant must be especially injurious in the cool season, when air, heat, and light, are to exercise on the surface of the soil their influence, in order that the young plant may be invigorated while its energies are most feeble, whereas an excess of moisture will hinder the temperature of the soil from rising to the needful standard, and impede the access of air to its surface.

I need not remark to the sagacious agriculturists around me how and why summer fallowing exercises its beneficent effect on the land, yet, the sometimes compulsory omission of this measure, together with the difficulty of providing, in all instances, an adequate supply of manure or rendering the requisite ingredients accessible from a good subsoil by trench ploughing, lead, not unfrequently in farming operations to disastrous results.

Mr Dickinson of Portarlington—who ranks among the foremost, in intelligently observing the varied conditions under which the dreadful ravages of the rust-plant in the Portarlington district occurred during the season before last—has drawn attention to the main reasons of the destruction, which, provoked by the unusually cold, wet, and boisterous season of 1863, was much aggravated he contends, by the unsatisfactory modes of cultivation adopted in the locality. Well may it lead also elsewhere to serious reflection, when he tells us, that, where 200,000 bushels were expected to be gathered, hardly any were harvested. His remark also is especially worth consideration, that hot weather suppressed the development of rust in places open to currents of air, by thin sowing, while thickly sown crops fell a prey to the unchecked spreading of the rust. That—from underground drainage, especially in retentive clays, vast amelioration to our agricultural land would accrue, cannot for a moment be disputed; whether it will prove a local protection against the disastrous effects of rust, is a point on which opinion is divided. I am inclined to think that whatever tends to establish a healthy growth is likely—if not directly, at least indirectly—to afford shelter from the rust disease, or to mitigate at least its destructive power. In referring to supposed precautionary means, I should not pass the circumstance, that, according to the main weight of the evidence before us, seashells applied to wheat land acted as a preventative of the rust disease. When their application proved thus beneficent the land was probably poor in lime naturally, yet otherwise excellent for its purposes, but, when, in the less numerous instances brought under our notice, this remedy failed to exercise a preventative effect, we may perhaps assume that either potassa or phosphates were to some extent wanting in the soil, or that some other conditions facilitated the extension of the fungus which the mere presence of lime could not overcome, or, that infection caused the mischief. For, be it remembered, not any single special condition will secure for us a healthy crop; but, for effecting a safe harvest we have to rely on many combined conditions, some, as stated before, within others beyond our reach.

This accounts for the discrepancies of statements on the subject under consideration ; indeed, it is not easy to penetrate the chaos of conflicting evidence on the rust question. That remedy, which on one spot may arrest the rust, or, at least, lessen its ravages, in correcting defective nutrition, may, in other instances, absolutely fail, where a state of the crop predisposing to disease arises from very different causes.

While we have carefully traced the organic development of the rust-fungus, and are closely acquainted with its nature, we have yet, I repeat, much to learn of the combination of means calculated to resist its inroads on our fields, nor are all the causes which call forth the disease free of obscurity, and we can only hope to elucidate them fully by bringing still more extended observations, and experiments of several branches of science combined to bear on them. Until this is attained we shall meet with unreconciled observations and discrepant statements. Hence, we learn, that crops in localities not subject to the extraordinary vicissitudes of the weather experienced in other places, did escape, while, elsewhere, the rust gradually, and probably by mere infection, made its appearance without any apparent marked action of the weather, and without any predominant humidity. Hence, again, we learn that, generally, crops near the seaboard remained singularly free of the disease,—if to this the immunity really can be ascribed,—while, on some other spots, the saline particles conveyed by the air, and perhaps contained in the soil, were insufficient to arm the wheat plant against the fungus,—other defective conditions, perhaps, in the soil or in the treatment of the crop being such as not to be counteracted by the influence of sea air. Therefore, dressing with common salt may prove in some instances directly or indirectly useful, and may in others fail ;—its special effect when transferred to the soil will be alluded to afterwards.—Hence, we learn, that, in the limestone formation of the Goulburn and Bathurst districts of New South Wales, rust is altogether absent, not simply because the presence of lime would prevent its attack, but because, I think, that, besides this one indispensable ingredient all others necessary were present, and the climatic conditions

were not such at the time as to affect, so severely, the crops in that part of Australia as here with us farther to the south. Hence, again, we may notice, that, on spots of cornfields where wood-ashes were scattered, and therefore an abundance of potash was attainable to the cereal, the latter, on spots so circumscribed, withstood the rust while the surrounding grain-plants perished, and yet, in soils already rich in alkalies, the application of wood-ashes as a preventative remedy against the rust would be of no avail, when perhaps phosphates were required for healthy assimilation.

