Tri-Basin Irrigator

Volume 17, Issue 8 August 31, 2017

Program Information

EQIP & CSP:

EQIP – Projected sign-up deadline for 2018 funds will be mid-October 2017.

CSP – We are finishing up contracts for 2017 pre-approved applications.

NSWCP: NSWCP funds are ONLY available for flow meters and soil moisture sensors at this time.

ENERGY EFFICIENCY GRANT: Signup deadline for 2018 funds will be October 31, 2017. For more information contact Kelley at Rural Development at the Kearney USDA Service Center at 308-237-3118, Ext. 4 or at 308-455-9837.

Calendar of Events

Sept 5: CNPPID Board of Directors Meeting - 9 AM
Sept 12: TBNRD Board Meeting -1:30 PM
Sept 12-14: Husker Harvest Days. Goto *http://huskerharvestdays.com* for more info.
Sept 20: Grazing Cover Crop Field Day @ Kearney, NE
See attached flyer for info and registration deadline.

How much water did I apply in 2017?

As irrigation season comes to an end, you can read your flow meters and calculate how much water was pumped in 2017. Flow meters vary as to their unit outputs (ac-in * 0.01, gallons * 100, ac-ft * 0.001, etc.). You simply subtract your beginning year reading from the ending year reading to get gross water pumped. See chart below to convert flow meter units to inches. Gross inches pumped is what's used for allocations, irrigation reports, etc. For your own information, you can multiply gross inches pumped by an efficiency factor to calculate net water applied to the crop.

How to Calculate Gross Inches Pumped

1. Acre-Inches / Acres = Inches Pumped

2. Gallons Pumped / 27,154 / Acres = Inches Pumped

3. (Acre-Feet * 12) / Acres = Inches Pumped

How to Calculate Net Inches Applied to the Crop

4. Inches Pumped x Efficiency Factor* = Net Inches Applied

*Efficiency Factors
Subsurface Drip Irrigation = 0.95
Pivot - low pressure drops = 0.90
- med. & low pressure impacts = 0.85
- high pressure = 0.80
Surge Valve = 0.80
Gated Pipe - with reuse = 0.7
- without reuse = 0.5

If you have any questions, you can call Curtis Scheele at 308-995-6121, Ext. 3 or email him at *curtis.scheele@ne.usda.gov*.

Curtis's Column

USDA United States Department of Agriculture
Natural Resources Conservation Service

Highly Erodible Land (HEL) Compliance!!!:

In the first Tri-Basin Irrigator of 2017 dated May 25th, I had this same article. Because of the emphasis in controlling ephemeral gully erosion and how it can impact a producers eligibility for USDA benefits I felt it important to repeat. I am repeating it now as you will soon be harvesting and these gullies will be noticed. You will want to watch for these areas and try to figure out how you will want to prevent them from happening. It's not about repairing them each year or every other year. It's about preventing them from even occurring. Here is the article with minor tweaks.

If you are farming HEL fields, you are REQUIRED to control ephemeral gully erosion in order to remain in compliance with USDA farm program benefits. Tillage to smooth the ditches is not a control practice. Tillage hides the problem and allows the problem to continue. Cover crops, terraces, waterways, grade stabilization structures, etc. are ways to help control ephemeral gully erosion.

Starting in 2017, Nebraska NRCS will be addressing this concern. Efforts will be made to assist producers in controlling ephemeral gullies and to remain in compliance with the Food Security Act of 1985.

For more info, visit this link for attachments and a video: *https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ne/programs/farmbill/cc/?cid=NRCSEPRD1322784*.
You can also contact your local NRCS office.

Soil Health Series: Earthworms

There are all kinds of livestock that live in the soil and have various roles in keeping a soil healthy. However the most common one that we all see and know are the earthworms.

Earthworms do so much for the soil. They improve soil tilth, aeration, infiltration, drainage, porosity, plant decomposition, nutrient recycling, provide nutrients, and they stimulate root growth deep into the soil. However they are not wonder workers. They have to be fed and cared for as do all the livestock in the soil just as we feed and care for our crops and cattle. Do you think our crops and cattle can survive without soil? Would people survive without soil? Soil is the base for all living things. Therefore we need to take care of it so it can take care of us.

Attached are two photos showing worm holes and earthworms. These photos were taken in the spring in multi-year no-till fields. NOTE: They are on the backside of the Grazing Cover Crop Field Day flyer. Also attached is a Soil Quality Indicator sheet providing wonderful information about earthworms.

