
The Advantages of Chemical Science (in an Agricultural point of view,) illustrated by a series of Observations on the Nature and Improvement of Soils, and on the Use and Application of Manures: principally abridged from Sir Humphry Davy's "Elements of Agricultural Chemistry." *

AGRICULTURAL Chemistry has for its objects all those changes in the arrangements of matter connected with the growth and nourishment of plants, the comparative value of their produce as food, the constitution of soils, and the manner in which lands are enriched by manure, or rendered fertile by the different processes of cultivation.—Inquiries of such a nature cannot but be interesting and important both to the theoretical agriculturist and the practical farmer: to the first, they are necessary in supplying most of the fundamental principles on which the theory of the art depends; to the second, they are useful in affording simple and easy experiments for directing his labours, and for enabling him to pursue a certain systematic plan of improvement. If land be unproductive, and a system of ameliorating it is to be attempted, the sure method of obtaining the object is by determining the cause of its sterility, which must necessarily depend upon some defect in the constitution of the soil, and which may be easily discovered by chemical analysis. Some lands of good apparent texture are still sterile in a high degree, and common observation and common practice afford no means of ascertaining the cause or of removing the effect; the application of chemical tests in such cases is obvious, for the soil must contain some noxious principle which may be easily discovered, and, probably, easily destroyed. Are any of the salts of iron present, they may be decomposed by lime; is there an excess of siliceous sand, the system of improvement must depend on the application of clay and calcareous matter; is there a defect of calcareous matter, the remedy is obvious; is an excess of vegetable matter indicated, it may be removed by liming, pating, and burning; is there a deficiency of vegetable matter, it is to be supplied by manure. A question concerning the different kinds of lime-stone to be employed in cultivation, often occurs; to determine this fully, in the common way of experience, would demand a considerable time, perhaps some years, and trials which might be in-

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jurious to crops, but by simple chemical tests the nature of a lime-stone is discovered in a few minutes, and the fitness of its application, whether as a manure for different soils or a cement, determined. There has been no question on which more difference of opinion has existed than that of the state in which manure ought to be ploughed into the land, whether recent or when it has gone through the process of fermentation; and this question is still a subject of discussion; but whoever will refer to the simples and principles of chemistry cannot entertain a doubt on the subject,—as soon as dung begins to decompose it throws off its volatile parts, which are the most valuable and most efficient. Dung which has fermented, so as to become a mere soft cohesive mass, has generally lost from one-third to one-half of its most useful constituent elements; and that it may exert its full action upon the plant and lose none of its nutritive powers, it should evidently be applied much sooner, and long before decomposition has arrived at its ultimate results.

The phenomena of vegetation must be considered as an important branch of the science of organised nature, but though exalted above inorganic matter, vegetables are yet, in a great measure, dependent for their existence upon its laws; they receive their nourishment from the external elements, they assimilate it by means of peculiar organs, and it is by examining their physical and chemical constitution, and the substances and powers which act upon them, and the modifications which they undergo, that the scientific principles of agricultural chemistry are obtained; according to these ideas, therefore, the surface of the earth, the atmosphere, and the water deposited from it, must, either together or separately, afford all the principles concerned in vegetation, and it is only by examining the chemical nature of these principles that we are capable of discovering what is the food of plants, and the manner in which this food is supplied and prepared for their nourishment.

The chemical composition of plants has, within the last ten years, been elucidated by the experiments of a number of chemical philosophers, and it forms a beautiful part of general chemistry; it is too extensive to be treated of minutely, but it will be necessary to dwell upon such parts of it as afford practical inferences. The value and uses of every species of agricultural produce are most correctly estimated and applied, when practical knowledge is assisted by principles derived from chemistry, the compounds in vegetables really nutritive, as the food of animals are very few,—farina or the pure matter of starch, gluten, sugar, vegetable jelly, oil and extract; of these, the most nutritive is gluten, which approaches nearest

in its nature to animal matter, and which is the substance that gives to wheat its superiority over other grain;—the next in order, as to nourishing power, is oil; then sugar, then farina, and, last of all, gelatinous and extractive matters; simple tests of the relative nourishing powers of the different species of food are, the relative quantities of these substances that they afford by analysis, and though taste and appearance must influence the consumption of all articles in years of plenty, yet they are less attended to in times of scarcity, and on such occasions this kind of knowledge may be of the greatest importance.

