Nutrient Management Newsletter for the Western U.S.

Nutrient Digest

VOLUME 6, ISSUE 1 *A publication of the WERA-103 Committee** SPRING, 2014

ONE-TIME SUMMER TILLAGE OF CHEMICAL FALLOW IN A DRYLAND WINTER WHEAT ROTATION DOES NOT NEGATE LONG-TERM BENEFITS ACCRUED UNDER NO-TILL MANAGEMENT

By Urszula Norton*, Prakriti Bista, Rajan Ghimire and Jay B. Norton – University of Wyoming
****Corresponding author; Assistant Professor of Agro-ecology, Department of Plant Sciences, University of Wyoming***

While producers who practice no-till are typically committed to keeping steel out of the ground, there are several reasons why occasional tillage may prove beneficial and offer solutions to some no-till related problems. These include dispersing low-mobility nutrients (i.e. phosphorous that can accumulate near soil surface), reducing soil compaction, and controlling weeds. It is known that tilling long-term undisturbed systems negatively impacts soil structural attributes and soil organic matter (SOM) quantities and characteristics, but little is known about the impact of one-time or occasional tillage on soil properties improved during periods of no-till.

Recent interest in converting dryland winter wheat to certified organic production has been on the rise driven by

Continued on page 2

THE NEW UNIVERSITY OF IDAHO COVER CROP CALCULATOR

By Amber Moore, Christi Falen, Lauren Hunter, Glenn Shewmaker, and David Graybill – University of Idaho

Idaho growers are interested in estimating plant available nitrogen (N) from their spring-tilled cover crops, but they have not had the tools available to do this. Tools like the Oregon State University (OSU) Cover Crop Calculator are useful, but are not designed to be used in regions beyond Oregon. To address these concerns, we decided to develop an Idaho Cover Crop Calculator by adjusting the OSU Cover Crop calculator to reflect Idaho conditions through N mineralization incubation studies with Idaho soils and plants. This project was funded through a State Conservation Innovation Grant from the Idaho division of USDA NRCS.

We selected a Portneuf silt loam for the incubation study, which is the most common agricultural soil in Southern Idaho. Plants included in the incubation study were triticale, hairy vetch, Austrian pea, daikon radish, and red clover. Tissue N concentrations ranged from 1.3 to 4.4 %N. Plant tissue was collected from existing cover crop fields in Kimberly and Aberdeen, Idaho. The plant tissue was clipped at soil level from four 1 ft. X 1 ft. square frames that were placed randomly throughout existing cover crop fields. Plant tissue samples were analyzed for tissue N concentration and dry matter content. Approximately 500 g of Portneuf silt loam was mixed with 2 grams of chopped dry plant tissue for 70 days at 22^{0}C in plastic bags. To reduce variability in moisture content between plant tissue samples, we chose to use dried plant tissue

Continued on page 4

**WERA-103 is the Western Extension/Education Region Activities Nutrient Management and Water Quality committee, composed of representatives from land-grant universities, public agencies, and private industry.*
Head Editor – Amber Moore, University of Idaho; Guest Editor – Jay Norton, University of Wyoming

One-time Summer Tillage of Chemical Fallow in a Dryland Winter Wheat Rotation, cont. from pg 1

high premiums from sales of organically certified grain and straw. Many farmers are considering transforming land previously under long-term no-till or in the Conservation Reserve Program (CRP). In both instances, re-instating repetitive tillage to manage weeds and prepare land for planting appears to be crucial.

However, even a single tillage operation can increase soil aeration and accelerate carbon and nitrogen mineralization and loss. This can result is immediate bursts of carbon dioxide (CO_2) and nitrous oxide (N_2O). Increase in soil aeration can also increase methane (CH_4) assimilation. These three gas species are very sensitive indicators of soil disturbance and SOM loss. Moreover, CO_2, CH_4 and N_2O are drivers of global atmospheric warming and agricultural practices that require frequent land disturbance are leading contributors of these greenhouse gases (GHGs). In general, agriculture contributes 84% of total anthropogenic N_2O, 52% of CH_4, and 25% of CO_2 emissions.