I consider it my duty to recall to the mind of the agriculturist some observations promulgated by the Rev G. A. Ambrosoli of Paramatta, according to which, in Northern Italy, by the application of slack-lime (two pounds diluted with water to every bushel of seed-corn immediately before sowing) the crops are rendered safe against the attacks of rust. We have found that lime alone applied to the land ordinarily treated, has not in itself the effect of banishing the rust, yet, it deserves consideration, whether or not this alkaline earth, offered in so immediately accessible a form to the young embryo plant, imparts at once to it such strengthening validity as to place it in a very advantageous position for further development. The observation is worthy of being followed up experimentally; it may be done with the greatest ease and without risk of injury.

Though it has been amply proved that rust appears independent of drainage, we have become nevertheless persuaded that it prevails more in low and wet land:—under any circumstance, surface and underground drainage, as tending to establish healthy growth, is likely to mitigate the inroads of rust. It is equally important that sowing should be effected while the genial autumn warmth is still retained in the soil, and certainly before any winter deluges set in, and while the soil is yet in a state of friability.

By some circumspect observers it has been affirmed that exposure of fields to gales had caused a diseased state of roots and of the entire young seedlings, such as naturally would affect the plant in its advancement, and predispose it to the reception of the rust-fungus. Rolling of the land after

sowing and feeding off with sheep when the plant had sprung up, have been indicated as a means of protecting the root from exposure. I am convinced, that, at least, in many instances, the roots of our crops afflicted with the *Uredo*, did not suffer, and, as we stood not in need of the precaution in years when the rust attacked our fields, it is evident that adherence to the advice, thoughtful in itself, can only be of local or periodical advantage. When, by the inclemency of the weather, many exposed crops have been damaged, we may assume that it was at once the whole plant which suffered. If, by direct mechanical injury, by a consequent derangement of its functional power, and perhaps a partial destruction of its tissue, the plant would linger, its vital activity would naturally be lessened, the circulation of its sap be impeded or arrested, and thus our cereal be rendered the easy victim of parasitic attack. Yet, losses of crops, through the severity of the weather and concomitant fungus-growth are not always witnessed, as, otherwise, the invariable sequence of a severe hailstorm would be the appearance of rust.

I concur fully with the excellent remark of Mr Thomas Mort, that the present vast range of the *Uredo Rubigo* over these parts of Australia, may, for a while, perhaps, militate against the safety of our crops; hence we are led to the reflection, whether or not such other field fruits as are not subject to fungus destruction should be more predominantly chosen, until we are comparatively free of the plague. Maize has not been found to suffer in this way; therefore, it is well deserving consideration why the cultivation of this highly productive cereal should not receive preference, at least, for a while, in such localities and soils as appear to be adapted for its growth. In many parts of North America a very strong predilection is entertained for this corn, as Porter in his "Agriculturist" very many years ago stated. It enters into a variety of ordinary domestic food much greater than that for which other grain is consumed; it is a food at once highly palatable and nutritious; moreover, it is there proved to yield an ampler return than any other cereal. Our climate would favor its growth. If potash with justice is held as a resistative to rust, we may have a clue to the immunity

of maize from rust, this corn ranking pre-eminently among the potash plants. Its failure in many localities may possibly be traced to the insufficiency of potassa on some of our fields.

A recently issued exquisite article on "Rust in Wheat" by J. Montague Smith—an observant rural settler of New South Wales,—has been placed in my hands by the author since Mr Mackenzie and myself promulgated the preliminary notes of our enquiries before the Board of Agriculture. He justly dwells on the fact, that the ashes of superior wheat grain consists nearly half of phosphoric acid, fixed mainly to potassa, and in various smaller proportions to soda, lime, and magnesia. He further reminds us that straw of the aged plant yields mainly silicate of potash. He also repeats to us the warning that these mineral constituents of the wheat are solely drawn from the soil, and that, however rich that may be, it must ultimately be exhausted if the same spoliation system which characterized husbandry in some of the American States, were adopted and continued in this country. Whether restorative means are applied by alternate growing of green crops—which carry much less of mineral substances from the soil, often by local consumption restorable—or whether by rearing of cattle, sheep, or other farm animals, rest and restitution of the fertility of the land is attained, and it is simultaneously freed of useless consumers in weeds, or, whether by the application of sewage, nightsoil, bones, guano, or stable and farmyard manure, the withdrawn elements are returned to the soil, the same golden rule will be adhered to—namely, that the proportions of alkaline earth and phosphoric acid withdrawn, should not vastly excel those returned, and, wherever possible should be equal to them, otherwise, the farm proprietor draws constantly on the capital he possesses in the value of his land, which should not be touched, but merely yield interest, and which otherwise requires to be restored by new investments in fertilizing means.

