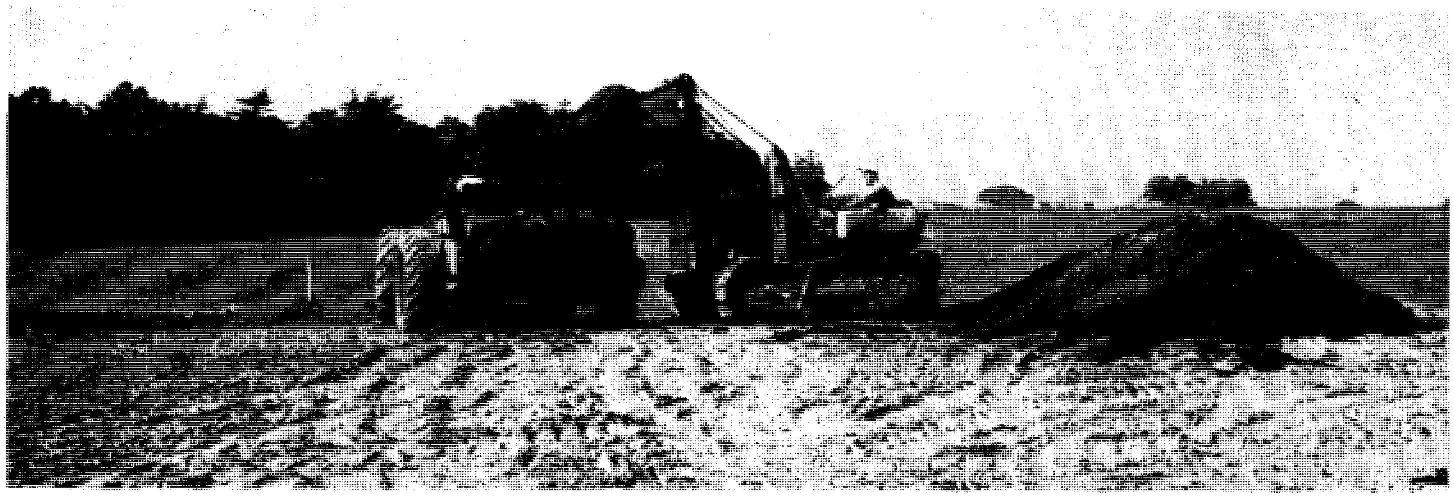

Good farming to make the best use of fertilizer chemicals requires that fresh organic matter, either as manure or crop residues, be applied frequently

Organic Farming with Chemical Fertilizers

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FARMING IS becoming a more competitive and a more highly specialized business in the United States. The horse has practically disappeared as a source of farm power. Many large farms have no livestock whatsoever. Without livestock, there is seldom a profitable outlet for a very large acreage of leguminous forages, and there is no manure. Farmers on such farms are asking us to re-examine the question: Just how important is the maintenance of organic matter on my soil and with my type of farming? How little can I get by with? How can I best provide that little? And how can I get the most out of that little? We have had but little experience with these questions in their modern setting. By modern setting I mean situations in which land and labor are priced higher than ever before, larger capital investments in highly specialized machinery are indispensable and ample supplies of commercial fertilizer are available at prices which compare more favorably than ever before with the prices received for most crops. Each of these factors has an important influence upon the feasibility of soil organic matter maintenance on the present day American farm.

Much of our thinking about soil organic matter in the past has been rather vague and general. It is still regarded as an entity in much of our thinking. We commonly calculate the organic matter content of soil by multiplying its organic carbon or nitrogen content by an empirical factor. This admittedly has a certain degree of validity. We know that organic materials from widely divergent sources of highly variable composition are, in time, converted in the soil into a characteristic soil product which we call humus. This material is much less variable in composition and properties than the original residues from which it was derived. The bulk of the organic matter, usually 85 to 90% of it, is stored in the soil in this humified form. I do not mean to imply that this material is a single chemical entity.