To assess GHG emissions and SOM after a single summer tillage event in long-term no-till winter wheat-chem fallow and conventionally tilled winter wheat-fallow, we conducted a study on calcareous silt loam soils at the University of Wyoming Sustainable Agriculture Research and Extension Center (SAREC) near Lingle, Wyoming. The SAREC climate is semiarid with a short growing season (125-day frost-free period) and average precipitation is 13 inches. The study fields were under different management scenarios that combined variable tillage intensities and chemical weed treatments, including: conventional (>60 years), notill (11 years), chemical free (11 years), and first-time tillage of plots in the 11-year no-till field (NTT). Herbicides were applied as needed in no till; a combination of herbicides and four tillage passes per year were used in conventional; and tillage only with six passes per year was used in chemical free (Figure 2). No fertilizers have been applied to any of the treatments for the last eleven years. Air and soil samples were collected before and immediately after a one-time pass with a tandem disk that loosened the soil to a 4 inches (Figure 1) in the conventional, NTT, and chemical-free plots, and concurrently

Continued on page 3

Figure 1. Summer tillage operation of fallow in dryland winter wheat production.

One-time Summer Tillage of Chemical Fallow in a Dryland Winter Wheat Rotation, cont. from pg 2

without tillage in the no till. Carbon dioxide, CH_4, N_2O fluxes and easily decomposed and lost soil carbon and nitrogen forms were determined for 0, 1, 5, 25, and 50 hours after tillage.

Results indicate that CO_2 emissions from NTT soils were 30 to 40% lower than from the frequently tilled chemical free and conventional soils. NTT soils also had lower dissolved organic carbon and mineral nitrogen concentrations, indicating less disruption of SOM. Moreover, the values from NTT soils were comparable to CO_2 emissions and DOC and inorganic N concentrations from no-till soils that did not receive the tillage treatment (Figure 2). This suggests that SOM stored in the previously long-term no-till soil was resistant to the single summer tillage operation. The same tillage operation caused NTT soils to remove 32% more CH_4 from the atmosphere than the untilled no-till soils. Importantly, tillage did not affect the magnitude of N_2O emissions in any of the treatments, suggesting that if performed during dry summer, this operation did not contribute to nitrogen loss as gas. In summary, soils under long-term no-till management were resilient to a single summer tillage operation, while frequently tilled soils lost SOM as CO_2 and had more carbon and nitrogen in forms vulnerable to loss. This practice can be used by no-till farmers during dry periods of summer for weed control or other management-related purposes, but we don't know how often tillage can be done before the SOM accrued under no-till management starts to unravel and be lost.