I also have a couple of links to videos. This first one is short and provides good earthworm information. I never heard of an earthworm midden until I saw this video. https://www.youtube.com/watch?v=AxCpehZ4wRg.
This second video is longer. It's from Italy but the same concept holds true for worms in the Tri-Basin NRD and around the world. What amazes me is their ability to move residue into the tunnels. I think this is an excellent video of earthworm education. https://www.youtube.com/watch?v=hSyX8g1V3bc.

Amazing stuff!

CNPPID Notes

2016 and 2017 monthly weather and ET data;

As shown below, the largest 2016 and 2017 seasonal differences at the Holdrege 4N station are in total precipitation and average solar intensity. With adequate irrigation and all else equal, yields should meet or exceed those of 2016.

2017 Month	Average T-high F	Average T-low F	Average Rel Hum %	Average Soil Tmp F@4 in.	Average Wind Spd mi/hr	Average Solar langleys	Total Precip inches	Total Et_a Corn inches	Total Et_a Beans inches
April	62.91	39.09	66.74	54.83	11.78	423.18	3.07	0.00	0.00
May	70.70	46.43	64.28	61.00	10.23	532.25	4.22	0.55	0.39
June	86.00	59.79	58.65	77.39	8.11	611.01	0.17	4.15	3.57
July	87.76	65.15	72.24	81.79	5.92	573.11	4.25	8.15	7.82
August	81.40	58.85	79.30	75.46	4.65	491.68	3.53	5.62	4.75
5 month	77.75	53.86	68.24	70.09	8.14	526.25	15.23	18.47	16.53

2016 Month	Average T-high F	Average T-low F	Average Rel Hum %	Average Soil Tmp F@4 in.	Average Wind Spd mi/hr	Average Solar langleys	Total Precip inches	Total Et_a Corn inches	Total Et_a Beans inches
April	64.16	38.24	62.59	54.46	12.89	397.25	9.11	0.00	0.00
May	70.44	47.79	70.12	61.39	9.77	452.75	4.17	0.46	0.31
June	86.95	61.70	61.88	77.35	8.57	588.01	2.35	4.13	3.86
July	85.49	63.95	79.11	78.70	6.76	494.34	1.75	7.38	7.12
August	82.45	61.59	75.97	78.40	6.22	472.31	1.08	6.55	4.57
5 month	77.90	54.66	69.93	70.06	8.84	480.93	18.46	18.52	15.86

Tri-Basin NRD News

Reminders for the End of Chemigation:

Chemigation Inspection Follow-Up Appointments:

If you had a chemigation system fail inspection and have received a notice about scheduling a follow-up inspection, call our office at 1-877-995-6688 as soon as possible to set up an appointment. **These systems must pass an inspection this season in order to be eligible for renewal in 2018.**

Drain Your Chemigation Check Valve:

When you are preparing your irrigation systems for colder weather, remember to drain your main line check valve to prevent freezing. This will extend the life of the check valve and may help prevent check valve failure.

Nebraska Extension Extras

Estimating Pre-Harvest CornYields:

As irrigation season draws to a close during the next few weeks, producers may benefit from pre-harvest corn yield estimation. There are *two* methods described in our new 2017 "Nebraska Soybean & Corn Pocket Field Guide" pgs 167-169.

The **Yield Component Method** can be used as early as the milk stage and estimates the number of kernels that will be harvested per acre combined with an estimated number of kernels per bushel to estimate yield per acre. **Step 1:** Determine the row length equivalent to 1/1,000th of an acre; for 30" row width corn (distance = 17 feet + 5 inches). **Step 2**: Record number of harvestable ears in the 1/1,000th of an acre sample row. (Recommend repeating this process at least 5-10 times and then averaging. **Step 3:** for every fifth ear in the 1/1,000th of an acre, count the number of kernel rows on each and count the average number of kernels per row. Multiply row number of that given ear by its kernels per row to calculate the total number of kernels for each ear. **Step 4:** Calculate the average number of kernels per ear. One bushel of corn usually has 85,000 kernels per bushel (range 65,000 to 100,000). **Step 5**: Multiply the number of harvestable ears x average number of kernels per ear; then divide by 85 = bushels per acre.

The second method is **Ear Weight Method** which can be used after the corn reaches the *black layer* stage of development. This usually occurs when growing season GDD's (growing degree days) totals 2450. For our region, this physiological maturity is predicted to occur in most fields around Sept. 11th this year. **Step 1**: Determine the row length equivalent to 1/1,000th of an acre. **Step 2**: Count the number of harvestable ears in the 1/1,000th acre. **Step 3:** Harvest & weigh every fifth ear; then shell for a grain moisture sample. **Step 4:** Determine percent grain moisture of sample. **Step 5:** Multiply ear number by average ear weight. **Step 6:** Multiply grain moisture by 1.411, add 46.2 to the result (adjusts for shelling percentage and 15.5% moisture). And, **finally,** divide the step 5 result by the step 6 result, then multiply by 1000 to estimate yield in bu./Acre. <u>Example:</u> 53 ears in 17.5 feet with 0.5 lbs ears & 30% moisture.