I think there is justification, even a degree of necessity—for our present purposes, at least—in thinking about the organic matter in the soil as existing in two major categories. First, the fresher and newer fraction, in various stages of decomposition, constitutes the raw material from which humus is made. This fraction is physically incorporated *in* the soil, but it is not yet *of* the soil. It has a very transient existence, and usually makes up 10% or less of the total in the case of mineral soils. Second, the older, more stable fraction—more uniform in both physical condition and chemical composition than the fresher material—usually makes up 90% or more of the total organic matter contained in most mineral soils. This fraction is the soil organic matter in the strictest sense. It is the form in which most of the nitrogen and a high proportion of the phosphorus is stored in the surface soil. It is the fraction which, more than any other, distinguishes top soil from subsoil, and fertile soils from depleted soils. Much of this organic matter is bound chemically to various inorganic constituents. This is the only fraction that can be maintained in the soil for very long, for it is the form to which all organic matter tends to pass as it accumulates in the soil under favorable farming conditions.

Only a little over a century ago, it was regarded as the probable source of the bulk of the carbon in plants. Practically all of the nitrogen stored in the soil is in this fraction. The carbon-nitrogen ratio is fairly constant and much narrower than most of the fresh plant residues which find their way into the soil. While it is the most stable form of organic matter in the soil, it is decomposed at a characteristic rate, usually from 1 to 2% a year. This depends upon the reaction of the soil, its drainage status, the cultural practices used, and many other factors. When crops are grown in continuous culture it has been found in many places that the yield of crops obtained without fertilization is usually a linear function of the content of organic matter in stored form. This is probably due to the fact that under such

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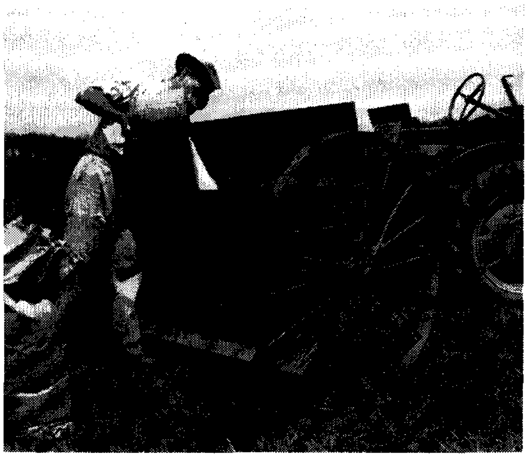

conditions the yield of crops is determined by the amount of nitrogen released from the organic matter, and the amount of nitrogen released, is, in turn, a function of the organic matter content of the soil.

There are other qualities of the soil, however, which are greatly influenced by its organic matter content which do not bear a linear relationship to the quantity of organic matter present. We know, for example, that heavy soils can contain very large quantities of humified organic matter and still have very poor structure. When such soils are poorly managed, crop yields decline much faster than 2% a year.

The fact that soil organic matter content declines at a relatively slow rate, 1 to 2% a year normally, while other properties affecting crop yields, such as structure, decline at a much more rapid rate, indicates that we must recognize that we are dealing with different forms of organic matter.

The nonhumified materials are made up of a very wide range of original materials. Plant roots, stubble, fallen leaves, animal manures, and soil microorganisms make up the bulk of the parent material. All of these materials may be present in a very wide range of state of decomposition, from the fresh state to the completely humidified state. This is the much more dynamic fraction. In degree of complexity, it will range from the simple end-products of decomposition of very transient existence, through innumerable intermediate products which also have only a temporary existence in the soil, such as amino acids, many polysaccharides, fats, antibiotics, and the like to the highly complex and relatively resistant end-product, the humified fraction. Because this fraction is more easily decomposed by soil microorganisms, microbiological activity is much greater in its presence, and carbon dioxide is produced at a more rapid rate. Carbon dioxide dissolved in the soil water increases the solubility of many of the mineral nutrients in the soil. The increase in microbial population brought about by the more abundant food supply also seems to accelerate the rate of decomposition of even the humified fraction of the soil organic matter.

These crop residues may have a very pronounced effect upon the physical properties of the soil. The roots of crops, especially of crops producing an abundant root system, like grass sods, have a very important and complicated effect on the structure of the soil. There is unquestionably a direct physical effect of the root fibers themselves in keeping the soil loose and porous, but in addition there is considerable evidence that as the roots decompose they yield complex polysaccharides and other similar materials which have a marked influence upon the formation and stabilization of soil granules.