All the varieties of substances found in plants are produced from the sap, and the sap of plants is derived from water or from the fluids in the soil, and it is altered by or combined with principles derived from the atmosphere. Soils in all cases consist of a mixture of different finely divided earthy matters with animal or vegetable substances in a state of decomposition, and certain saline ingredients. The earthy matters are the true basis of the soil; the other parts, whether natural or artificially introduced, operate in the same manner as manures. Some earths generally abound in soils, the aluminous, the siliceous, the calcareous, and the magnesian; these earths consist of highly inflammable metals united to pure air or oxygen, and they are not, as far as we know, decomposed or altered in vegetation. The great use of the soil is to afford support to the plant to enable it to fix its roots and to derive nourishment by its tubes slowly and gradually from the soluble and dissolved substances mixed with the earths. That a particular mixture of the earths is connected with fertility cannot be doubted, and almost all sterile soils are capable of being improved by a modification of their earthy constituent parts.

Tull advanced the opinion, that minute earthy particles supplied the whole nourishment of the vegetable world; that air and water were chiefly useful in producing these particles from the land, and that manures acted in no other way than in ameliorating the texture of the soil, in short, that their agency was mechanical. This ingenious author of the new system of agriculture, having observed the excellent effects produced in farming, by a minute division of the soil, and the pulverisation of it by exposure to dew and air, was misled by carrying his principles too far.

Duhamel adopted the opinion of Tull, and stated, that by finely dividing the soil any number of crops might be raised in succession from the same land. He attempted also to prove, by direct experiments, that vegetables of every kind were capable of being raised without manure. This celebrated horti-

culturist lived, however, sufficiently long to alter his opinion. The results of his later and most refined observations, led him to the conclusion, that no single material afforded the food of plants: the general experience of farmers had long before convinced the unprejudiced of the truth of the same opinion, and that manures were absolutely consumed in the process of vegetation. The exhaustion of soils by carrying off corn crops from them, and the effects of feeding cattle on lands, and of preserving their manure, offer familiar illustrations of the principle; and several philosophical inquirers, particularly Hassensfratz and Saussure, have shown by satisfactory experiments, that animal and vegetable matters deposited in soils are absorbed by plants, and become a part of their organized matter. But though neither water nor air, nor earth, supplies the whole of the food of plants, yet they all operate in the process of vegetation. The soil is the laboratory in which the food is prepared; no manure can be taken up by the roots of plants unless water is present, and water or its elements exist in all the products of vegetation.—The germination of seeds does not take place without the presence of air or oxygen gas; and in the sun-shine, vegetables decompose the carbonic acid gas of the atmosphere, the carbon of which is absorbed, and becomes a part of their organized matter, and the oxygen gas, the other constituent, is given off, and, in consequence of a variety of agencies, the economy of vegetation is made subservient to the general order of the system of nature. It is shown by various researches, that the constitution of the atmosphere has been always the same since the time that it was first accurately analysed, and this must, in a great measure, depend upon the powers of plants to absorb or decompose the putrifying or decaying remains of animals and vegetables, and the gaseous effluvia which they are constantly emitting; carbonic acid gas is formed in a variety of processes of fermentation and combustion, and in the respiration of animals, and as yet no other process is known in nature by which it can be consumed, except vegetation. Animals produce a substance which appears to be a necessary food of vegetables; vegetables evolve a principle necessary to the existence of animals, and these different classes of beings seem to be thus connected together in the exercise of their living functions, and to a certain extent made to depend upon each other for their existence. Water is raised from the ocean, diffused through the air, and poured down upon the soil so as to be applied to the purposes of life. The different parts of the atmosphere are mingled together by winds or changes of temperature, and successively brought in contact with the surface of the earth, so as to exert their fertilizing influence. The modifications of the soil, and the appli-

cation of manures, are placed within the power of man as if for the purpose of awakening his industry and of calling forth his powers.