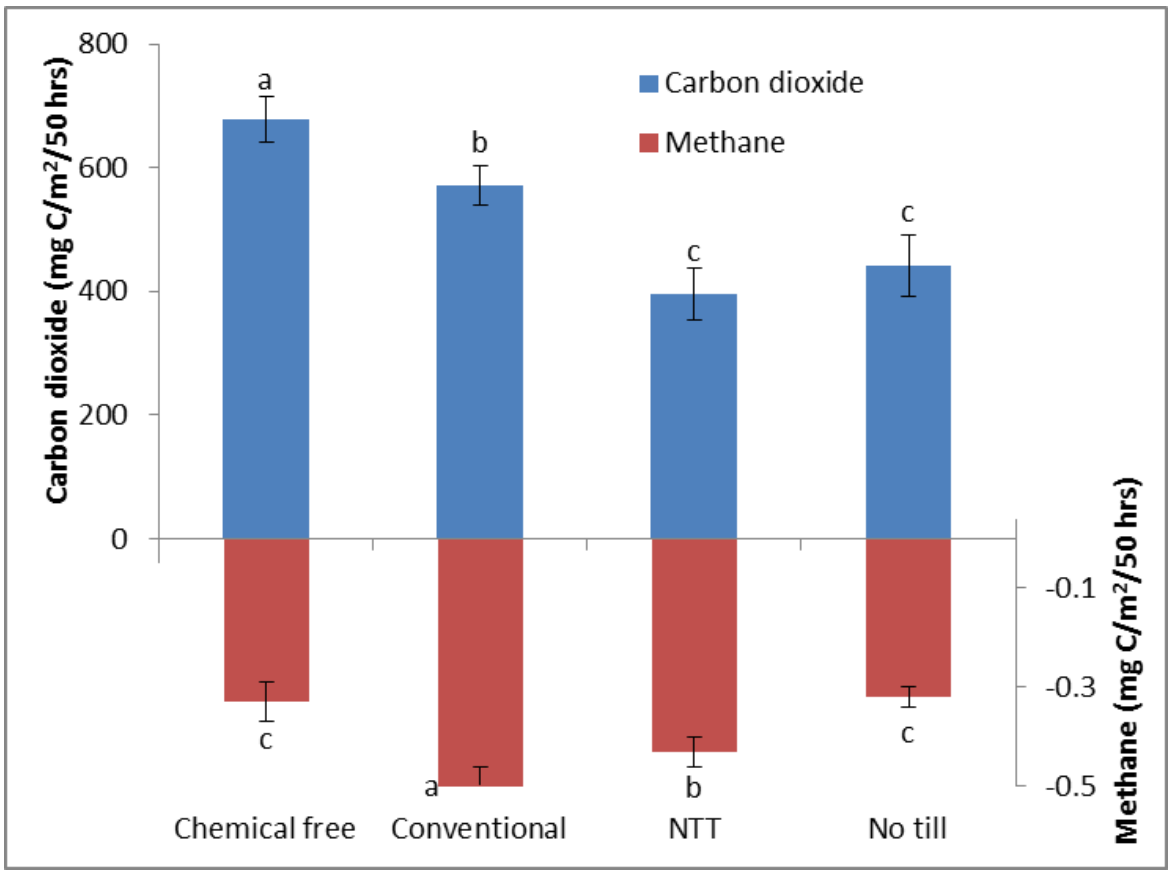

Figure 2. Cumulative carbon lost from the soil through microbial carbon dioxide respiration, and gained by the soil through microbial methane assimilation following a single tillage event in chemical-free, conventional, no-till, and no-till first time tilled (NTT) winter wheat production during summer of 2011. Different letters indicate significant differences among tillage treatments at $P<0.01$.

The New University of Idaho Cover Crop Calculator, cont. from pg 1

instead of frozen tissue (frozen tissue was used for the OSU incubation studies).

After 70 days of incubation, we fit a quadratic model to the tissue N vs. PAN relationship, as was done in Vigil and Kissel (1991). For tissue N concentrations ranging from 1.3 to 4.5%, our PAN results were much lower (-10 to 27% PAN) than the OSU incubation study PAN results (10 to 60% PAN) (figure 1, brown dashed line). A second incubation was conducted to determine if PAN differences between the dried and fresh plant tissue. Fresh tissue samples released approximately 15.7 ppm more PAN than dried tissue samples, regardless of tissue N concentration. As a result of this finding, we added 15.7 ppm to PAN values from the dried plant tissue calibration study PAN values to more accurately predict PAN from living moist plant tissue (figure 1, green solid line). We used this adjusted model for prediction of PAN from fresh tissue (aka green manures) and original model for prediction of PAN from dried tissue (aka crop residues).

We compared the University of Idaho Cover Crop Calculator equations to Vigil and Kissel equation used to support Oregon State University cover crop calculator and the calibration equation used to justify use of the VK equation for the OSU cover crop calculator. The Idaho calculators predicted less PAN than the Oregon calculator at tissue N above 2.0 %. This difference may be due to the alkaline nature of Idaho soils, which could limit N mineralization activity in the soil. While the comparison between Oregon and Idaho soil did not show a significant effect on PAN, more soils were needed in this comparison to adequately state that there is not a soil effect between the two regions.

