Starter Fertilizers and Sustaining Fertility

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There are two major factors in getting a crop off to a good start, namely, the seed and the soil. The careful selection of the seed, its purity, proper storage, its correct labelling, the germination test of it, and all the other cautions exercised by the seedsmen have so standardized the seed that irregularities in the germination, the emergence, and the stand can no longer be charged against this factor of crop production. As for the soil, however, equally as much guarantee by it for the future crop cannot always be claimed. The necessary nutritional helps from the soil fertility are not always available early enough in the seedling's life. For improvement of this the fertilizers have been drilled with the crop seedings. They have been **starter fertilizers.**

Soils fertile naturally or by treatments give higher percentage of emerging seedlings from planted seeds

That such use of plant nutrients is a good practice has been shown by accurate counts of young plants to find the larger percentage of the emerging planted seeds as seedlings on soils of higher fertility. Better stands from less seed occur as the soils are naturally more fertile or are made so by fertilizer treatments. The crop "takes" the fertile land over.

Our waste of seed has become more serious as the fertility of the soil has been declining. That we should scatter two million red clover seeds per acre of 43,560 square feet shows the foolhardiness of expecting those 45 seeds per square foot to make 45 plants on that little area. Is it not wise to ask ourselves why no more than four or five plants result in spite of that large number of seeds thrown there? Careful tests of increasing rates of seeding demonstrated decreasing percentages of emergence of seeds planted. That percentage drops more rapidly on the soils of less fertility than on those more fertile. Getting the crop off to a good start on many soils calls for starter fertilizers as a seed-saver and a stand-getter.

"One has no trouble getting a stand of weeds" farmers commonly tell us. But when weeds don't make much that is nutrition they don't go very far in food production and don't need much to arrive there. But when seeds are very small, like those of alfalfa and red clover, and when the crops are generous producers of proteins, there is too little initial reserve in the seed to carry the seedling very far along its course of growth. It must "root" into the soil right soon, which every seed does before its shoot goes up for sunshine. Even a seedling looks to the soil first and to the weather second. Weeds, as crops that don't make enough to tempt a cow, can get themselves up right soon to use sunshine, water and air. They can make good stands on their little of needed fertility that can be provided by most any soil.

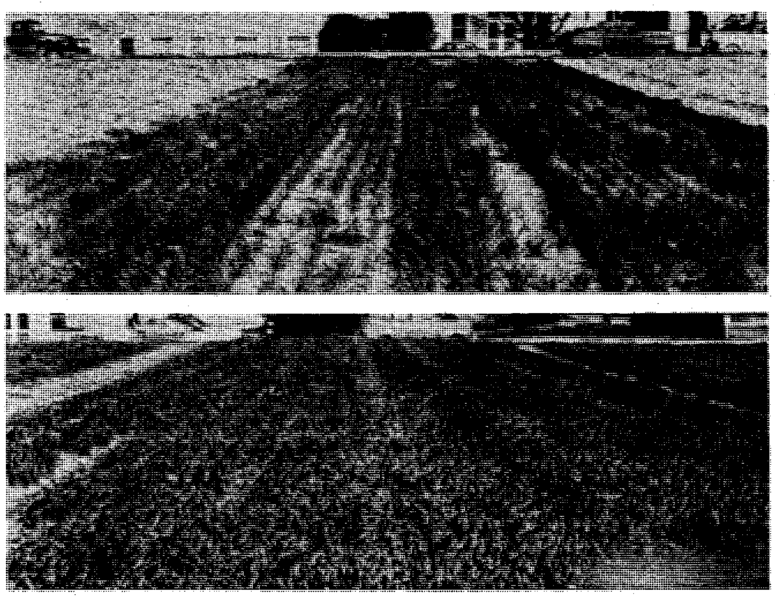
Starter fertilizers militated against heavier applications of themselves until better placement resulted

Putting the fertilizers right with the seed has long been the more common procedure in their application. On our virgin soils, this method nursed the young plants until their roots moved down into the subsoil, much of which was of glacially mixed origin and fertile enough to be **sustaining fertility** for the remainder of the season's growth of the plants. Satisfactory crop yields then were not so large. A single crop was not so highly exhaustive of the soil. The decay of the virgin organic matter was an active process bringing release of much carbonic acid. This was active in decomposing the silt mineral reserves. Their nutrients were restocking the soil's colloidal complex and making up for the small amounts of fertility the lower crop yields had removed. Surface soils given starter fertilizers, and deeper soils over subsoils containing much natural sustaining fertility left most of us unmindful of the fact that fertilizers were really not growing the crop completely.