The theory of the general operation of the more compound manures may be rendered very obvious by simple chemical principles, but there is still much to be discovered with regard to the best methods of rendering animal and vegetable substances soluble, and the chemistry of the more simple manures, the manures which act in very small quantities, such as gypsum, alkalis, and various saline substances, has hitherto been exceedingly obscure. It has been generally supposed that these materials act in the vegetable economy in the same manner as condiments or stimulants in the animal economy, and that they render the common food more nutritive. It seems, however, a much more probable idea that they are actually a part of the true food of plants, and that they supply that kind of matter to the vegetable fibre which is analogous to the bony matter in animal structures.

The chemical theory of Fallowing affords no new source of riches to the soil; it merely tends to produce an accumulation of decomposing matter, which, in the common course of crops, would be employed as it is formed, and it is scarcely possible to imagine a single instance of a cultivated soil which can be supposed to remain fallow a year with advantage to the farmer. The only cases where this practice is beneficial, seems to be in the destruction of weeds and for cleaning foul soils.

Paring and burning is destructive to vegetable matter, and must be principally useful in cases in which there is an excess of this matter in soils. The instances in which it must be obviously prejudicial, are those of sandy dry siliceous soils containing little animal or vegetable, there it can only be destructive, for it decomposes that on which the soil depends for its productiveness.

The advantages of Irrigation act not only by supplying useful moisture to the grass, but likewise the water carries nourishment dissolved in it, and defends the roots from the effects of cold.

No general principles can be laid down respecting the comparative merits of the different systems of cultivation, and the different systems of crops adopted in different districts, unless the chemical nature of the soil, and the physical circumstances to which it is exposed, are fully known. Stiff coherent soils are those most benefited by minute division and aeration, and in the drill system of husbandry these effects are produced to the greatest extent, but still the labour and expense connected

with its application in certain districts, may not be compensated for by the advantages produced. Moist climates are best fitted for raising the artificial grasses, oats, and broad-leaved crops; stiff aluminous soils, in general, are most adapted for wheat crops; and calcareous soils produce excellent clover. Nothing is more wanting in Agriculture than experiments, in which all the circumstances are minutely and scientifically detailed. This art will advance with rapidity in proportion as it becomes exact in its methods. As in physical researches, all the causes should be considered; a difference in the results may be produced even by the fall of half an inch of rain, more or less, in the course of a season, or a few degrees of temperature, or even by a slight difference in the sub-soil, or in the inclination of the land. Information collected after views of distinct inquiry, would necessarily be more accurate and more capable of being connected with the general principles of science; and a few histories of the results of truly philosophical experiments in agricultural chemistry would be of more value in enlightening and benefiting the farmer than the greatest possible accumulation of imperfect trials conducted merely in the empirical spirit. It is no unusual occurrence for persons who argue in favor of practice and experience, to condemn generally all attempts to improve agriculture by philosophical inquiries and chemical methods. That much vague speculation may be found in the works of those who have lightly taken up agricultural chemistry it is impossible to deny. It is not uncommon to find a number of changes rung upon a string of technical terms, such as oxygene, hydrogen, carbon, and azote, as if the science depended upon words rather than upon things. But this is in fact an argument for the necessity of the establishment of just principles of chemistry on the subject; whoever reasons upon agriculture is obliged to recur to this science. He feels that it is scarcely possible to advance a step without it; and if he is satisfied with insufficient views, it is not because he prefers them to accurate knowledge, but, generally, because they are more current. It has been said, and undoubtedly with great truth, that a philosophical chemist would most probably make a very unprofitable business of farming, and this certainly would be the case if he were a mere philosophical chemist, and unless he had served his apprenticeship to the practice of the art as well as to theory. But there is reason to believe, that he would be a more successful agriculturist than a person equally uninitiated in farming, but ignorant of chemistry altogether; his science as far as it went would be useful to him. But chemistry is not the only kind of knowledge required, it forms a small part of the philosophical basis of agriculture, but it is