Another observation was that both Continued on page 5

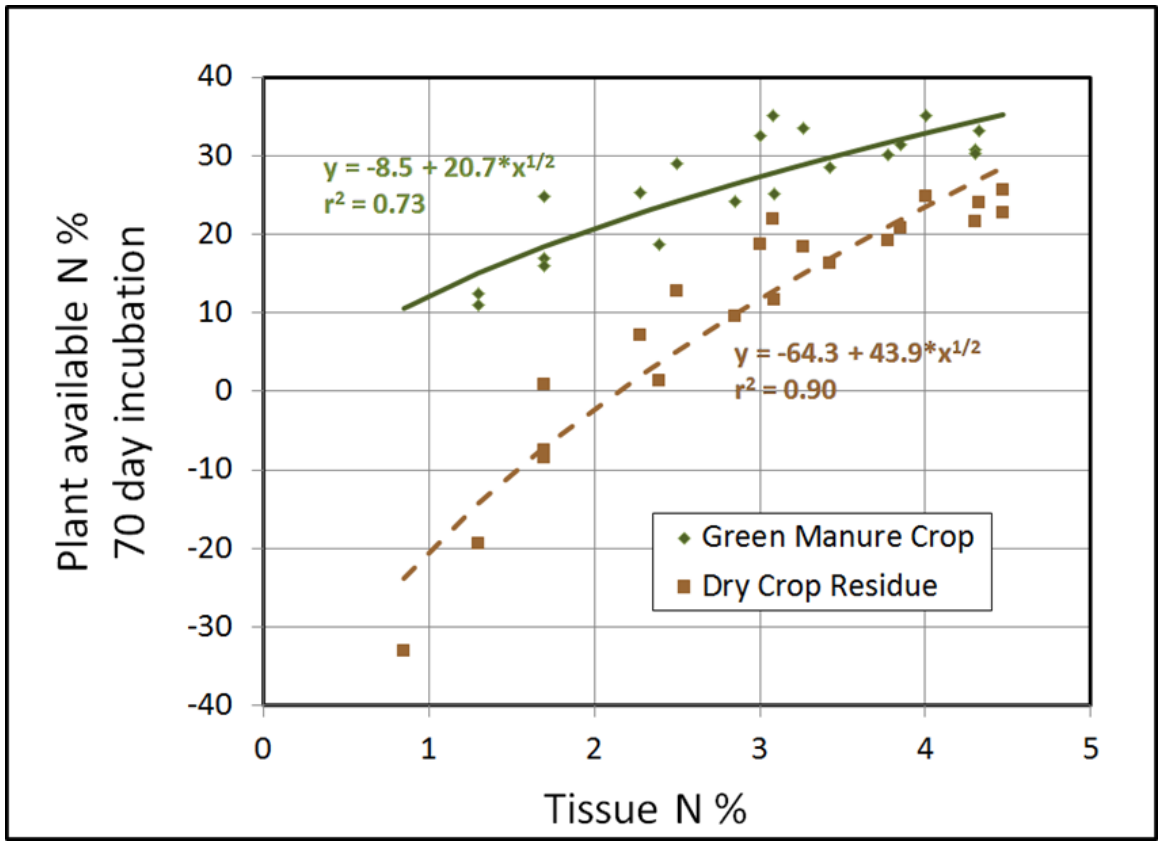

Figure 1. Equations and calibration data supporting the University of Idaho Cover Crop Calculator, which estimates plant available nitrogen (PAN) in the soil over a growing season for spring-tilled green manure crops or crop residues on irrigated cropland in Southern Idaho.

The New University of Idaho Cover Crop Calculator, cont. from pg 4

dry tissue models predicted immobilization below 1 and 2% tissue N, respectively, while the fresh and frozen tissue models do not predict immobilization at any tissue N concentration. This finding reiterates the importance of not relying on incubation studies using dried plant tissue for prediction of PAN from fresh tissue.

The online version of the Idaho Cover Crop Calculator can be accessed online at: http://www.extension.uidaho.edu/nutrient/CC_Calculator/Cover_Crop_Main_page.htm. Similar to the OSU calculator, the user is required to take several plant tissue samples and submit information regarding tissue weight, tissue N content, and moisture content. This information along with the equations in figure 1 are used to give the user an estimate of how much plant available N to expect over the growing season in lb N/acre. Additional pages include: Calculator User's Guide, Plant Tissue Sampling Guide, and Calculator Development Information.