(53 ears x 0.5 lb) ÷ ((30 x 1.411) + 46.2)) x 1000 = 299 bu./acre

Estimating Pre-Harvest Soybean Yields:

For soybeans, pre-harvest yield estimation is based on 1/10,000th of an acre beginning at the reproductive stage (R5). This length is equivalent to 21" of row with 30" row spacing. For drilled soybean (7.5" row spacing), hand harvest four rows (21 inches long for each row). **Step 1**: harvest plants in 21" of row and count total number of pods in the plants row sample. **Step 2:** Estimate the number of seeds per pod. The standard is usually 2.6 seeds per pod. Or, select 2 random plants from the sampled area and count total seeds and calculate average seeds per pod. **Step 3:** Estimate soybean seed size for multiplication factor. (Normal soybean seed size is 3,000 seeds per pound) Use 15 factor of 2,500 seeds / pound.; 18 factor for 3,000 seeds / pound; or 21 factor for 3,500 seeds per pound. **Step 4**: multiply number of pods from 1/10,000th of an acre times seeds per pod divided by factor = bushels per acre. And, **finally,** adjust for 5% harvest loss by multiplying bushels per acre in step 4 times .95 = final bushels per acre estimation. <u>Example:</u> 577 pods x 2.6 seed/pod ÷ 18 x .95 = 79 bu/Acre.

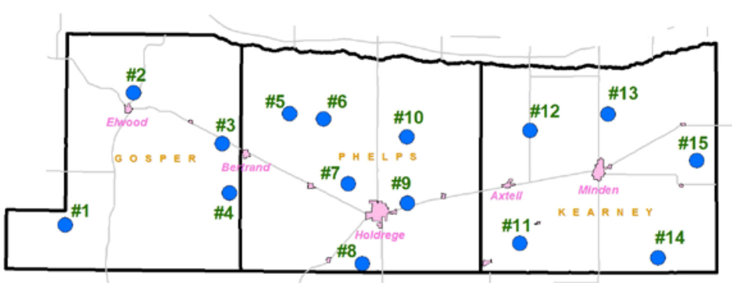
For more information refer to: http://extension.unl.edu/statewide/burt/estimating-corn-soybean-yields/

NAWMN Crop ET Information

Additional Information and other ET resources can be found at websites listed under “ET Information Sites” below.

Inches of Crop Water Use (ET) = Evaporation x Kc

	Aug 14 – Aug 20		Aug 21 – Aug 27	
Site	Evaporation	Rain	Evaporation	Rain
1	1.60	0.90	1.50	0.00
2	1.30	0.80	1.30	0.12
3	1.00	0.63	1.10	0.24
4	1.30	0.71	1.50	0.20
5	1.30	1.10	1.20	0.50
6	1.10	1.70	1.20	0.60
7	1.40	1.45	1.10	0.76
8	1.55	0.80	1.30	0.57
9	1.40	2.10	1.20	1.00
10	1.50	1.40	1.60	0.74
11	1.40	0.90	1.10	0.68
12	1.50	1.38	1.20	0.67
13	1.80	1.10	1.10	0.41
14	1.50	0.83	1.30	0.25
15	1.40	0.80	1.10	0.48



2017 Map of NAWMN Sites across the Tri-Basin NRD.

Crop Coefficients (Kc)

Corn Stage	Kc	Soybeans Stage	Kc
2 leaf	0.10	Cotyledon (VC)	0.10
4 leaf	0.18	1st Node (V1)	0.20
6 leaf	0.35	2nd Node (V2)	0.40
8 leaf	0.51	3rd Node (V3)	0.60
10 leaf	0.69	Beg. Bloom (R1)	0.90
12 leaf	0.88	Full Bloom (R2)	1.00
14 leaf	1.01	Beg. Pod (R3)	1.10
16 leaf	1.10	Full Pod (R4)	1.10
Silk – Beg. Dent	1.10	Beg. Seed (R5)	1.10
¼ Milk Line	1.04	Full Seed (R6)	1.10
Full Dent (½ Milk)	0.98	Yellow Leaf (R6.5)	1.00
¾ Milk Line	0.79	Beg. Mat. (R7)	0.90
Black Layer	0.60	Full Mat. (R8)	0.20
Full Maturity	0.10	Mature	0.10

Crop Stage Information

Corn (R4.7-Beginning Dent to R5.8-3/4 Milk Line stage): Stress at R5 will reduce yield by kernel weight, not kernel number. At the beginning of R5, kernels have about 55% moisture.
Avg. daily water use from Aug 21 – Aug 27 was 0.09”-0.24”.

