United States Department of Agriculture
National Institute of Food and Agriculture

Manual for Participants

Participatory Breeding and Testing Networks: A Maize Based Case Study for Organic Systems

OREI Project Number 2017-02413

Introduction to the Guide

This is a guide for members of a participatory network that is designed to help researchers, farmers, educators and industry members to work together to develop new varieties for organic markets. While many aspects of the project apply to organic breeding and testing in general, our testing network will focus on corn as a sort of case study, to help us develop protocols to efficiently identify varieties that perform well on organic farms and have nutritional and quality traits desired by producers, buyers, and consumers. The guide has separate sections describing different ways to participate and includes appendices that contain datasheets and sharing agreements.

Contents

Educational Network

Goals

Farmers participating in the On-Farm Testing Network (aka growing strip trials) are critical members of the educational network organized to support partnerships that develop valuable crops and successful organic markets. Through the educational network, we hope to foster a close collaboration between farmers, researchers, buyers, and consumers and translate our research activities in a clear and timely manner.

Activities

Participants in the network's educational exchange will engage in regional and/or online workshops, and contribute input through discussion, and/or through the completion of surveys or questionnaires. Network and research activities will help us discover how on- and off-farm factors currently influence seed supply and determine how changes in these factors can improve the success of participatory breeding efforts and support profitable partnerships and organic markets. Research conducted in the testing network and replicated trials explore on-farm/agronomic factors that include seed resources, weather, cultural practices, pest and disease pressure, soil health, harvest and storage. Activities will consider important off-farm factors that include intellectual property protections, sharing agreements, the organizational structure of the value chain, and market relations influencing breeding efforts for organic markets.

Upcoming activities

Agronomy Day, August 2019, Urbana IL
United States Testing Network, December 2019, Chicago IL
OGrain Conference, Feb 2020, Champaign IL
Field days August 2020, Macomb IL and TBD WI
Moses Conference, February 2021, La Crosse WI

Outcomes

Participants in the educational network will have access to summary reports that contain publicly available data from the testing network and replicated trials, all project materials (presentations and meeting notes) from network meetings, as well as access to all educational materials produced by the group.

Timing and administration

Participants in the network should complete the network agreement contained in Appendix A4a and A4b and depending on the levels of participation. Network meetings will typically include winter interactions through conference calls or face-to-face visits, summer field days and or conferences. Individuals can engage based on interest and availability. Activities will be facilitated by project coordinator Emily Marriott (emarriot@illinois.edu; 413-362-9682) and/or graduate students Christopher Mujjabi (mujjabi2@illinois.edu; 919-623-0490) and Binod

Ghimire (binodg2@illinois.edu; 575-888-5117) in IL and IN, and by Walter Goldstein (Walter wgoldstein@mandaamin.org; 262-348-7534) and Emily in WI.

On-Farm Testing Network

Goals

On-farm strip trials will be used to gather information about corn varieties of interest that have been identified by participating breeders based on their agronomic performance and quality traits, anticipated market use (baking, brewing, livestock etc.), but have not yet been tested under "real world" growing conditions. The information from the testing network reported back to the breeders will determine the future market potential of the tested corn varieties and will inform further breeding efforts.

Activities

Strip trial partnership

Grain yield and quality alone do not provide us with sufficient information about the various strategies that cultivars use to cope with diverse environments or how crop cultivars respond during the growing season to specific farming practices as well as biotic (pests, diseases, competition against weeds and "neighbors", etc.) and abiotic (cold, hot, dry, wet growing conditions, lack of nutrients, etc.) stresses. Gaining a deeper understanding of the cultivar's potential to respond to inputs and stresses is the first step to improving efficiently the crop's productivity within complex organic farming systems. Farmers and research coordinators participating in the on-farm testing network will communicate regularly. Farmers will share information about field management and participate in the Educational Network.