In reference to restorative means let it be remembered that rotation of crops in the abstract is a spoliation system also, unless the produce of root-crops of clover or any other

plants,—which draw their food from deeper strata—are grown for the purpose of consuming them on the farm, with a view of returning to the soil the potash and phosphoric acid obtained by them from the depth for the nourishment of the future cereal crop; otherwise, the same object of bringing from deeper strata the mineral elements of vegetable life to the surface for the annual roots of the cereal grasses might be attained to some extent by trench-ploughing. Neither will fallow positively enrich the land in what of mineral food has been withdrawn, but will relatively augment again its capability for cereal-culture from the original stock of minerals possessed by the soil, the decomposing and capillary processes—which go on while the soil is at rest—bringing new nutritive particles of it within reach.

The farming gentleman who desires to make a valuable heritage of his estate to his children—allow me to say so—should seek a pride in realizing on it the greatest possible amount of fertilizing substances, more especially in farmyard manure, for the benefit of his soil. He never can make a safer investment. But it should be phosphate and alkaline fertilizers under any circumstances, to which he ought to look for maintaining the fertility of his farm. Ammonia available from the atmosphere is merely valuable to the soil in accelerating the assimilation of the fixed food referred to, to which and to carbonic acid its assimilation by plants stands always in unalterable proportion. In itself, therefore, ammonia merely speeds exhaustion. The value of guano is therefore great, because, like egesta it combines as well the volatile as the fixed substances, which conjointly are wanted for the sustenance of plants, unless it should prove wanting in potassa for special crops.

Much might be achieved on each estate by not wantonly parting with the ingredients on which the growth of future crops must depend, unless substitutes for them are easily and cheaply at command for refertilization.—If local distilleries could be instituted the mineral food of potatoes and other field fruits could be returned to the soil.—If, of wheat or potatoes, starch were manufactured, the phosphatic earthy and alkaline elements would be serviceable anew for another

crop.—If oil plants were cultivated the mineral food in the residue of the pressed seed would be given back to the then unimpaired ground. But, above all, it is to the obtaining of egesta from centres of population that the rational agriculturist must largely direct his attention for reparation of losses sustained by his land. Cities now-a-days absorb the vital riches of the culture-lands of whole countries, as Rome of yore those of subjugated or subservient nations, and the losses thus suffered and the injuries inflicted through the waste of what should be given back to the soil, are absolutely beyond all conception. I quote from the illustrious Liebig—an ever undeniable authority,—otherwise, what I say to exemplify my statements might be received with scepticism, though many other enlightened benefactors of the world have warningly enunciated similar startling facts. The egesta of the inhabitants of large cities—but too frequently for ever lost by flowing to the ocean,—these ruinously wasted egesta of a million of people, would yield annually 10,300,000 lbs of those salts,—containing 4,580,000 lbs of phosphates alone,—on which vegetable life so largely depends, and which were all abstracted from the soil to form the mineral constituents of bread and meat. But this does not comprehend the entire irreparable loss, for, vast quantities of horse-dung are likewise sacrificed, and of the millions of tons of bones from meat consumed, only a very small share is brought back to the land which nourished the cattle furnishing these bones. Statistics in this respect, concerning the metropolis of this colony and the neglected rural land, would be truly astounding. The phosphates of the hides and many other parts of cattle are of course never restorable. Carey, a North American philanthropist, informs us, that, the phosphoric acid and potash carried away annually by the sale of field products of the American States, without scarcely any compensation, are to be estimated at twenty millions of dollars,—that the mineral food of six hundred million bushels of cereals alone is brought away each year without restoration,—and that the entire annual sacrifice of these ingredients—without which vegetation cannot exist,—is amounting, in the territory

of the States alone, to what would suffice to grow fifteen hundred million bushels of corn. Decrease of yield, or absolute barrenness, is met in every direction as a retaliatory consequence. Can we suppose that the national wealth of these youthful countries, under such systems of husbandry, should not finally sink, like that of the empires of the ancients?