Soybeans (R5-Beginning Seed to R6.5-Full Seed/Yellow Leaf stage): Rapid leaf yellowing over the plant begins shortly after R6. Root growth is complete after R6.5. Stress from R6 to R6.5 may cause large yield reductions.
Avg. daily water use from Aug 21 – Aug 27 was 0.13”-0.25”.

Aug 21-Aug 27 (15 of 15 NAWMN sites reporting): Average weekly rainfall was 0.48 (range 0.00 to 1.00). Average weekly ET for corn was 1.31 and for soybeans was 1.25.

ET Information Sites

NAWMN Sites:
- http://www.cnppid.com/news-info/weatheret-data/nebraska-agricultural-water-management-network/
- https://nawmn.unl.edu/ETdata/DataMap

CropWatch: http://cropwatch.unl.edu/gdd-etdata
CNPPID: http://www.cnppid.com/news-info/weatheret-data/
Water Use Hotline: 1-800-993-2507

Corn Stage		DESCRIPTION
R4.7	Beginning Dent	Kernels at the base of the ear are beginning to dent.
R5.5	Full Dent 1/2 Milk Line	Starch line is 1/2 the way down the kernel. Top 1/2 is hard and bottom 1/2 is softer near the cob.
R-6	Black Layer	The starch line has advanced to the cob. Physiological Maturity. Black layer formed, kernel moisture is between 25%-35% moisture. 0.0 inches needed for yield.

Soybean Stage		DESCRIPTION
R6	Full Seed	At least one pod whose cavities are completely filled with green seeds is present at one of the four uppermost main stem nodes that have fully developed leaves.
R6.5	Full seed Yellow leaf	Leaves begin to yellow, beginning in the lower canopy and progressing upwards.
R7	Beginning Maturity	At least one (normal) pod that has attained its final mature color (tan or brown, depending on variety) is present on any main stem node. 0.0 inches needed for yield.

Lake and River Levels

CNPPID Reservoir Elevation and Platte River Flow data listed below and other locations can be found on CNPPID's website at http://cnppid.com/wp-content/uploads/2016/06/lakeRiverData.html.

	August 31, 2017, 8:00 AM	*1 Year Ago*
Capacity of Lake McConaughy	73.5%	NA
Inflows to Lake McConaughy	951 cfs	1717 cfs
Flows on the North Platte at North Platte	662 cfs	1758 cfs
Flows on the South Platte at North Platte	123 cfs	181 cfs
Flows on the Platte at Overton	253 cfs	1729 cfs

Nothing is ours except time.
- Seneca

Websites of Interest

Soil Health:
www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/

Climate	agclimatenebraska.weebly.com
SAM Registration	www.sam.gov
NRCS Nebraska	www.ne.nrcs.usda.gov
Central Irrigation District	www.cnppid.com
TBNRD Home Page	www.tribasinnrd.org/
Farm Service Agency	www.fsa.usda.gov
UNL Cropwatch	cropwatch.unl.edu
UNL Extension	extensionpubs.unl.edu/
K-State SDI Website	www.ksre.ksu.edu/sdi
No-till On The Plains	www.notill.org

Rainfall

Rainfall amounts listed below and other locations come from NeRAIN which can be found at website https://nednr.nebraska.gov/NeRain/Maps/maps.

Location:	Aug 17 – Aug 30	May 1 – Aug 30
Arapahoe 6.9 NW:	0.00	12.71
Bertrand 6.1 mi. SE:	0.19	11.29
Funk 4.1 mi. NNE:	0.89	16.01
Minden 0.855 mi. W:	0.61	17.26
Minden 8.8 mi. ESE:	0.26	15.57

Average Rain for May-August in Holdrege = 14.21 Inches

****** If you wish to receive this newsletter via e-mail, or have any questions, comments or ideas, feel free to contact Curtis Scheele at the NRCS office in Holdrege or you can email him at curtis.scheele@ne.usda.gov. ******

