Traditional Plant Varieties and Low Fertility Soil

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One of the most common agricultural improvements is the introduction of an “improved seed” for the particular species of plant that is traditionally grown in an underdeveloped area. A second is to increase both fertility and organic content of soils. These two approaches are seldom questioned, and scientists and development workers seem eager to replace all traditional farming methods with improved seed and high fertility soils with high organic content.

While the benefits of traditional varieties are being re-assessed in agricultural research, there has not been a similar reassessment of the possible benefits of what I term “traditional soils” (low fertility and low organic matter). My work in Niger with Maradi Integrated Development Project has forced me to question the wisdom of assuming that increases of organic content and fertility are always best.

Millet is the staple crop of much of West Africa, and several improved varieties have been introduced. One particular variety “HKP” is multiplied at the national agricultural research center and made available for sale to farmers. Most often, the benefits of improved seed include early maturity, higher yield, and superior response to fertilizer. This millet matures in 70 days, as compared to 90, 100, or even 120 days for traditional varieties. Although early maturity may be a desirable quality in many situations, it may actually be a liability in a traditional farming system.

If higher or earlier yields are the only criteria, then these varieties make a lot of sense. However, early maturing cereals normally require higher levels of fertility than longer season varieties, and achieving these higher levels of fertility is very difficult for traditional farmers. Those who plant HKP and other improved varieties in low fertility areas are invariably disappointed with meager yields. In fact, where fertility is low, traditional varieties will often perform ***better*** than improved varieties. This is a fact that is often overlooked by development workers and researchers.

Now one could argue that farmers need to increase soil fertility on their farms—there is certainly nothing wrong with higher fertility in certain situations, but it is not a panacea.

In fact, there are situations where lower fertility is preferred to higher!

But how can this be? My experience with farmers in West Africa had forced me to challenge the assumption that higher fertility is always better.

Experienced farmers in the Sahel argue that in years of low rainfall, high fertility soils will not support plants as well as sandy non-fertile soils. Scientists and development facilitators would say that high fertility encourages root growth, plant vigor, disease resistance, and consequently, drought resistance. But if we were to follow these farmers to their fields during a drought, we would see an amazing thing— traditional varieties of millet seemingly unaffected by drought, on fields of very low fertility.

It seems that two “wrongs” can make a right in certain situations, in fact they can be doubly right! The claims of West African farmers are consistent with my observations. In very light rainfall conditions (2-5mm), plants definitely cope better on light sandy soils with low organic content and low fertility. The addition of either chemical fertilizer or manure reduces the ability of plants to cope with these conditions. To make matters much worse, it seems that even the addition of organic mulch increases drought stress.

There are several things working simultaneously here. First, observations of lower drought tolerance in higher fertility sandy soil is probably explained by some sort of reverse osmotic condition which occurs with high levels of dissolved salts—moisture is pulled from the plant tissue into the soil [Ed: or osmotic conditions make it more difficult for water to be pulled from the soil into the roots]. This does not seem to occur in very sandy soil with very low levels of dissolved nutrient salts. Thus, Hausa farmers categorize high nutrient soils as *zafi* (hot/dry), and sandy nutrient poor soils as sanyi (cool, moist). Secondly, the explanation for organic mulches increasing drought stress is that in very low rainfall situations (2-5mm) organic mulch absorbs moisture rather than allowing it to penetrate the soil. This limitation does not seem to apply where soils have had a good soak, and are then subjected to droughty conditions, but specifically to conditions of very light rainfall on dry soil, which is a common condition in the early months of the Sahelian wet season. Thirdly, very sandy soils absorb small amounts of moisture very quickly to a deep level where moisture is protected from evaporation. Finally, traditional cereal varieties are better able to take advantage of lower fertility sites, providing high yields where improved varieties do poorly.

Therefore, contrary to conventional agricultural thinking, it is *not* desirable to convert all farms to mulched, high fertility, high organic soils, as this would make them more susceptible to drought *in conditions of very light rainfall on dry soils*. Risk management will be improved if farmers utilize both improved cereals in smaller fertile farms, and traditional varieties in low fertility, low organic sandy soils.

[Ed (MLP): Another factor might be that plants grow larger and more quickly in fertile soils. If there is a subsequent drought, there is greater leaf area and hence more water is pulled from the soil through evapotranspiration. ECHO staff member Tim Motis wrote, “These observations underscore the value of doing variety trials under conditions similar to those under which farmers are growing their crops. If a trial in a drought situation had been done using irrigation with fertilizer and/or organic matter, one would not pick up on the fact that local varieties might perform better than new varieties under conditions of drought with poor soil fertility.”]

More about Traditional Varieties and Low Fertility Soil

Stan Doerr, an ECHO staff member who worked for several years in Mauritania, had several comments after reading Joel's article. Below we share Stan's comments and Joel's responses.

