IS NITROGEN GOING WEST?

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THE FRENCH farmer collects all vegetable wastes about the farm and brings in forest leaves, bracken fern and any wayside or swamp growths that represent possibilities for animal bedding and more manure. Barn manures, supplemented by any farm refuses, are composted into the carefully built, flat-topped, and straight-sided pile for the heating or fermentation process by which the European farmer truly "makes manure." This finished product is then put on the field in regular, seemingly measured piles from the two-wheeled ox-cart or single-horse wagon. Later it is spread very carefully at a uniform but relatively heavy rate.

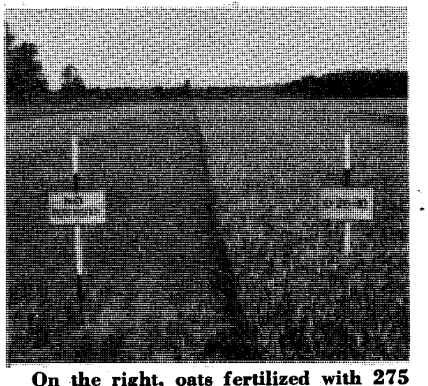
When one observes the laboriousness of this procedure and the detailed attention to farm manure in contrast to the way we, in the United States, hastily get rid of barn wastes with the minimum of thought except for their speediest disposition, it provokes thought about nitrogen, and other fertility elements, so parsimoniously treasured by the farmer in Europe. It reminds one that the organic matter, and in it the nitrogen, of our own soils in the United States has seemingly taken to following the advice of Horace Greeley, and it too, like many other things, is "going west."

Soil Nitrogen Fits Climatic Pattern of Different Carbon-Nitrogen Ratios

Viewed in relation to the map of climate of the United States, and consequently to the forces developing our soils, the eastern states under higher rainfall have a low supply of soil nitrogen in relation to the carbon, or they have an organic matter of a wide carbon-nitrogen ratio. The western states have the reverse, namely, a high supply of nitrogen in the microbial diet of decay as related to the carbon, or a narrow ratio. Then, too, in the former area, which was originally one of forests, the carbon was added on the top of the surface soil by the annual drop of the highly carbonaceous, tannin-laden leaves. In the latter area, the addition was one well distributed through the surface soil in the form of the annual contribution of deeply penetrating, more proteinaceous roots of native grasses and legumes. These features, carefully considered, point to an interesting pattern of varying carbon-nitrogen ratios along any line of constant temperatures but of decreasing rainfall as one goes west.

Beginning in the eastern United States, one's going west means a shift from conifers to deciduous forests; a shift from soft woods to hard woods. In going still farther west there is a shift from hard wood forests to starchy food grains; and then, even within the wheat grain area, a traverse westward as limited as one across Missouri and Kansas means a shift from soft wheat to hard wheat.

From "soft" to "hard" in the case of wood means more ash as to both amounts and kinds of chemical elements included. From "soft" to "hard" in the case of wheat means also more ash and chemical elements in the products of plant growth. In both the wood and the wheat, there has always been an increasing nitrogen content connected with the increasing concentrations of the chemical ash elements or the fertility in the plants as taken from the soil. In the wood, however, we have emphasized the ash and disregarded the nitrogen. In the wheat our emphasis has been reversed. We have pointed to the nitrogen as protein, making the so-called "hard" wheat. But we have disregarded the high ash or fertility taken from the soil that plays an important part among the soil conditions making the wheat hard in terms of its synthesized protein at the same time that they make it high in fertility ash.



On the right, oats fertilized with 275 pounds per acre of 0-20-10 produced 72.6 bushels; left, no fertilizer, 33.8 bushels. ***(Courtesy, C. J. Chapman, Wisconsin.)***

Harder wheat represents a greater microbial "turnover" annually of the nitrogen in the soil organic matter which gives more of the soluble nitrogen. It means, too, that there is no deficiency in the microbial diet of the mineral nutrients in relation to its supply of energy. Microbial "burning" of the carbon within the soil puts the carbon out of the soil as the gas, carbon dioxide. It gives a narrow carbon-nitrogen ratio in the humus of the soil. It brings the nitrogen out of its less soluble, organic combinations and puts it into the more soluble, mineral, nitrate forms. This plant nutrient is thereby no longer in the hoard of the microbes which are competing with the crop for it. It is released and can move downward in the soil to be temporarily recombined, or to remain soluble in the deeper soil horizons as one finds it more commonly in the soils of the western, hard-wheat belt where the lower annual rainfalls do not leach it down and out through the soil profile.

Nitrates in Surface Soils of the East Mean Soft Wheat—in Deeper Horizons of the West Hard Wheat

Under the higher annual rainfalls the soil situation represents a shortage of mobile nitrogen in terms of the crop, both because of the leaching of the minerals and nitrates, and because of the control of the nitrogen by the microbes that are keeping it combined with the excessive carbon. The same situation prevails in old agricultural soils farmed for many years. There the microbial fires had been fanned so long by tillage as to have burned the humus out and lost the nitrogen. Only a woody crop growth is now possible there as green manure for organic matter returned to the soil. There some nitrogen can be released in the form of mobile nitrates in the limited surface soil only during the spring by tillage and the rising temperatures that burn the carbon and reduce the carbon-nitrogen ratio. But that nitrate supply is soon exhausted by the multiplying roots of the wheat crop, for example, which spends this protein-producing nutrient in making its vegetative skeletal structure. Over the usually infertile subsoil, the nitrogen is then deficient in the plant's later, seed-making performances which are limited to putting out mainly starch, and are prohibited from converting much of that into the liberal content of protein that makes a hard wheat. It is not, therefore, the high rainfall of the eastern states that

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makes soft wheat, but instead it is the limited supply of soluble nitrogen in the soil at the time when the plant is really "making the grain," as the farmer commonly describes it.