USDA - Natural Resources Conservation Service

1609 Burlington Street
PO Box 798
Holdrege, NE 68949-0798
308-995-6121, Ext. 3

309 Smith Street
PO Box 41
Elwood, NE 68937-0041
308-785-3307, Ext. 3

1005 South Brown Street
Minden, NE 68959-2601
308-832-1895, Ext. 3

Central Nebraska Public Power & Irrigation District

415 Lincoln Street
PO Box 740
Holdrege, NE 68949
308-995-8601

Tri-Basin Natural Resources District

1723 Burlington Street
Holdrege, NE 68949
308-955-6688

Nebraska Extension

1308 2nd Street
Holdrege, NE 68949
308-995-4222

PO Box 146
Elwood, NE 68937
308-785-2390

424 North Colorado
PO Box 31
Minden, NE 68959
308-832-0645

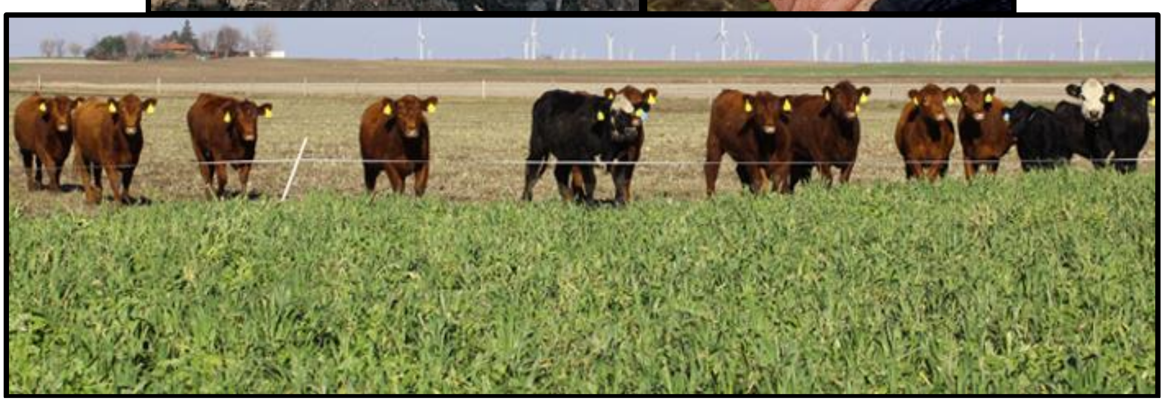
GRAZING COVER CROP FIELD DAY

SEPTEMBER 20, 2017

HOSTED BY: JIM CAMPBELL

KEARNEY, NE

- 10:00 AM-MEET AT FIELD ¼ MI EAST OF HAWK (N ST) ON 130th ROAD FOR TOUR
- 12:00 PM –BUFFALO COUNTY EXTENSION ROOM
- LUNCH PROVIDED BY ROBERTS SEED—AXTELL
- (RSVP TO RESERVE YOUR MEAL BY SEPTEMBER 15)
- 1:00-2:30 DISCUSSION WITH EXTENSION, NRCS, ECONOMICS, SEED MIXES AND OTHER TOPICS