While either total carbon or total nitrogen content is a fairly satisfactory rough criterion of the amount of humified material in a soil, since the humified material makes up 85 to 90% of the total, it is not an adequate measure of the influence of the nonhumified matter. For example, an amount of organic matter which is within the normal field sampling error may have a marked effect on plant growth and physical properties of the soil. A single application of manure may bring about a marked increase in the yield of certain crops. A clover or alfalfa sod may increase the yield of the succeeding corn crop by 20 to 25 bushels per acre. One or two years in grass sod will produce a marked effect upon the physical properties of many heavy soils the first year after they are plowed and put in a cultivated crop. The classical experiments at Rhode Island on the effects of crops on those which follow illustrate a different type of effect.

The nonhumified fraction of the soil organic matter bears somewhat the same relationship to the humified fraction that the available plant nutrients bear to the total analysis. I think it is obvious, when we stop to think about the facts mentioned above, that it is indefensible scientifically to speak of soil organic matter as an entity. If we are to make maximum use of organic materials in soil management, we must be more specific in our thinking and in planning our experiments.

One of the oldest experiments to compare the effects of manure and chemical fertilizers, at Rothamsted, England, showed that crop responses to the two fertilizers did not vary widely, but the chemical fertilizer was quicker acting and gave somewhat better results the first few years. That difference became smaller with time, and eventually the manure pulled ahead. Similar results from the Wooster, Ohio, results are shown in Table I. This indicates that a combination of organic and chemical fertilizers might be superior to either alone.

Organic Matter as Soil Fertility Measure

In searching for a yardstick to measure the inherent fertility of different soils, it was found at several stations, Ohio and Missouri particularly, that the organic matter content of the soil was the most reliable, provided other factors, such as drainage and pH, were satisfactory.

When soils are used to grow intertilled crops such as corn or potatoes, the organic matter content of the soil declines about 2% a year in the Corn Belt. If a perennial leguminous sod crop, such as clover or alfalfa, is grown in a rotation with corn, it will add to the soil about as much nitrogen as the average corn crop will remove.

If, in addition to growing the legume in the rotation, we feed the legume and the corn to livestock, use the other crop residues for bedding, and then return the manure to the soil, the organic matter content of the soil and the yield of crops can be maintained at higher than present average yields with the addition of limestone where needed and modest applications of phosphatic fertilizers. On soils having a fairly good reserve of fertility to start with, these practices will maintain corn yields at 75 to 80 bushels per acre almost indefinitely. I base this statement on the results of long-time experiments at Wooster, Ohio, and the famous Morrow plots in Illinois. While crop residues and organic manures usually have a greater residual effect than chemical fertilizers, they are most active on a per pound dry matter basis when freshly applied. The effect of the residues of the crop immediately preceding, particularly if it is a leguminous crop, is usually greater than that from the total accumulation of all older residues combined (Table II).

On very heavy clay soils, crop yields are often influenced more by the effect of the preceding crop on the structure of the soil than they are by chemical fertilizers. The beneficial effects of sod crops on the structure of such soils is brought about largely in the first one to two years, and when the sod is plowed

Table I. Comparative Direct and Residual Effects of Manure and Chemical Fertilizers. (Rotation: Corn, Oats, Wheat, Clover, Timothy)

	Nutrients Applied Per Rotation[a]				Average Increase in Total Produce per Rotation (1894–1936)[b]			
					Direct Effect of Treatment (Grain Crops)		Residual Effect of Treatment (Hay Crops)	
Plot No.	N (Lb.)	P_2O_5 (Lb.)	K_2O (Lb.)	Total (Lb.)	(Lb.)	(Relative)	(Lb.)	(Relative)
18, Manure	145	80	130	355	6909	89	4211	153
12, Chemicals	112	51	130	293	7781	100	2747	100
20, Manure	72	40	65	177	3983	69	2248	150
14, Chemical	50	35	90	175	5766	100	1497	100

[a] Chemicals divided among all three grain crops; plot 18 received 16 tons of manure, divided between corn and wheat, and plot 20 is manured in the same way but at one half the rate.

[b] Averages for limed and unlimed ends.

SOURCE: Salter, Robert M., and Schollenberger, C. J., Ohio Agricultural Experiment Station, Wooster, Ohio, Bull. **605**, 1939.

up and planted to an intertilled crop the effect disappears just about as quickly. In an experiment started in 1939 at the Paulding County Experiment Farm in Ohio, corn yields in 1949 varied from 15.9 bushels per acre on the continuous corn plots to 102 bushels per acre where corn followed a sweet clover–orchard grass sod. Crops seldom respond to chemical fertilizers on this soil unless its structure is improved.