I have dwelt on these subjects to some length, because I am far from being convinced that our defective system of farming is not closely connected with the losses experienced from rust during unfavorable seasons. My opinions, based on scanty observations, are advanced, not as those of final decision, but on the contrary—with hesitation. As such, I trust they will be received with courtesy.

Whenever silicate of potash is available in a state ready for the absorption of the plant and in a quantity for its requirements, the cereal will deposit it largely in its epidermal parts, for, Nature, in her ever wise arrangements, has ordained that this substance should offer to the stem, as a covering, that protective polished firmness by which the cereal is enabled to withstand the effects of changeable and otherwise hurtful weather, and likewise be shielded against the ingress of parasitical fungi.

Mr J. Montague Smith refers with great propriety to a rule, laid down by Mr Mechi—the wise and renowned promoter of agriculture in Britain—who insists that the most fertile soil should be the most sparingly sown, to avoid a close vegetation. Mr Mechi contends that on his rich land the consumption of two bushels of seedwheat, as compared to one, reduces the yield by a sum equal to the rent of the land. Though operating in low-lying localities, or, at least in such as are subject to fog and rust, he guards—apparently with complete success—against the latter by deep drainage and by saturating his clay lands with liquid manure, which conveys not merely the combustible and incombustible food of plants, but, moreover, sets the latter free from the clay stratum.

Therefore, while we may find it periodically impossible to subdue the rust when once it has commenced its ravages

extensively in any district, much may be done by a rational system of farming, in guarding against all the varied conditions which will provoke it, and, by affording all the means of a rigorous and healthful development to our cereals, for combating with its minute but prodigiously numerous assailants.

The law which in the animal world teaches us how a healthy constitution and a normal process of life will be but seldom endangered by disease,—that same law of nature holds equally good for the vegetable empire. Mr Montague Smith quotes some interesting facts which came under his notice in the Hunter district of New South Wales, and which bear on this question. He says that in 1828 the plains and forest land of the upper localities alone suffered, whereas, the scrub land beneath—then unexhausted,—escaped from rust, and last year he notices only virgin soil free of the dreaded fungus. In the Geelong district, Mr Mackenzie, on the contrary, followed the rust ravages from long cultivated to new land; nevertheless, it should not be forgotten that even in such virgin land, as mentioned before, the inorganic constituents may not be normal, and that the immediate contact of rusted crops may become as dangerous to those of new lands as once established epidemics of the human race to innumerable healthy beings. Indeed, again, in the richest land an abnormal over-luxuriance of cereals may render it as liable to disease as it would be in a state of debility.

That the variety of field fruits hitherto drawn into the cycles of cultivation is far too limited, and that rotation of crops for the sake of renewing fertility, is far too little adhered to, cannot for a moment be doubted. Scientific investigation, particularly chemical analysis, must here be mainly the guidance. If it has disclosed a comparative richness of potash in the soil to be cultivated, we may, under otherwise favorable conditions, rely on a remunerative yield of maize, potatoes, beet, turnips, and similar roots. Should lime comparatively predominate or be readily available, leguminous plants and tobacco are among those that advantageously could be selected for cultivation. Cereals,

again, are somewhat arbitrarily classed as silica plants on account of the comparatively large quantity of that mineral assimilated by them.

Notwithstanding all precautions adopted, our crops may, in a climatically unfavorable season, fall more or less a sacrifice to the rust,—perhaps, as pointed out, through the irrational method of culture adopted in surrounding fields, or even in distant localities. For, not merely millions on millions of seeds (or phytologically speaking, spores) of this vegetable scourge may be produced on a limited field, but their extreme subtilty allows them to be wafted by currents of air with rapidity over wide tracts of country, ever ready to lodge in the minute pores, or stomata,—through which plants maintain their contact with the atmosphere—to vegetate, if a healthy vigorous vitality of the cereal is not able to expel them. Should the weather be unfavorably moist,—should, moreover, alternate heat and wet be following in rapid succession, the fungus will seize with avidity the favorable opportunity offered for its development, and should this take place at a period before the fruit spike is fairly formed, the crop can only be saved—as farming gentlemen are aware—by immediately converting it into hay. If, however, the rust invades a field whilst the grain is advancing to maturity, the seed grain may be beyond the reach of the fungus, and the straw only may be suffering. If the sun dries up the superfluous moisture, the fungus generally is prevented from spreading, and the healthy maturation of the grain continues. Of the amazing fertility of this vegetable bane an estimate may be formed when we learn from Fries, one of the most eminent of all mycologists, that the *Uredo Rubigo* may produce ten millions of seeds or spores on a single wheat plant.