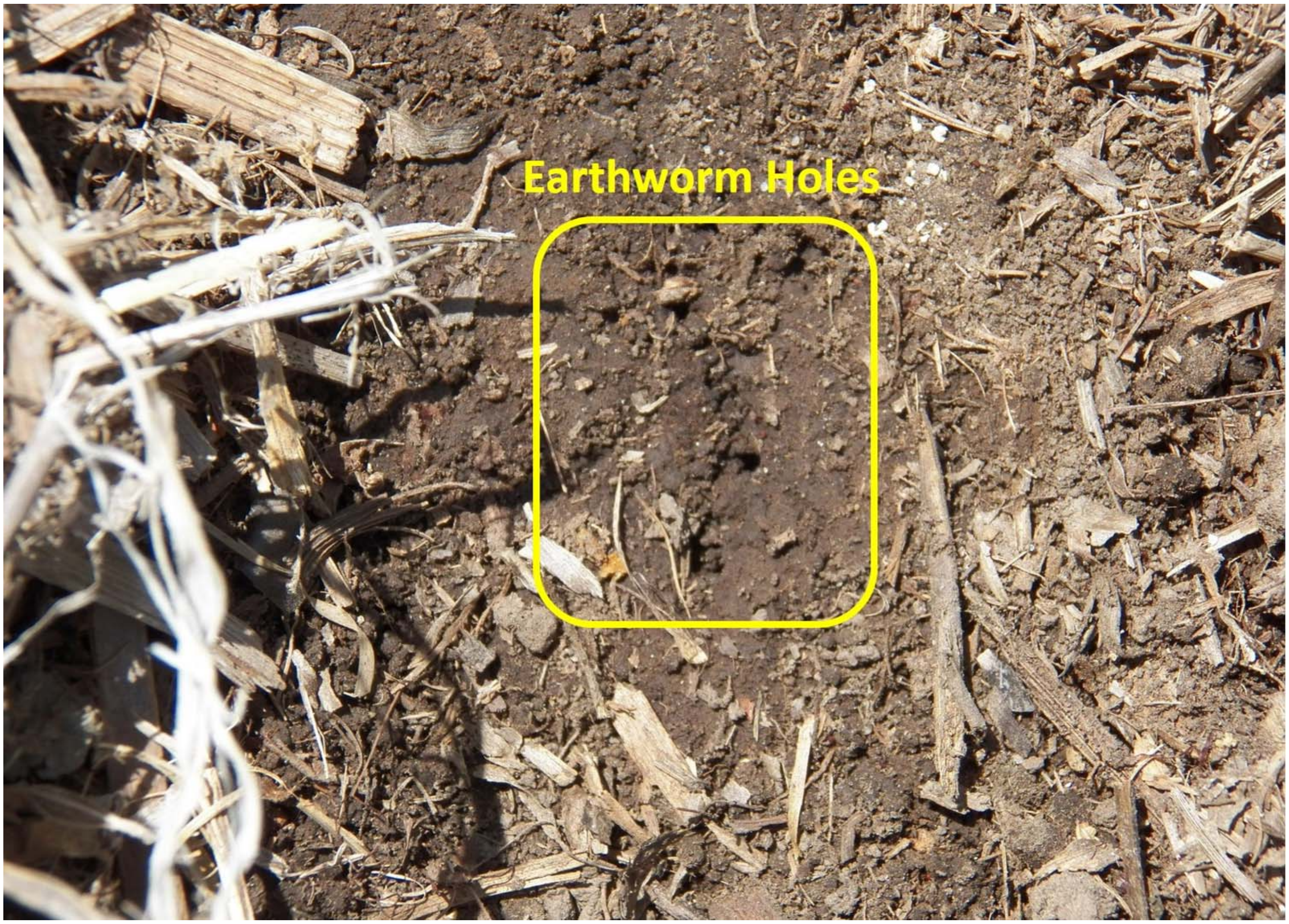
FIELD DEMONSTRATIONS

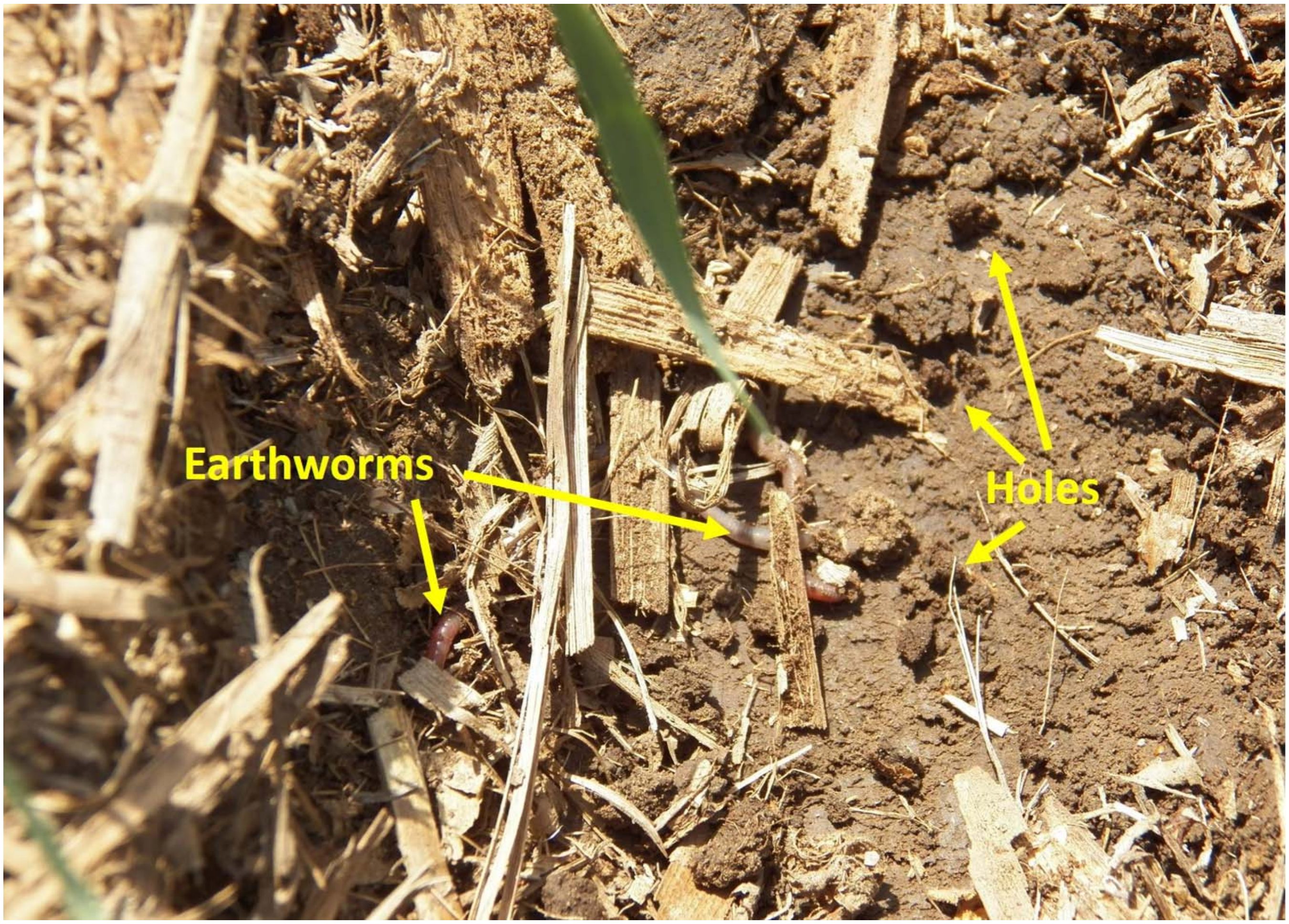
GROWING FIELD PEAS AS A CASH CROP

COVER CROP MIXES-ROBERTS SEED

STRIP GRAZING COVER CROPS

FENCE/WATER DEMONSTRATION BY JASON GROSS, HIGH PLAINS SOLUTIONS


Earthworm Holes


Earthworms
Holes

Earthworms

Earthworms are native to non-glaciated areas of North America, but non-native species from Europe and Asia also exist here. Earthworms are classified into three groups based on their habitat. Litter-dwellers live in the litter, ingest plant residues, and may be absent in plowed, litter-free soil. Mineral soil-dwellers live in topsoil that is rich in organic matter. They burrow narrow channels and feed on a mixture of soil and plant residues. Deep soil-burrowers (night crawlers) dig long, large burrows into deep soil layers. They carry with them plant residues for consumption. Earthworm cast is digested material that is excreted back into the soil. Cast is enriched with nutrients (N, P, K, and Ca) and microorganisms during its passage through the worm's digestive system. Fresh cast is a site of intense microbial activity and nutrient cycling. Earthworms contribute nutrients to the soil and improve porosity, tilth, and root development. They are measured in number/m^2.

Factors Affecting

Inherent - Earthworms are found in various environments, but seasonal and climactic variations affect their abundance, distribution, and activity. They are most active in the spring and autumn. Soil moisture, aeration, temperature, and texture affect earthworm populations. Water makes up more than 75% of the earthworm's body weight, so moist soils are preferred to prevent dehydration. Earthworms acclimate quickly by moving to humid sites or by entering a resting state. In the absence of mulch, very high or freezing soil temperatures can drastically reduce earthworm populations in a short time, but the lethal temperature is variable among species. A generalized range for earthworm activity is 32 – 86 degrees F. Stable aggregates contain organic matter and improve porosity, consequently improving air circulation, drainage and infiltration, which favor earthworm establishment.