The classical experiments on the influence of crop plants on those which follow (which have been in progress at the Rhode Island Experiment Station since 1907) present much additional evidence of the importance of the short-time effect of crop residues upon the yields of the following crops. In a recent publication dealing with these experiments, Odland, Bell, and Smith (Rhode Island Agricultural Experiment Station, Bull. **309,** Kingston, R. I., 1950) state:

"The least favorable crops to precede mangels were carrots, mangels, and millet. Potatoes, rutabagas, and millet were most deleterious to a subsequent crop of potatoes. Low yields of rutabagas followed mangels, millet, or rutabagas, while onions were unfavorably affected by preceding crops of mangels, cabbage, or rutabagas. It seems significant that for three crops out of four, millet, mangels, and rutabagas proved to be deleterious. Rye, oats, and onions were usually followed by high yields of the subsequent crops....No simple explanation exists for the effect of crop plants on those that follow. The relationships are complex, and are associated with the chemical, physical, and microbial conditions in the soil. These conditions are interdependent. An unfavorable soil reaction, for example, may accentuate a poor physical condition of the soil and retard vital microbial activity." It should be pointed out that in this experiment, especially in the more recent phases, the crops were well fertilized to minimize any effect due to an insufficient nutrient supply.

Since all available evidence seems to indicate that a ton of fresh organic matter is much more effective on crops than an equal weight of dry matter in the form of humified organic matter, it would appear that primary emphasis should be placed on having fresh organic material in the form of manure or crop residues available for turning under each time the soil is plowed, instead of on the changes in the total content of organic matter in the soil. I subscribe wholeheartedly to the conclusion reached by M. F. Miller (Missouri Agricultural Experiment Station, Bull. **409,** Columbia, Mo., 1947).

"In general, the conclusion has been reached that it is uneconomical under the climatic conditions existing in Missouri and under the usual systems of cropping and fertilization to increase very greatly the nitrogen content of the average soil above what it is today. This, however, need not be a matter of great concern so long as reasonably large amounts of organic matter, particularly that from legume crops, are regularly returned to the soil. *The important thing, from the standpoint of continued crop production, is to provide, from rotation to rotation, or year to year, a regular and abundant supply of readily decomposable organic matter that is reasonably high in nitrogen.* The decay of this within the soil will set free sufficient available nitrogen for satisfactory crop yields. In other words, it is the decomposition of these regular and abundant additions of organic matter, largely from legumes, that is important, although the accumulation of a large nitrogen reserve within the soil would be advantageous." (Italics mine.)

Work like that reviewed from Rhode Island indicates that we must be prepared in the future to go even beyond the philosophy expressed by Prof. Miller. We must be in position to take maximum advantage of specific decomposition products derived from certain types of crop residues in order to realize the full potentialities of organic matter in soil management. To this end, we should emphasize that soil organic matter is complex, that it has diverse effects, and that the farmer can control to a certain extent some of these organic matter transformations which are of agricultural significance. We must no longer think of organic matter in the soil as an entity, or something to be maintained at a certain level, but as something which catalyzes certain types of activities within the soil and is itself decomposed in the process. We must stress the importance of the rate of "turn over" of organic matter in the soil.

I do not want to minimize its importance as the form in which most of the nitrogen and much of the more available phosphorus is stored in the soil, stored in such a form that its release by microbiological processes tends to be synchronized with the needs of the crop. But we must remember that the rate of release from one ton of fresh organic residues of appropriate type may be as great as from 20 or more tons of humified material. I am inclined to feel that if a farmer would provide ample fresh organic matter frequently in his rotations he would not need to worry about the resultant slight fluctuations in the total organic matter content of the soil.

On most soils the amount of fresh organic matter needed for optimum yields cannot be produced without the liberal use of commercial fertilizers. Nor, on most soils, can the most profitable returns from commercial fertilizer be obtained without these organic residues. For the highest type of agriculture it is not a question of organic or chemical fertilizers; both are essential and as inseparable as Siamese twins.