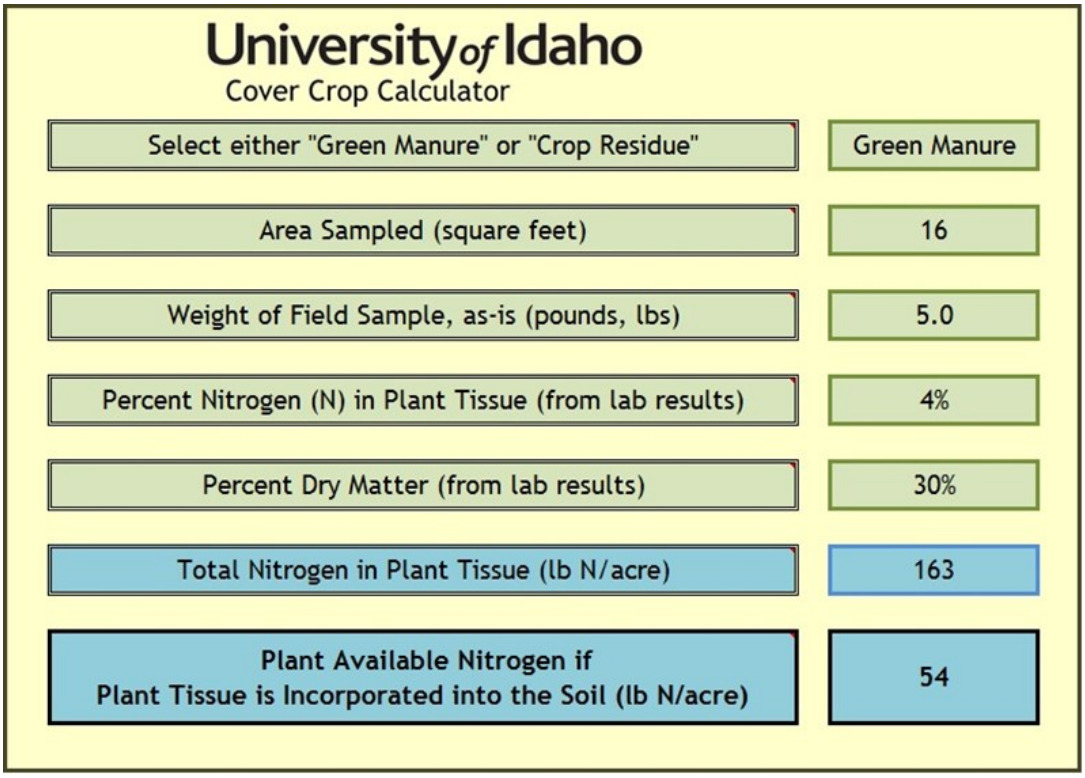

Figure 2. Online interface for the University of Idaho Cover Crop Calculator, with example input and output values.

The new University of Idaho Cover Crop Calculator developed from this project will allow for Idaho growers to account for N from their cover crop, which will help to prevent over- and under-application of N fertilizers.

References:

Vigil, M.F. and D.E. Kissel. 1991. Equations for estimating the amount of nitrogen mineralized from crop residues. Soil Sci Soc Am J. 55:757-761.

Andrews, N., D. Sullivan, J. Julian, and K. Pool. Organic fertilizer and cover crop calculator. http://smallfarms.oregonstate.edu/calculator. Accessed October 2013.

Sullivan, D.M. and N.D. Andrews. 2012. Estimating plant-available nitrogen from cover crops. PNW 636. 23 pp. Oregon State University Extension.