Silty soils with high water holding capacity and organic matter provide ideal habitat for earthworms compared to sandy soils, which have lower organic matter content and water holding capacity, and dry and reach uncomfortable temperatures quickly. Deep soils are the favorite niche for earthworms, especially shallow soil-burrowers.

Dynamic - Earthworm abundance and activity trend with the amount and quality of plant residues, which provide food and mulch for habitat. Mulch helps maintain soil moisture and moderates soil microclimate, providing adequate time for earthworms to migrate and escape high or freezing temperatures. No-till and other conservation practices create ideal conditions for earthworms. The population in no-till fields can reach two to three times that in conventionally tilled fields (fig. 1). Populations of litter-dwellers and night crawlers may drop and even vanish in conventional tillage systems because of the destruction of burrows and depletion of surface residues. Earthworm populations are generally high and active in grassland due to the thick surface cover and continuous supply of food from residues and animal wastes.

While neutral pH is ideal, earthworms can adjust to pH 5–8 with some species tolerating even more acidic soils. Oxygen requirements also vary among species with some tolerating low amounts. Ammonia and ammonia-based fertilizers are toxic to earthworms due to acidic conditions created by their use. Herbicides tend to have low toxicity to earthworms if used at the recommended rate, especially when applied in bands. However, atrazine, which is widely used, is reported to be slightly toxic. Carbamate insecticides (table 1) and fungicides (carbendazim, benomyl) have severe adverse effects on earthworms.