The problem of soil organic matter maintenance assumes different forms and receives different emphasis in different sections of our country. Most of the evidence cited above has been derived from experiments conducted in the Corn Belt. The experiment stations of that area have been more concerned with the problem throughout their history than the stations in any other section of the country, probably because the maintenance of soil organic matter has been more feasible there than in any other section of the country. It is a general livestock type of farming area, which uses forage crops and sod-forming perennial legumes found to be so effective in building soil structure and maintaining soil organic matter. Livestock production means, also, that about 80% of the nutrients removed from the soil in crop production can be circulated back to the soil in the form of animal manures.

In the dairy farming sections of the Northeast and of Wisconsin and Minnesota, the situation is very similar and, in the Northeast, even more favorable for the maintenance of the organic matter content and general productivity of the soil because even a higher proportion of the land is in grass and a high proportion of the concentrates fed are imported from the West. The northeastern dairy farmer has for a half century been building up the fertility of his soils at the expense of those in the West. This is even more true of the poultry farmer in the Northeast whose business is built up almost exclusively upon imported concentrates. The one exception is potato and vegetable growers, who formerly depended upon commercial supplies of manure, but who now depend largely upon liberal use of commercial fertilizers and the growing of cover crops. Large areas of the poorer soils in the Northeast have been abandoned. In New York State alone 9 million acres have passed out of farming since 1900.

In the West, until comparatively recently, water has been the all-important factor in crop production. Farmers in that area have not been seriously concerned with soil fertility problems in general nor organic matter maintenance in particular.

Southern Soils Less Fertile

In the South, the soils, as a general rule, were not as fertile originally as those in the Corn Belt or Wheat Belt. Most of the farms were smaller and the livestock industry was not highly developed. Hence, the acreage of perennial forage crops was small, and little animal manure was produced. The soils were not protected by a blanket of snow during the winter, and the crops grown were largely intertilled cash crops —cotton, peanuts, and tobacco. As a result, farmers in this section came to use commercial mixed fertilizers more regularly and more liberally than the farmers in any other section of the country. With this system of farming, organic matter maintenance was much more difficult. Soil structure tended to decline; erosion became a serious problem. Such, in brief, was the situation for the first 50 to 75 years after our agricultural experiment stations were established.

During the same period, before 1930, most of our nitrogen fertilizers were imported from Germany or Chile and were so expensive that, if used with normal efficiency, nitrogen produced just enough corn to pay for itself. We were dependent on France and Germany almost exclusively for potash. Superphosphate was the most universally used commercial fertilizer with which farmers were familiar. In contrast, the supply of all these materials is abundant now, even nitrogen becoming reasonably abundant. The ratio of the price of fertilizers to the price of agricultural products is much more favorable, a bushel of corn now being able to buy 15 pounds of nitrogen instead of two, as in the earlier period.

The question naturally arises as to what should be our policy with respect to the use of fertilizers under these circumstances. Very divergent views are being presented. I would like to discuss some of the extreme views first.

The organic farmers and gardeners, a small but vociferous group of city agriculturalists and not dirt farmers, claim that chemical fertilizers are poisonous and that we should use, instead, organic fertilizers, preferably in the form of composts.

Agrees with Some Views of The Organic Farmer

I, and I think that agronomists generally, subscribe to some of the views championed by the "organic farmers." We recognize the importance of soil organic matter in the maintenance of good soil structure. A year or so ago some chemists thought that the problem of soil structure would also be solved by soil conditioners, but most of us are now convinced that for the immediate future, at least, we shall have to depend upon the time-tested methods on most of our farms. We also agree with our friends in the organic school, that organic matter is a valuable form in which to store nutrients, especially nitrogen and phosphorus, a form in which they will be held against leaching when crops are dormant in the winter months. We think there is a real advantage in having some of the crop nutrients stored in a form from which microorganisms can release them as soon as the temperature becomes favorable for both crop and microorganism. I cannot overemphasize the importance of this property of organic matter to release its nutrients in synchrony with the needs of the growing crop.

I think we must keep an open mind, too, on the possibility that certain types of organic matter when incorporated in the soil may have some antibiotic influence on certain types of plant pathogens. There is rather convincing evidence that plowing under large quantities of certain leguminous cover crops helps to control certain soil-borne diseases. There are other effects of organic matter which are probably of considerable significance, such as that of the carbon dioxide evolved in the decomposition of organic matter in increasing the hydrolysis and solubility of certain mineral nutrients in the soil. There is also the possibility that this increased concentration of carbon dioxide in the atmosphere next to the soil may have a growth-stimulating effect on the lower leaves of dense crops among which air movement is restricted. The practical significance of this has never been evaluated under field conditions, but work under controlled conditions leads me to think that it may possibly have some significance. Carbon dioxide fertilization has been shown to be beneficial in greenhouses.