Improper and excessive credit

and Sustaining Fertility

No treatment (above) in contrast to six tons manure annually (below), tell us that manure has been the sustaining fertility during sixty-two years of continuous wheat, when the plot with no treatment ceased to pay its costs long ago. Sanborn Field, Missouri Agricultural Experiment Station.



Manure at three tons per acre (above) in contrast to nitrogen, phosphorus and potassium in fertilizers equivalent to a forty bushel crop (below), tell us that the starter fertilizers have also been sustaining fertility for sixty-two years of continuous wheat. Sanborn Field, Missouri Agricultural Experiment Station.

to fertilizers was a common mistake because their functions in the plant, and their behaviors in the soil, had not been understood in terms of the chemical and biochemical reactions involved. The fallacious belief that fertilizers had to be water soluble, and that they served the plant because they remained in solution in the soil, has been finally displaced. Those concepts were pushed out by our knowledge of the fact that soluble cations are absorbed on the soil's colloidal complex. Therewith they are no longer water soluble. After a day or two in soil contact they cannot be washed out from there by water. Placed with the seeding as a starter fertilizer they are, nevertheless, taken quickly by the plant for its early stimulation to better growth.

Deeper placement made starter fertilizers become sustaining fertility too

Were not the soluble starter fertilizers quickly absorbed on the soil to become insoluble, they would "salt out" the young seedlings. Fortunately in this respect, the superphosphate carrying much calcium has been a protector since much of it goes into the fertilizer mixtures carrying the dangerous salts of nitrogen and potash. Calcium salts are not so damaging as those of the other elements. Because of the ever-present dan-

Deep Placement* of Fertilizer on Potash-Deficient Soil is "Sustaining Fertility" Throughout Rotation.

Fertilizer	1946 Corn bu/A	1947 Corn bu/A	1948 Soybeans bu/A	1949 Wheat bu/A	1950 Red Clover lbs./A
8-8-8	75.1	72.6	31.5	29.0	3650
8-8-0	60.0	60.5	31.0	26.5	3290
0-8-8	65.5	61.6	33.0	23.8	3750

*Fertilizers were placed behind the TNT subsoiler at 1500 lbs. per acre of 8-8-8 and the others at the corresponding nutrient equivalent. Differences in potash effect were still apparent in the clover crop five years after the placement.

ger from salt injury and damage to the stand, starter fertilizers in seed contact have always been used in limited amounts. In larger amounts they offered trouble rather than hope when at the same time the declining soil fertility was calling for heavier applications to make up the difference which would have been better business for the fertilizer distributor as well as for the farmer.

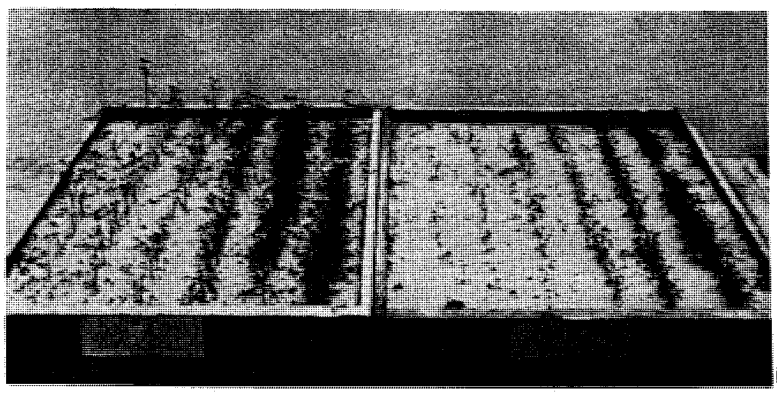
The placement of the starter fertilizers in a soil position other than seed contact was an evolutionary step of more importance than either the farmer or the fertilizer producers anticipated. For the latter it meant heavier applications without danger of seed injury, thereby more and bigger sales of fertilizers. For the former it meant bigger and more nutritious crops with less risk of stand loss. It was going forward on a sounder principle in plant nutrition. It was allowing the root to move toward the fertilized soil volume and into the specific concentration there of most effective nutritional service for the root. It was no longer a case of immersion of the seedling into a "salty" environment. It was offering nourishment later in the plant's growth, after the seed reserves were dwindling, and when the roots were moving down into soil horizons more regularly of good moisture content. Placement of fertilizers at greater depths was more wise than originally expected, since the ordinary plow served soon to put the fertilizers down with greater effectiveness resulting. It burried greater quantities of them than had ever been used before. It moved fertilizer use on where little had been used before. Other factors soon added their force to push the curve of fertilizer consumption upward at a sharp angle and one not yet stabilized in that respect at this date.