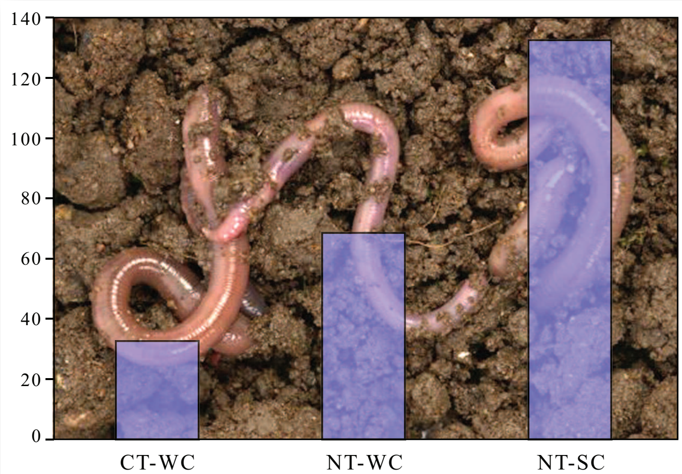


Figure 1. Effect of tillage and crop on earthworm number/m^2
CT=conventional till, NT= no-till; W=wheat, C=corn, S=soybean
Adapted from Hubbard, et al. 1999.

Relationship to Soil Function

Despite some reservations, there is evidence that earthworms contribute to crop production. Earthworms play a key role in modifying the physical structure of soils by producing new aggregates and pores, which improves soil tilth, aeration, infiltration, and drainage. Earthworms produce binding agents responsible for the formation of water-stable macro-aggregates. They improve soil porosity by burrowing and mixing soil. As they feed, earthworms participate in plant residue decomposition, nutrient cycling, and redistribution of nutrients in the soil profile. Their casts, as well as dead or decaying earthworms, are a source of nutrients. These beneficial effects stimulate root growth and proliferation deep into the soil to satisfy nutrient and water requirements. Roots often follow earthworm burrows and uptake available nutrients associated with casts. *Lumbricus terrestris*, or the night crawler, and other non-native earthworms have displaced many native species across the United States. In Northern forests, their populations can reach such high levels that no litter can be maintained on the forest floor.

Problems with Poor Populations

Low or absent earthworm populations are an indicator of little or no organic residues in the soil and/or high soil temperature and low soil moisture that are stressful not only to earthworms, but also for sustainable crop production. Earthworms stimulate organic matter decomposition. Lack of earthworms may reduce nutrient cycling and availability for plant uptake. Additionally, natural drainage and aggregate stability can be reduced. Soil remediation to increase nutrient cycling, break up compacted layers to improve aeration and drainage, and stabilize soil to protect it from erosion may be needed. Some soils are naturally productive without earthworms because of their inherent properties.

Improving Populations

No-till increases plant residues and improves soil structure, providing improved habitat for earthworms. Studies conducted in the Midwest showed that in no-till systems, the combination of soil moisture, temperature, and quality of food supply are essential factors for earthworm population growth. Legumes, alone or in rotation, seem to be preferred by earthworms because of the quality of food they provide (fig 1). Deep soil-burrowers are lacking in plowed fields and changing to no-till may not help their quick establishment unless they are introduced first. Seeding earthworms is a potential technique to reintroduce them, but it is not practical on a large scale. Compared to other ecosystems, agricultural soils are generally dominated by species adapted to disturbance, low organic matter content, and a lack of surface litter, so the management practices listed below should increase earthworm populations. Sandy or wet heavy clay soils may not naturally harbor significant earthworm populations, but irrigation and drainage can help provide favorable conditions for earthworms to thrive. (In areas where restoration of native species is a goal, removal of exotic species is a must.)

The following practices boost earthworm populations:

- Tillage Management (no-till, strip till, ridge till)
- Crop Rotation (with legumes) and Cover Crops
- Manure & Organic By-product Application
- Pasture & Hayland Management
- Soil Reaction (pH) Management
- Irrigation or Drainage

Measuring Earthworm Abundance

Earthworm populations are measured by counting the number of earthworms/m^2 as described in the Soil Quality Test Kit Guide, Section I, Chapter 10, p 22-23. See Section II, Chapter 9, p 73 - 75 for interpretation of results.

References:

Brady CN and RR Weil. 1996. The Nature and Properties of Soils. Prentice-Hall.

Edwards CA and CI Bohlen. 1996. Biology and Ecology of Earthworms. Chapman & Hall, NY.

Hubbard VC, et al. 1999. Earthworm response to rotation and tillage in Missouri claypan soil. Biol Fertil Soils 29:343-7.

Specialized equipment, shortcuts, tips:

Use recommended products to bring deep-burrowing earthworms out at the soil surface. A count of 100 earthworms/m^2 in agricultural fields is considered good.

Time needed: 30 minutes

Table 1. Insecticides harmful to earthworms

Insecticide	
Common Name	**Trade Name**
Aldicarb	Temik
Carbaryl	Sevin
Carbofuran	Furadan
Clorpirifos	Dursban
Methomyl	Lannate