CONSERVATION IN FURROW-IRRIGATED CROPPING SYSTEMS

By Jay Norton - University of Wyoming

Farmers are aware of low organic matter levels that hamper productivity and become lower each time the soil is disturbed. Under furrow-irrigation, declining soil organic matter (SOM) leads to loss of soil structure that causes sealing and erosion, as well as loss of nutrients and increasing fertilizer needs. Reversing those trends is difficult because furrow irrigation requires tillage to level and furrow the soil, and root crops require soil disturbance for harvest. Conserving surface residues can impede water flow and reduce irrigation efficiency. Research is sparse but shows that there are ways to improve soil quality in furrow-irrigated cropping systems. Recent research in Latin America, Australia, and Asia emphasizes advantages of permanent raised beds in furrow irrigated production. This article summarizes information from several key studies.

Reduced tillage. While disturbance is necessary for making clean furrows and harvesting root crops, tillage operations can be strategically reduced to conserve SOM. Halvorson and Hartman (1988) found that strip till yielded better than conventional tillage and no till in furrow-irrigated sugarbeet in Sidney, Montana. No till yielded the same as conventional till in terms of both root and sucrose yield. In a similar Nebraska panhandle study, Smith et al. (1990) found that sugarbeet was the weak link for soil erosion control: the soil had almost no cover for over a year and a half from early spring furrowing for the beet crop to harvest of the following corn crop. They recommend an alternative beet harvesting technique that would place residues on the soil surface.

Other studies on fine-textured soils suggest that no till can lead to decreased porosity and increased runoff compared with conventional and reduced tillage systems (Dieckmann et al., 2006; Mailapalli et al., 2012). In Dieckmann et al.'s (2006) long-term study of a sugarbeet-wheat rotation in Germany, no till resulted in much denser soil, 4% lower wheat yields, and 15% lower beet yields than conventional tillage. Lower production costs more than made up this difference for wheat, but not for sugarbeet. Their conservation tillage treatment (loosening and mulching), however, produced equivalent yields, and higher profits, compared with conventional plowing.

None of these authors discuss problems with residue blocking water flow, and farmers report mixed results using reduced- or no-till systems with furrow irrigation. The scale of the problem apparently has a lot to do with individual farmers' tolerance of trash in their furrows, and their willingness to occasionally walk the furrows, but generally, residue-conservation is not embraced by producers practicing furrow irrigation.

Cover crops. Some producers in western Wyoming use cover crops after barley and dry beans. There is not a great deal of information in the scientific literature about cover crops in furrow-irrigated systems, but Mailapalli et al. (2012) reported much less runoff and greater infiltration when they combined a wheat cover crop with standard tillage (including several 8-inch-deep passes with a disk plow) compared with no cover crop and with no till in a California sunflower-Sudan grass-corn rotation. Fast-growing grain, grass, legume, and other crops can be planted following small grains and dry beans to create winter soil cover, contribute nutrients, and add considerable organic matter to the soil.

Longer rotations. A study in the Big Horn Basin of Wyoming showed that the longer the rotation, the more organic matter and the higher the sugarbeet yields (Mukhwana, 2011), with four-year alfalfa-alfalfa-sugarbeet-sugarbeet rotations outperforming sugarbeet-bean-barley and sugarbeet-barley rotations. Wilson et al. (2001) note that long-term studies in Nebraska, Montana, and South Dakota established that sugarbeet production improved when alfalfa was in the rotation, and kept improving with longer rotations up to one beet crop every six years.

Combining principles: Permanent raised beds. The problem of soil depletion under furrow irrigated cropping systems is especially acute in tropical semiarid and arid agroecosystems, and the practice of permanent raised beds, in which two or three rows of crops between furrows are managed with zero or minimum tillage, and furrows are maintained as needed (Figure 1) has received a great deal of attention in recent research (Devkota et al., 2013; Li et al., 2014; Verhulst et al., 2011). Furrows double as wheel tracks for cultivating, spraying, and other operations. These studies each compare permanent-raised-bed furrow systems with typical furrow irrigation and with no till management, and each report marked improvements in

Continued on page 7

Conservation in Furrow-Irrigated Cropping Systems, cont. from pg 6

soil quality, including lower density, warmer soil temperatures, better water productivity, and increased corn and wheat yields by 5 to 42%. Root crops like sugarbeet would require destruction and rebedding each time beets are harvested, but four- to six-year rotations with grain or forage crops would allow recovery of soil quality as observed in other regions. Perennial crops like alfalfa in the rotations, and cover crops following early-harvested crops like barley and dry beans would speed soil quality improvements.

