From the Ground Up: Managing Soil for Increased Crop Productivity

By Dr. Robert Kolberg, Research Agronomist
USDA-ARS NPARL, Sidney, MT; rkolberg@sidney.ars.usda.gov; 406-433-9408

The following is the latest offering in a monthly series discussing ongoing research efforts at the USDA-ARS Northern Plains Agricultural Research Laboratory (NPARL) in Sidney, Mont.

There is a whole Aother world@ beneath our feet, in the soil! It is said that a handful of soil will easily contain enough individual microbes to equal the human population of the world and that understanding the complexity of its physical structure alone can take a soil physicist a lifetime to accomplish. And that is only Ascratching the soil surface.@

For example, soil microbiology is a relatively new field of science, so we are just beginning to understand the important role soil fungi, bacteria, and numerous soil fauna play in the soil and how their activities affect plant growth. Add to that human beings and their efforts to grow plants for food, and things start to get real interesting.

Despite these obvious complications, all too often, we tend to manage the soil as something that will always be there B after all, in most of the places we grow crops we can dig down many feet before we reach something we wouldn=t call "soil." However, today we know the darker colored topsoil, representing only a small portion of that overall "soil" layer, is the key to healthy plant growth.

Tools for Conserving a Valuable Resource

Topsoil, then, should be regarded as one of our nation=s most valuable natural resources and great care should be taken to understand how our use of the soil affects its ability to remain productive for the future. Consequently, in our struggle to maintain or increase production to feed more people with our soil, we need to also think in terms of soil conservation. Unless we do so, the direct and indirect costs will continue to climb beyond the tens of billions of dollars already estimated to be lost annually in this country due to soil erosion.

At NPARL, researchers are attempting to address this basic problem B what tools can we effectively use to grow more crops and still keep the soil in its place? Let's look at a couple of options being studied.


The "explosive" impact of a drop of rain on unprotected soil.

Reduced Tillage/No-Till: Under non-irrigated or dryland conditions, where tillage has been the traditional way to prepare the soil for planting and to control weeds, soil erosion can be a problem, because the soil is left unprotected. During an intense thunderstorm when wind-driven raindrops bombard the unprotected soil, soil particles can be Ablown-up@ in a mini-explosion (see picture). These particles can then begin to move and be carried off as the storm continues and water accumulates, particularly if it is on any kind of sloping ground. This condition is worsened because the impact of the rain also compacts the surface layer of the soil,

effectively sealing it and preventing water from soaking into the ground.

However, if more plant material from previous crops (crop residues or Atrash@) is left on the soil surface, which usually means using less tillage, it can serve to break the impact of raindrops and help keep soil in place. Research has already shown that soil erosion can be reduced by over 90% using no-tillage management. Reduced-till or no-till management is therefore one of the tools we use in our research.

Crop Diversity: A second tool being studied at NPARL is based on the fundamental idea that we are not just growing a crop during a particular season, but are trying to intensively manage an ecosystem that will successfully produce a number of crops from one year to the next. As in a natural ecosystem, an intensively managed agro-ecosystem will be more stable and productive if there are many different kinds of plants growing in it, i.e., if there is more diversity.

Residue left from a previous crop, like that shown here, is being studied to determine whether it may impede weed emergence in succeeding years.

Unfortunately for producers, weeds can be thought of as nature=s way of increasing the biodiversity of any particular field and attempting to make it more stable. As any farmer knows, weeds are an inevitable consequence of disturbing the soil, and some weeds will become a serious problem if the same type of crop management is used over three or four years.

Consequently, another tool we are using at NPARL is crop diversity or growing different types of crops from year to year. Crops with different growth habits, such as cool season grasses (small grains), warm season grasses (corn and millet), cool season broadleaves (field peas), and warm season broadleaves (sunflower and dry beans), can provide different opportunities to control weeds throughout the different seasons and will serve to keep weeds Aoff balance@ and prevent them from becoming a problem.

New Tools Create New "Puzzles"

Naturally, if a farmer decides to grow more kinds of crops, the difficulty in managing these crops also goes up. Decisions such as crop choice, fertilizer rates, weed control, and equipment needs begin to multiply quickly in any attempt to be more diverse. On top of this, there is also the growing concern among the general public regarding the use of agricultural chemicals to grow our food.

"Putting the Pieces Together"

At NPARL we are attempting to Aput the pieces of this puzzle together.@ Of all the management options available to a farmer, which combination of choices will best protect the soil, allow minimal use of chemicals, and also produce a profitable yield?

A new project currently being planned at the lab will compare two sets of management practices when growing any particular crop within a rotation. One set will comprise management practices designed to give the crop a better growth advantage over weeds, while the other set is

based on more traditional practices. These practices include banding instead of broadcasting fertilizer, higher seeding rates, taller crop varieties, or narrower row spacing.

Current research at other locations in the Great Plains indicates that three or more of these practices can work in concert to effectively compete with weeds and allow a reduction in the use of herbicides. These two sets of management options will each be tested in two types of crop rotations, one consisting of small grain crops and the other a more diverse set of grass and broadleaf crops to give four combinations of crop rotation and crop management. A comparison between tillage and no-till management will also be made within the above combinations to give a more complete picture of how the soil responds to these types of farming practices. This new study begins this summer.

Other NPARL Research

Weed Emergence Study: Another experiment at NPARL is examining how tillage or no-till in combination with previous crop residues removed or left in place affects the emergence of weeds. This experiment is being conducted within the setting of a three-year rotation of canola, corn, and fallow in all possible combinations of crop, tillage and residue management. This kind of experimental design allows us to study how weeds emerge under 12 unique environments and thus gives us a better understanding of which combination of practices are most effective in suppressing weeds. Begun this past year, preliminary results to date indicate less emergence in canola than in corn or fallow. At this point there is also evidence that crop residue left on the soil surface discourages weed emergence.

Malting Barley/Nitrogen Study: Since malting barley is generating a lot of interest locally, we are also testing what is the optimal amount of nitrogen fertilizer to apply following different types of management from the previous year. These managements include field peas and canola as well as fallow. Since proper nitrogen management is very important in producing malting barley, and since field peas, being a legume, can provide a portion of that nitrogen, it is important to know if a farmer should reduce his nitrogen application when following field peas with malting barley. Fallow also can provide nitrogen through a process known as mineralization where organic forms of nitrogen are converted by microbes to inorganic forms which plants can use. This study, initiated last year, is expected to continue for another three years.