Deeper placement of much larger amounts of fertilizers in the soil has allowed them to take on the added services of becoming sustaining soil fertility as well as being starter fertilizers. Heavier applications in the limited but deeper soil zones are no longer feared. Rates as high as 1500 pounds of 8-8-8 per acre put down behind the subsoilers of an Oliver TNT plow in experimental trials have been anything but damage. As sustaining fertility, such rates bid fair to carry their visible effects from the initial application through the entire six-year rotation. Their effects on the yields are a matter of simple record. Their higher nutritional values can be demonstrated by animal choice. As our knowledge of the fundamental principles of plant nutrition developed and our concepts moved away from those of solution to those of the soil's adsorption and exchange of the fertility elements, the use of fertilizers has now become an activity in truly nourishing the crops.

Sustaining fertility must become the prevention of soil erosion

Because soil erosion has reached the dimension of disaster, we have become conscious of the weakness of the soil body under falling rain water. While terraces are a means of reducing the rate of water runoff, they are not a means of restoring the internal strength for granulation or the stability of good structure by which rainwater goes into the soil in place of sealing off its surface. Terraces may be likened to the splints holding in place the broken bones of a limb. Splints cannot provoke the physiological functions by which the break in the bone is healed. The healing of the broken soil body comes through restoration of the fertility, the internal strength of it, by which the crop cover grows rapidly, the organic matter is increased. and the granular structure is restored to a stability much beyond that so readily broken down by the impacts of the falling raindrop. We are slowly realizing that there is no longer much natural sustaining fertility left in many cultivated soils. Where not so long ago it was estimated that 20 percent of our crop production resulted from starter fertilizers and 80 percent from natural sustaining fertility, now the soils of lowered fertility coupled with ambi-

Better stands of alfalfa from less seed are "natural" on more fertile soils. Increasing rates of seeding (left to right) give decreasing percentage of emergence, and stand, but more so on poorer soil. Sanborn Field, Plot 12, Limestone and manure, Plot 13, No treatment. (White sand cover)



Farm manure and virgin organic matter have been the sustaining fertility (for the winter cover of weeds as well as the corn crop) and the shock absorber for fertilizer misuse. Sanborn Field, Missouri Agricultural Experiment Station. Left—no treatment. Right—6 tons manure annually (since 1888.)

tions and necessities for hundred bushel crops make a larger share of that crop yield come from applied fertility. There is the call to cover both the decline in sustaining fertility and the greater need for starter fertilizers by soil treatments of extra plant nutrients.

These facts are crowding the issue right up before us as to whether we dare neglect the fertility of the soil and expect the mechanical obstructions against running water to remedy the troubles associated with erosion. The fertility call is one for not only heavier applications of the three elements, nitrogen, phosphorus, and potassium com-

Starter fertilizer below (left) gave neither a good stand nor the growth of corn to keep the weeds out as was the result from (right) starter fertilizer after the heavy treatment of sustaining fertility had been plowed under. (Poirot Farms, Golden City, Mo.)

monly contained in the starter fertilizers, but also for attention to the sulfur, the calcium, and the magnesium unwittingly carried with, or inserted into, fertilizers as acid neutralizers or other contributors to the better storage and drillability of the goods. There is the call also for the trace elements in many instances, now that we are coming to look at crops as animal and human nutrition with more than bulk and caloric output as their values. Not only the trace elements needed by plants, but all of them known to be essential for plants, animals, and man, inclusive, must come to be considered in proper balance within the soil, if our nutrition is to be on a plane higher than that of the minimum and disaster, to say nothing of pushing it up to guarantee the optimum health of our livestock and ourselves.

Nutrient minerals and soil acidity foster sustaining fertility

The closer study of natural sustaining fertility has demonstrated soil acidity as a benefit more than a detriment. With the organic matter of our soils gone so low, we are realizing that the crop-yielding power of unfertilized soils, or what has been sustaining fertility, consists of that which is becoming available because the soil acidity is breaking down the silt mineral reserves. That isn't any speedy performance. It doesn't deliver enough to sustain much of a crop. It isn't bringing much along on the soil's assembly line for food output by the crop Nevertheless, we can take advantage of the soil and root acidity acting on the soil's rock and mineral fragments as an acid treatment of them to give some sustaining fertility. That is just what Nature has been doing all these years. That is what the farmer has been using when he limes the soil. The soil acid treats the limestone and makes its calcium highly available. Instead of interpreting the liming for that service, we called it a method of "fighting soil acidity."