Soil degradation is an issue of growing concern in furrow-irrigated cropping systems in the western US. This article summarized several approaches toward conservation and soil quality improvement in furrow irrigated systems.

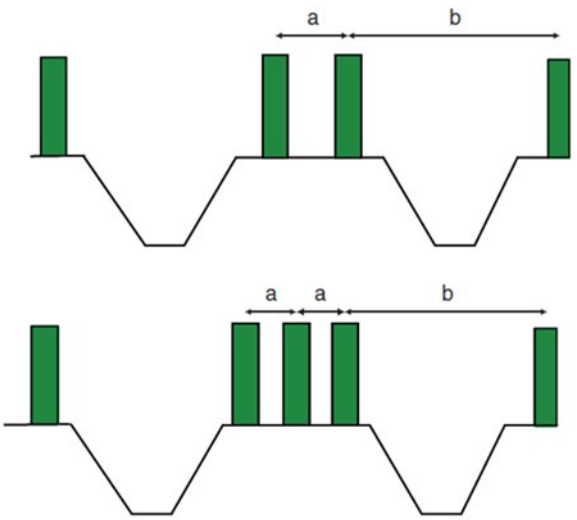

Figure 1. Bed planting with two and three rows spaced 'a' inches apart and furrow gaps 'b' inches wide (left), and direct-seeded wheat on permanent beds (right; E. Humphreys). From Roth et al. (2005).

References:

Devkota, M., C. Martius, J.P.A. Lamers, K.D. Sayre, K.P. Devkota, and P.L.G. Vlek. 2013. Tillage and nitrogen fertilization effects on yield and nitrogen use efficiency of irrigated cotton. Soil and Tillage Research 134:72-82.

Dieckmann, J., H. Miller, and H.J. Koch. 2006. Beet growth and soil structure: Results from a long-term on-farm research project. Sugar Industry/ Zuckerindustrie 131:642-654.

Halvorson, A.D., and G.P. Hartman. 1988. Nitrogen needs of sugarbeet produced with reduced-tillage systems. Agronomy Journal 80:719-722.

Li, H., Q.J. Wang, J. He, H.W. Li, Z.Y. Lu, R.G. Rasaily, C.Y. Lu, X.C. Zhang, and Z.Q. Zheng. 2014. Permanent Raised Beds Improved Soil Physical Properties in an Annual Double-Cropping System. Agron J 106:7-14.

Mailapalli, D., W. Horwath, W. Wallender, and M. Burger. 2012. Infiltration, runoff, and export of dissolved organic carbon from furrow-irrigated forage fields under cover crop and no-till management in the arid climate of California. Journal of Irrigation and Drainage Engineering 138:35-42.

Mukhwana, E.J. 2011. Soil organic matter, microbial community dynamics and the economics of diversified dryland winter wheat and irrigated sugar beet cropping systems in Wyoming. PhD, University of Wyoming, Laramie.

Roth, C.H., R.A. Fischer, and C.A. Meisner. (eds.) 2005. Evaluation and performance of permanent raised bed cropping systems in Asia, Australia and Mexico. ACIAR Proceedings No. 21, Canberra.

Smith, J.A., C.D. Yonts, M.D. Rath, and J.E. Bailie. 1990. Mass of crop residue and its relationship with soil cover for a corn, dry bean, and sugarbeet rotation. Transactions of the American Society of Agricultural Engineers 33:1503-1508.

Verhulst, N., F. Kienle, K. Sayre, J. Deckers, D. Raes, A. Limon-Ortega, L. Tijerina-Chavez, and B. Govaerts. 2011. Soil quality as affected by tillage-residue management in a wheat-maize irrigated bed planting system. (in English) Plant Soil 340:453-466.

Wilson, R.G., J.A. Smith, and S.D. Miller. (eds.) 2001. Sugar beet production guide. Coop. Ext. Bull. EC01-156. University of Nebraska, Lincoln, NE.