The effect of two rotations (corn, barley, wheat, and clover; and corn, barley, clover, and timothy) on yields of various crops grown without nitrogen and with various applications of manure and sodium nitrate. Lime, potash, and phosphate fertilizers were supplied liberally on all plots. The most significant difference, as far as corn yields were concerned, was the nature of the crop immediately preceding the corn crop. Immediately preceded by clover, corn yields were 61 to 73 bushels an acre and, preceded by timothy, 38 to 55 bushels an acre

Table II. Average Annual Yields per Acre of All Crops from 1923 to 1938 (Oven Dry)

Amounts of Nitrogen Carriers Per Acre	*Corn Grain (Bu.)*	*Barley Grain (Bu.)*	*Wheat Grain (Bu.)*	*Clover Hay (Lb.)*	*Timothy Hay (Lb.)*
No nitrogen	61.30	38.29	34.78	7542	. . .
4 Tons manure	67.61	39.93	35.36	8106	. . .
4 Tons manure, 50 pounds sodium nitrate	68.97	40.27	35.48	8019	. . .
4 Tons manure, 100 pounds sodium nitrate	70.35	41.67	36.80	8068	. . .
4 Tons manure, 200 pounds sodium nitrate	72.94	43.08	37.95	6975	. . .
No nitrogen	38.42	37.30	. . .	8253	4807
200 Pounds sodium nitrate	47.54	43.02	. . .	8266	5031
4 Tons manure	41.46	38.55	. . .	8259	4953
4 Tons manure, 50 pounds sodium nitrate	46.12	39.25	. . .	8424	4752
4 Tons manure, 100 pounds sodium nitrate	49.75	43.89	. . .	7979	5283
4 Tons manure, 200 pounds sodium nitrate	55.93	47.45	. . .	8535	5163
8 Tons manure	44.94	40.67	. . .	8494	5001
8 Tons manure, 100 pounds sodium nitrate	51.36	45.45	. . .	8351	5199
8 Tons manure, 200 pounds sodium nitrate	50.45	46.22	. . .	7690	5328

SOURCE: Bizzell, J. A., and Leland, E. W., Cornell Agricultural Experiment Station, Ithaca, N. Y., Bull. **817**, 1945.

I cannot support some of the other claims made for crops grown with organic fertilizers—such as freedom from disease and insects and that such crops are more nutritious. The potato blight, which destroyed Ireland's potato crop and decimated its population, took place before the widespread use of commercial fertilizers; and wheat rusts have caused famines in areas which have never used the slightest bit of commercial fertilizer. We have had invasions of grasshoppers since Biblical times, and invasions of army worms and Japanese beetles do not discriminate between crops fertilized with organic materials and those fertilized with chemical materials. To a chemist the claim that chemical fertilizers are poisonous and should never be used in food production does not make sense. So far as I have been able to find out, there is no valid evidence to support the nutrition claim.

Compost a Low-Grade Fertilizer

There is no question but that the properly made compost is a good fertilizer. In terms of its plant food content, however, it is a low-grade, bulky fertilizer. It is made up of garden waste, garbage, leaves, and such materials, well piled in the proper manner, moistened to the proper moisture content, and turned two to three times during ripening. Losses during this process are high. Frequently half of the organic matter is lost during the composting process. Commonly, 20% of the nitrogen in farm manure is lost during rotting and 76% of the available nitrogen disappears. All of this seems to me to indicate that making a compost of farm wastes is wasteful of organic matter, wasteful of nitrogen, and wasteful of human labor. We have made many studies of the best ways of handling the supplies of farm manure produced on our farms. These studies all indicate that the less handling the better. Wherever possible, dairy farmers haul manure directly from the barns to the fields and plow it under as soon as possible. The cost of handling even this product, which is probably the most valuable of all organic manures, is, with the present price of farm labor, so great that it is difficult for farmers who have no use for manure to get their neighbors to take it out of their barns for the hauling.