Those soils that do not have higher rainfalls to grow decayable organic matter generously and to produce lots of carbonic acid from it, do not have so much, nor such speed, of that reaction. They haven't left in them many of the minerals that can be broken down. There we came on the geological scene too late from much in that respect to be left. Fortunately in the Midcontinent, the rivers flowing in from the drier West, especially the Missouri, bring flood-season supplies as river bottom land deposits. These are picked up by the wind during the rest of the year, and deposited at rates approaching a thousand pounds per acre annually after being carried northeastward long distances. This unweathered mineral, put on the acid soil for processing to give new fertility makes us appreciate the productivity of the "windblown" soils. The wind didn't make them fertile. It was this mineral reserve brought from the low-rainfall or unweathered area and processed by soil acidity under higher rainfall of the humid area.

On the other hand, there are soils that have had so much rainfall and are so warm during all the year that their minerals are weathered too far in this acid processing tratment. In the humid but more temperate zone, the weathering makes a clay that holds much acid, or hydrogen ions, and holds them firmly. But in the warmer, wetter soils, there results a clay that doesn't hold much acid. Southern soils go into that category and more so on becoming more tropical. "Our soils are not acid" you say, "in the South," apparently in consolation of escaping the need to fight soil acidity. But you miss some of the more effective soil acids' processing services that can give sustaining soil fertility from minerals, like limestone and rock phosphate, and can help to rebuild a soil.

High demand for protein calls for more sustaining fertility

That the clay fraction of the more acid soils is an effective reagent in the soil for decomposing the minerals there and for making their nutrient contents available to plants comes as a fact from the work by Dr. Ellis R. Graham at the Missouri Experiment Station. By using rock phosphate within a membrane suspended for six months in colloidal clay aliquots at different degrees of acidity (pH values) he could measure the phosphorus mobilized into the clay by its acid. With the ratio of two parts of rock to one of an acid clay, pH 4.7, a quarter percent of the phosphorus was made available. With a more acid clay, pH 3.5, that is with it completely saturated by acidity or hydrogen, two percent of the phosphorus in the rock was broken out. Other minerals demonstrated their decomposition under similar treatment to point out that reserve minerals in an acid soil can be the sustaining fertility, and in a larger way according as the soil depth for more root contact is greater.

Starter fertilizers put no deeper than only the shallow surface layer of a profile, which is not increasingly fertile with greater depth, means pushing the crop off to a good start for much vegetative growth. But it means also the failure by it to find enough fertility as the roots go deeper to carry the plant through on that level for high seed yield with high concentration of protein in it. Kansas wheat makes higher protein grain as the roots find extra nitrate nitrogen at greater depths in the soil. Experiments at Missouri showed that early spring applications of nitrogen on the wheat increased the yields of bushels per acre. But it was its application later in the growing season that increased the concentration of protein in the grain. Such results tell us that the starter-fertilizer nitrogen in the surface soil was only starter protein. It was responsible for larger yields of wheat per acre. But it was only the sustaining fertility nitrogen down deeper in the soil that could put the higher concentration of protein into the final harvest.

It is about time to rethink some of our concepts about fertilizers now that chemical nitrogen is telling us that as fixers of nitrogen the legume crops were not giving us all the extra nitrogen in the soil needed for growing the bigger crops while maintaining its nitrogen supply. Evidently legumes were not fixing nitrogen significantly on soils where so many of the other elements—including the trace elements—besides nitrogen, phosphorus and potassium were not given attention for their help in the better functions by legumes as gatherers of nitrogen from the atmosphere. Now with the added inorganic nitrogen under favorable economic settings correcting the present major fertility deficiency, higher crop yields than ever are exhausting all the other fertility elements from the soil more speedily.

Food security demands more fertilizers on more soils

All this is telling us that starter fertilizers applied at rates per acre that once were common are not even enough for that function which ceases to be served when the surface soil dries. It ceases when the roots must find their sustaning fertility deeper in the soil where they must go to get also the extra water needed to guarantee their larger yields.

Sustaining fertility is a new demand for more fertilizers now that we appreciate more fully the decline in natural fertility and the threatening exhaustion of that supply. It is a new market when larger acre-yields are given larger margin of profit on the input into crop production. While the higher nutritional quality is being brought into the larger yields also, this will call for the balance of the soil treatments more accurately according to soil and plant tissue tests. Nevertheless, it brings about a more efficient use of fertilizers and more economical returns on all the items listed on the cost sheet.

More fertilizers will be demanded for some time ahead as the conditions assembled to form the rising curve of recent past amounts used indicate. At the same time the returns from them will be on a sounder basis when all of the different materials on the market are used most effectively both as the starter fertilizers and as the sustaining fertility. Such judicious procedures will not only build up bigger and more nutritious crop yields, but will also build up the soil by building the fertility deeper down into it. They will put more security for all of us into more of our soil.