It must, however, be encouraging to the agriculturist in this country to be conscious of possessing a strong safeguard against failures of crops, in being enabled to extend the scope of his operations over much more diversified field products than the cultivator in the less clement climatic zone of middle or northern Europe can command for selection. In extending his choice over a greater variety of cul-

ture plants he will lessen the liability to suffer. If a British farmer, in the less genial climate of his islands, were enabled to cultivate with advantage the vine, tobacco, maize, tea plant, olive, and many other products, which either in the shorter summer heat will not advance to ripening, or which the severity of the winter altogether precludes him from cultivating, he unquestionably would establish them on his grounds, in order to add to the chances of his success. For this extended range of operation we have facilities which he does not enjoy.

We have therefore, in this climate, to assimilate our modes of husbandry largely to those of countries of a similar izothermal zone. Hence we may learn much from South European culture, and we might advantageously draw some of the products of the Chinese empire—as auxiliary to our husbandry—into the cycles of our farm products.

The Chinese, for periods immemorial, have annually restored to their agricultural land the mineral substances which the crop removed, and hence their fields are maintained in a constant fertility; this is mainly effected by the return of egesta to the land yielding the consumed field produce. Wherever, on the contrary, in other countries the agricultural land is deprived annually of portion after portion of its most valuable mineral ingredients, and no adequate provision is made for their restoration, the fertility of such land—let me repeat it—must proportionally decrease; of this, alarming instances may be witnessed in every direction in this country, and absolute devastation has followed exhaustive cultivation from these causes in many parts of America. Were it not that Britain, to a large extent, relied annually on the importation of guano—whereby the mineral particles needed for the renewed crop are secured,—it would be impossible to maintain the productiveness of its fields—unless, more extensively, the animal egesta and other fertilizing substances now wasted in losses there as prodigious as in most countries, were turned carefully to account. How well aware thoughtful men are of the necessity of vast changes in this direction may be instanced by the fact that the corporation of London have drawn Baron von

Liebig permanently to their metropolis in order that the highest talent available may be brought to bear on the utilizing of the sewage of the great city. It is but too evident now, that, with the augmenting requirements of our increasing population, we shall ere long nowhere be able to afford the enormous waste of fertilizing substances which is still so extensively witnessed. Perhaps in a newly settled country like ours the adherence to this principle may not be deemed of such prominent importance; nevertheless, we have seen here already, in these early days of colonisation, enough of the ruinous effect of the exhaustive system of husbandry, and it is well to bear in mind from the commencement, that the final aim of agriculture must be to utilize every acre of available land to the fullest extent possible and permanently, and this can only be done, on the one hand, by choosing that particular and most lucrative field-fruit especially adapted to the soil and climatic conditions of the spot, and on the other hand, by returning to the soil what of mineral food has been withdrawn from it.

Though rotation of crops, irrigation, and repeated deep working of the lands—for which the all commanding power of steam is also in this branch of industry gradually being made available—will do much, they will not for an infinite period do to all render the cultivation of our soils commensurate to our wants and remunerative.

Liebig adduces, as some striking facts, that, in Britain, within ten years, by the mere application of phosphate of lime when treated with sulphuric acid, the provender in green crop had increased as if the area of each field had been doubled. Where—as in our new countries—for a time, an abundance of yet uncultivated land may remain accessible, the necessity of provision in this direction may not force itself so prominently on general attention, yet, in countries which have to support a densely crowded population, it becomes of telling significance.