We have, then, two problems if we would follow the recommendations of our organic colleagues. First, to produce the vast amounts of organic matter that would be necessary, and, second, to supply the immense amount of labor that would be required to process and distribute it. By their foolish and unreasonable attitude toward chemical fertilizers, the organic farmers deprive themselves of the most powerful aid available to them for increasing the amount of organic wastes which could be used for organic manures. Without chemical fertilizers, the production of the amount of organic matter needed would be impossible in most areas.

Lady Eve Balfour, one of the most ardent exponents of organic farming in England, estimates that in that country one extra farm laborer would be required on every 100 acres if the organic system were put into effect! Can you imagine trying to put such a program across in this country with the constantly diminishing labor force on our farms? I do not see how we can escape the conclusion that while the organic farmers have developed a philosophy which is good for some backyard gardeners, and/or even some areas which cannot yet get access to commercial fertilizers, the adoption in this country of the practices which they advocate would be a very serious step backward and would result in a declining agriculture and a serious lowering of our standard of living, to say nothing of its effect on our industrial economy, especially the fertilizer business.

At the other extreme of the spectrum, we have the farmer I shall refer to as the "continuous cropper." He feels that rotations and a diversified agriculture were all right in the past but are neither necessary nor desirable now that we have chemical fertilizers in abundance at a reasonable price. He points out that this is an age of specialization, that he has a farm that is well adapted to some particular crop. "If I use plenty of fertilizer, I can grow my most profitable crop every year, year after year. I can plant my entire farm to it. I can make money faster that way."

Surpluses Result

I have no doubt that if just a few farmers would do just that they would make more money per year for a few years. But I wonder what would happen if all the farmers in the United States to whom the argument applies just as effectively decided to follow such a program. As I see it, it could have two possible results: if allowed to spread rapidly with the aid of controlled prices but without acreage restrictions, the conditions which, of course, he would recommend, it would soon result in surpluses way beyond anything we have yet conceived. If, on the other hand, prices were not supported, it would soon result in ruinously low prices. If the Government supports prices, it will, sooner, or later, have to restrict acreages. And to use his land efficiently under such circumstances, the farmer will be forced to diversify. Since some diversification, then, is forced upon him, should it not follow the pattern slowly evolved through the ages which will best maintain soil organic matter, improve soil structure, increase yields per acre, increase production of labor per hour, and increase production per dollar of investment? Only in that way will the interests of all concerned be safeguarded. I am sure that the wiser course for us to follow lies between these two extremes.

We should avoid the limitations which the philosophy of the organic school imposes upon us, on the one side, and the enticements of larger immediate profits promised by the continuous culture of the most profitable crops, on the other, and try to steer an intermediate course through the safer waters between these extremes.

Organic farming with chemical fertilizers is much more feasible than it is without them. As we pointed out above, a well-designed system of organic farming can be a fairly efficient way of maintaining soil fertility under favorable circumstances. Since one can never return to the soil more than he takes from it in this system, the best one can expect to do is to hold his own. One can, of course, build up the fertility of the soil in his garden by hauling it in from the back fields or from his neighbor's farm. This is not building up fertility; it is merely transferring it from one spot to another. Because of the bulk of organic matter, we will not be able, by this technique, to make any rapid shifts in fertility over any large areas, or in areas very far away from the source of supply of the organics. For most farmers, the only economical way to get more organic matter in their soil is to grow more organic matter on their own farms. Larger crops will mean more roots, more stalks and stubble, more feed for livestock, and hence more manure to return to the soil. The cheapest way to grow these larger crops is by more liberal fertilization and by the use of good soil building rotations in which the soil is so handled that maximum efficiency is obtained from the fertilizers. This will require the best available seed, the best adapted cultivation practices, and the most efficient use of all organic residues. Organic farming with chemical fertilizers will result in even higher yields per acre and even more organic matter in our more productive soils in the Corn Belt, and in many other sections of the country. It will result in higher production per hour of farm labor. When we need to expand agricultural production to take care of our rapidly expanding population, organic farming with chemical fertilizers will make it feasible to expand our agriculture into areas of abandoned farm land, and, when necessary, even into areas of very poor soil resources which have the other necessary conditions for good crop production, such as a good water supply and a favorable climate.

Based on an address before the National Fertilizer Association, Hollywood, Fla., Nov. 12, 1954.