More mobile nitrogen in the soil during a particular phase in the crop's physiological cycle comes about through a relatively limited carbon supply as energy for the soil microbes. It is such conditions that allow the nitrogen to occur as mineral form or nitrate. It is these conditions that we provide, for example, when we turn under nitrogenous green manures, or as we feed the microbes on a diet with a narrow carbon-nitrogen ratio so that the nitrogen can be released from the carbon and move downward in the soil. It is in such that we can see the wheat crop prompted to send its roots down for their arrival at this more abundant supply of soluble nitrogen so timed as to deliver this nutrient, not early and for excessive vegetative production, but late in the plant's growth cycle for conversion of the starch into protein and for making the hard, high-protein wheat grain.

Such hard wheat has commonly been believed to be caused by the low rainfall rather than by the complex set of soil conditions including: (1) a liberal supply of mineral fertility to encourage microbial conversion of organic nitrogen into nitrates; (2) a limited annual rainfall that prohibits excessive vegetative growth and does not seriously leach the soluble nutrients out of the soil; (3) the narrower carbon-nitrogen ratio of the organic matter grown and decayed there; and (4) the location of the nitrates in liberal quantities in the deeper soil horizons to provide nitrogen generously at those stages in the plant's physiological processes that may mean less yields as bushels per acre but in place of a soft, starchy, or highly carbonaceous grain they mean more in terms of a highly proteinaceous food product of the quality so much desired.

Declining Protein Content of Kansas Wheat Brings Nitrogen West

The exploitation of the soil fertility has compelled the hard wheat to go west. That condition of the soil is inducement also for other phases of agriculture to go west. Is it pure coincidence that Kansas City surpassed Chicago recently in the number of beef cattle handled annually on the market? Isn't this a case where our big protein crop, or meat, is already in the West? There is the suggestion, too, that hard wheat is going still farther west, if the complaints by the bread bakers in Kansas are an indication. They say that the Kansas farmers are abandoning the varieties of hard wheat and taking to those of soft wheat. They claim it is high time to search and research for new varieties of hard wheat.

The farmer will, of course, grow whatever kind of wheat maintains his volume of output as measured in bushels per acre. For him that volume may as well be a soft wheat as a hard wheat when volume alone or bushels per acre determines his earnings. Bakers want to maintain their volume of output, too. But this is of a bread loaf that can be blown into big volume from the minimum of flour and with maximum retention of water as guarantee of weight. This is possible only by means of protein or colloidal nitrogen put into the dough-mix by way of some particular soil conditions under the growing grain. Soft wheats of low protein, or low nitrogen content can't meet the baker's specifications even though they may well satisfy those laid down by the farmers. Shall we, therefore, match the bakers against the farmers in a squabble about

Planter lister with large fertilizer box capacity. ***(Courtesy, W. H. Pierre, Iowa.)***

varieties of wheat, or shall we suggest that both groups have a common or mutual problem in the dwindling fertility of the soil?

Both the bakers and the farmers may well be reminded that hard wheat is "going west" for them as it did for the folks in the Genesee River Valley of New York State where hard wheat once made that area the "bread basket" of the United States, and Rochester, "the Flour City." When they can't move on or go west with their wheat-growing and baking businesses, shall they plan to reduce their outputs or shall they think about using some nitrogen as fertilizer on the soil?

For the recent five years, 1941-1945 inclusive, Kansas has had more favorable rainfall and has produced wheat yields each year approaching the state's maximum crop of 1931. These five years represent a rate of nitrogen removal from the soil in the wheat crop almost double that of a previous five-year period, like 1932-1936 inclusive, for example. Cannot such excessive removal of nitrogen and other soil fertility elements from the soil by these large crops be considered as causally connected with the declining quality of the wheat? Is it not wiser that the bakers and farmers should recognize the dwindling soil fertility as a mutual problem rather than that they should fly at each other with accusations of the one attempting to maintain his own high volume of output regardless of having an equally high output go to the other? Would it not also be a wiser national policy in terms of food values in our "staff of life" to think about keeping high the protein and ash contents of the wheat by fertilizing the soil than to agree to lower the standard figure of percentage of protein for a product that all of us eat?

"Westward Empire Takes Its Way," But Stays Permanent Only by Conservation of Its Soil Fertility

Yes, I believe you will agree that nitrogen is "going west," at least in the proverbial slang sense of that term, when we merely shrug our shoulders with indifference to the conservation of our soils. But if we are going to have a hard wheat always and a highly proteinaceous flour, nitrogen may be going west in a distinctly geographical sense and in terms of its application more widely as a fertilizer in our better attention to the fertility of the soil. We shall then be treasuring the chemical nitrogen of industrial output as well as the urinary nitrogen of farm manures which the so-called "French peasant" is still guarding today as he always has—ever since the revolutionary days when nitrogen from his manure pile meant gun powder in the fight for freedom from dictators.