It is also a wise doctrine which teaches us not to depend on the importation of manuring substances, such as guano, of which the supply at any time may fall short of the requirements of a country, but that each land should seek,

as far as possible, the restoratives of its soils independently within its own precincts. Thus, the price of American guano, since the time of its introduction has risen much. Yet, as long as any rich guano can be obtained it will be one of the most powerful stimulants in the hand of the agriculturist to secure a fruitful succession of various crops, as is patent from the fact, that, the mineral particles contained in a ton of guano are generally equivalent to those of thirty tons of flour; and, so much had England to depend on the efficacy of this manuring agent, that, for a series of years it alone absorbed—according to Liebig's estimate—nine-tenths of all the guano imported into Europe. While, not very many years ago, hardly any guano came to North America, it has since become so far appreciated as to find during the year 1858 alone, its way to the fields of the North American States, to the extent of nearly half a million of tons.

Nevertheless, a cultivator is by no means entirely dependent on guano, nor should he be so. Thus, in Northern Italy but little of it is used, because, under the advantages of superior systems of irrigation, successions of crops—in some spots two a year—are reaped from land never lying fallow. But the utmost industry is displayed by the cultivator there to collect the refuse of field fruits, the sewage, dung and animal substances of any kind, for placing uninterruptedly within the reach of his crop what anew is needed for its nutrition.

If we, in this country, had already to support a population as dense as that of Northern Italy, we would, in a few years hence—unless more general advantage were taken of facilities for manuring,—either be mainly dependent on imported vegetable food, or be subject to famine and all the horrors concomitant to it.

Though a vast amount of scientific information is accessible to the agriculturists of all countries in the works on chemistry bearing on husbandry, among which those of Baron von Liebig are the most luminous, I cannot but feel that the doctrines of those writings should be imparted in a more vivid form, and be seconded among us by

practical demonstration and teaching. Long since, I entertained the persuasion that a rising man of Liebig's school, or one who elsewhere followed the rapid strides of agricultural chemistry, and who made its study a profession, should be called to us for inaugurating a new era in Australian husbandry and to become here its scientific leader.

Let it not be said that we are wanting in talent for this purpose among us, for, the contrary is the fact;—but be it understood, that, amidst multifarious other duties entrusted to our scientific functionaries it is beyond their fair reach to devote the needful attention to a task of such magnitude,—a task which would occupy exclusively all the energies and the undivided attention of one man, howsoever bright may be his genius.

Hence, in my opinion, one of the wisest measures which could be adopted for advancing permanently the agricultural interests of this country, would consist in creating a professorship of chemistry applied to agriculture, in our rising university.

The proposal of such a measure, it is gratifying for me to record, has met with the thoughtful reflection of those who rule among us.

The occupant of such a chair should be a man of vigour and youthful elasticity,—who has a life of activity yet before him;—he should glory in the very highest ability,—should be placed in a position of ease, which would induce him to relinquish cheerfully all other purposes of life, to sacrifice and devote all his time, exertions, and talents, solely for the objects entrusted to his care, and thus to concentrate all his efforts for the purpose of raising agriculture in this country to the highest standard; but this should be done without the likelihood of his feeling after a series of years, that he had adopted a wrong plan of life or his being then disheartened by glancing back to a thankless past, or viewing an unpromising future.

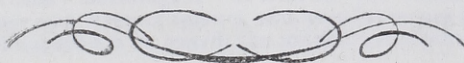
The lectures of such a savant should not be limited to the ordinary students of the university. His addresses should be freely offered to the agricultural community. He

should make known the chemical and physiological principles on which rational cultivation depends. He should in all special instances disseminate information on soils submitted for rigorous examination, and be ready, by his teachings, to guide the farmer in rendering his area the most productive.

Perhaps he might even find it within the range of possibility to extend his beneficent exertions by teachings in chemistry applied to technology, whereby he would not only exercise a favorable influence on many of the works of our artizans, but render also boundless resources and inexhaustible riches, now lying dormant, accessible to the capitalist and thousands of perhaps otherwise unoccupied people,

The important question of sewage, involving the gain or loss of great—indeed, unconceived—wealth, might prominently engage his attention.

He would bring with him a knowledge of all the improvements effected up to the latest day, in the appliances required to turn to account the products and educts of the combustion or destructive distillation of the woods of our endless forests; and, if gratefully supported in a felicitous position he would finally enrich the treasures of the country by millions of wealth, and be the originator of the prosperous independence and happiness of many a family throughout this favored land.



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It would bring with him a knowledge of all the improvements effected up to the latest day, in the appliances required to turn to account the facts and objects of the

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and as a means; and if gratefully supported in a delinquent position he would finally enrich the treasury of the country by millions of wealth, and be the originator of the prosperous independence and happiness of many a family throughout the favored land.



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