an important part, and whenever applied in a proper manner must produce advantages.

In proportion as science advances, all the principles become less complicated, and consequently more useful, and it is then that their application is most advantageously made to the arts. The common labourer can never be enlightened by the general doctrines of philosophy, but he will not refuse to adopt any practice of the utility of which he is fully convinced, because it has been founded upon these principles. The mariner can trust to the compass, though he may be wholly unacquainted with the discoveries of Gilbert on magnetism, or the refined principles of that science developed by the genius of *Cepinus*.—The dyer will use his bleaching liquor even though he is perhaps ignorant not only of the constitution, but even of the name of the substance on which its powers depend.—The great purpose of chemical investigation in agriculture ought undoubtedly to be the discovery of improved methods of cultivation. But to this end general scientific principles and practical knowledge are alike necessary; the germs of discovery are often found in rational speculations, and industry is never so efficacious as when assisted by science. It is from the higher classes of the community, from the proprietors of land, those who are fitted by their education to form enlightened plans, and by their fortunes to carry such plans into execution; it is from these that the principles of improvement must flow to the labouring classes of the community. There is no idea more unfounded than that a great devotion of time and a minute knowledge of general chemistry are necessary for pursuing experiments on the nature of soils, or the properties of manures. Nothing can be more easy than to discover whether a soil effervesces or changes colour by the action of an acid, or whether it burns when heated, or what weight it loses by heat; and yet these simple indications may be of great importance in a system of cultivation. The expense connected with chemical inquiries is extremely trifling,—a small closet is sufficient for containing all the materials required. The most important experiments may be made by means of a small portable apparatus:—a few phials containing acids, alkalies, and chemical unguents; some foil and wire of platinum, a lamp, a crucible, some filtering-paper, some funnels, and glasses for receiving products, are all that can be considered as absolutely essential for pursuing useful researches.

It undoubtedly happens in agricultural chemical experiments, conducted after the most refined theoretical views, that there are many instances of failure for one of success, and this is inevitable from the capricious and uncertain nature of the causes that operate, and from the impossibility of calculating on all

the circumstances that may interfere, but this is far from proving the inutility of such trials, one happy result which can generally improve the methods of cultivation is worth the labour of a whole life; and an unsuccessful experiment, well observed, must establish some truth, or tend to remove some prejudice. Even considered merely as a philosophical science, this department of knowledge is highly worthy of cultivation;

for what can be more delightful than to trace the forms of living beings and their adaptations and peculiar purposes, to examine the progress of inorganic matter in its different processes of change, till it attains its ultimate and highest destination, its subserviency to the purposes of man.

Many of the sciences are ardently pursued, and considered as proper objects of study for all refined minds, merely on account of the intellectual pleasure they afford, merely because they enlarge our views of nature, and enable us to think more correctly with respect to the beings and objects surrounding us.

How much more then is this department of inquiry worthy of attention, in which the pleasure resulting from the love of truth and of knowledge is as great as in any other branch of philosophy, and in which it is likewise connected with much greater practical benefits and advantages. Discoveries made in the cultivation of the earth, are not merely for the time and country in which they are developed, but they may be considered as extending to future ages, and as ultimately tending to benefit the whole human race, as affording subsistence for generations

yet to come, as multiplying life, and not only multiplying life, but likewise providing for its enjoyment.

(To be continued.)