Stan: I have seen how sand can hold the moisture in the desert. Several months after the last rains I have dug into the sand and found the sand wet only a foot or so below the surface. I suspect this is due to the lattice nature of the pure clean sand in the Sahara. Organic material could possibly increase the evaporation of the soil moisture if it is in fact the lattice nature of the sand that holds the moisture.

Joel: I cannot confirm that organic material may increase evaporation. But Stan's observation that several months after a rain, moisture can be found only a foot below the surface in pure sands confirms my observations concerning soil moisture retention and sand.

The issue here is organic material shedding moisture. You can conduct a simple experiment by filling two glass jars with dry soil, one with high organic content, the other pure sand. You will see that the pure sand immediately absorbs water as the spaces between particles are filled to saturation. The soil with dry organic content must absorb the moisture more slowly and may puddle on the surface initially. This is because some materials, when dry, will repel moisture initially.

Another experiment that can be conducted is to spread out dry manure and dry organic material on a plot of land while leaving an adjacent plot of untreated sandy soil. Sprinkle both areas with the same quantity of water then dig a hole in each area and measure the penetration of water. Normally, the sands with low organic content will have the greatest depth of moisture.

This same phenomenon can also be observed with zai holes [a technique in which holes are dug and filled with mulch to encourage termite activity and increase the rate of water infiltration when rains come. Seeds are planted in the holes. See Amaranth to Zai Holes page 133, or search our web site for more information.] In our experience in Niger, zai holes often have less moisture after a light rain than surrounding untreated sandy soil. This too is due to organic material repelling initial moisture.

Stan: Using chemical fertilizers in low rainfall situations would most likely just burn the plants instead of dissolving the fertilizers. I suspect most farmers cannot afford commercial fertilizers anyway.

Joel: [Stan's] comment that chemical fertilizer will burn in dry soil is correct. One of the innovations we promote is to powder NPK for application where rainfall may be low or erratic. Powdered fertilizer dissolves much more quickly in low moisture soil [Ed: which could also cause burning]. However small amounts of chemical fertilizer added to poor soil probably contributed to soil nutrient mining and is not generally encouraged.

Stan: Drought is drought and I have seen too many farmers lose everything due to lack of rainfall and they would never have been able to add chemical fertilizers nor did they have enough organic material to add (all was eaten by the animals) so I have trouble *buying into the cause for bad yields being due to organic materials or fertilizers although I do think that locally adapted varieties are often better than "improved" varieties.* ***That is why variety trials by development agencies and then by local farmers are an essential first step before introducing a "new and improved variety" to the communities that we work in.***

Joel: [The] comment that "drought is drought" is an over generalization. Drought for farmers is normally defined by the effect on plants rather than actual rainfall. Drought comes by degrees. During droughty periods it is very common to see some crops doing fine, while others are wilting and drying. Sometimes the difference can be chalked up to soil differences. Heavy clays on the surface will repel moisture leading to run off rather than infiltration. Likewise, hardpans either on or below the surface limit infiltration (this is why the best time to buy a field in drought prone regions is during a drought—choose a field where plants show less drought stress than adjacent plots.)

Differing cultivation treatments also make a difference. Frequent cultivation will reduce drought stress because of the dirt mulch that is created when tilling after a rain.

Other times it can be determined that areas experiencing wilting have a much higher fertilizer content (all other factors being the same), leading to the burning mentioned above. This discovery can only be made by observing different fields during droughty conditions.

Stan: Have you tested soil fertility or are you just assuming the Sahel soils are depleted? We found in Mauritania that often the soil fertility was good because nothing had been growing and thus the soils were not depleted.

Joel: Sahel soils are notoriously low in phosphorus; and nitrogen and potassium are also low where continuous cropping is practiced. This can be demonstrated by the high response to small applications of fertilizer, either organic or chemical. Higher fertility areas do not show nearly as much response to fertilizer application.

Stan: As has been well documented, we have also found that farmers like to grow sorghum in millet areas ("millet is for the poor") and maize in sorghum areas ("sorghum is for the poor"). Isn't this what Tony Rinaudo calls the green drought? [See EDN 77]

Joel: As to choice of crops, our observations are for the same crop planted the same date, mostly millet, but also sorghum. Corn is very risky in low rainfall areas since it requires higher fertility, which causes burning in drought. It will not perform well in low fertility soils, as will millet and sorghum.

Finally, one of the best ways to learn about farming is to interview traditional farmers in the region. Many will confirm that traditional varieties are grown on low fertility soils because longer season varieties (100-200 days) can take advantage of the low fertility levels while short season (60 - 80 days) need higher fertility to do well. This is one reason why "improved varieties" (early maturing) have not done well in this region.

I still maintain that in droughty conditions, especially where scant rainfall occurs, and where the soil is already dry, that high fertility plots will suffer moisture stress much earlier than low fertility high sand plots.