Cultivar supply and selection

Farmers will select entries from a list of cultivars available for the following growing season. Information about the management practices used for their production, cultivar maturity, quality, and agronomic characteristics will be provided by the end of March of each year of the project. Table 1 provides a tentative list of the 2019 entries. Final details on seed availability will be completed by early April.

Each year we will ask participants to include a core set of common varieties. This will allow us to understand cultivar ("genotype") by environment (GXE) interactions. The core set will be tailored for areas based on cultivar maturity, cultivar availability, and farmer interest. In 2019, participants are asked to plant eight cultivars, one of which is a control, and can select additional cultivars based on their interests and seed availability. Farmer's feedback on 2019 cultivars will be used to identify hybrids that will be increased in 2020 and then made available to farmers in 2021.

Strip trial planning and design

During early spring, farmers will meet with research coordinators either virtually or face-to-face to develop a plan of action for each farm. Typically plans will be derived by meetings between Martin Bohn, Carmen Ugarte and farmers in Illinois and Indiana, and by meetings between Walter Goldstein and farmers in Wisconsin. During these meetings, we will select a suitable area (0.25 acres) within a field rotating into the corn phase of the rotation this season. The selected area should not have severe problems with drainage or weed pressure, and have low variability in topography and soil type.

Table 1. Cultivars offered for 2019.

Hybrids	Relative Maturity	Characteristics	Source	Core Sets
UIUCO-001	110	yellow dent, high yield, tolerant to high plant density	MB UIUC	
UIUCO-002	112	yellow dent, high yield, tolerant to high plant density	MB UIUC	
UIUCO-003	112	yellow dent, good root strength	MB UIUC	IL-IN
UIUCO-004	114	yellow dent, good root strength	MB UIUC	IL-IN
UIUCO-005	112	yellow dent, good yield in organic management experiments 2018	MB UIUC	IL-IN,WI
UIUCO-006	113	yellow dent, PHZ51 inherits higher yields under low N availability	MB UIUC	IL-IN
UIUCO-007	112	yellow dent, good performance in organic management experiments 2018	MB UIUC	IL-IN,WI
Great Harvest 59R5	109	yellow orange, hard kernel high yield, food grade	Great Harvest	IL-IN
17.C4-6	105-107	high methionine, soft kernelled, N efficient, good yield.	WG Mandaamin Institute	IL-IN,WI
C2B2-7.17	108-114	high methionine, soft kernelled, N efficient, high yield.	WG Mandaamin Institute	IL-IN,WI
C2B2-7.C4-6	106-108	high methionine, soft kernelled, N efficient, good yield.	WG Mandaamin Institute	WI
15.C4-6	103-105	high methionine, soft kernelled, N efficient, good yield.	WG Mandaamin Institute	WI
C2B2-1.C4-6	106-108	high methionine, soft kernelled, N efficient, good yield.	WG Mandaamin Institute	WI
AR21BxNG.591	105-107	cross incompatible, soft and hard kernelled, N efficient, fair yield.	WG Mandaamin Institute	
NG10-2-3-2 x Md1	103-105	high methionine, soft kernelled, N efficient, good yield.	WG Mandaamin Institute	
FOS8507	105-108	normal hybrid, very high yield potential	Steve Mohr	WI

Yellow indicates highest priority, green are regional controls

The basic trial design includes strips 4 rows wide and 100 feet long per cultivar (Figure 1). This permits us to evaluate each cultivar using the center 2 rows where the influence of neighboring cultivars is minimized. If all entries in a trial are of similar height, a 2-row design can be used if strips are planted at least 300 feet in length. Farmers will only be able to plant significantly larger areas of any cultivar if sufficient seed is available.

Individual farmers will finalize the design of their strip trial when they meet with research coordinators. The example below illustrates what a strip trial may look like. The contents of farm action plans, which will vary from farm to farm as a result of seed availability, climatic conditions,

interests and infrastructure of the farmer, and perceived opportunities, will be documented using forms available in the strip trial planting guide in Appendix 1.

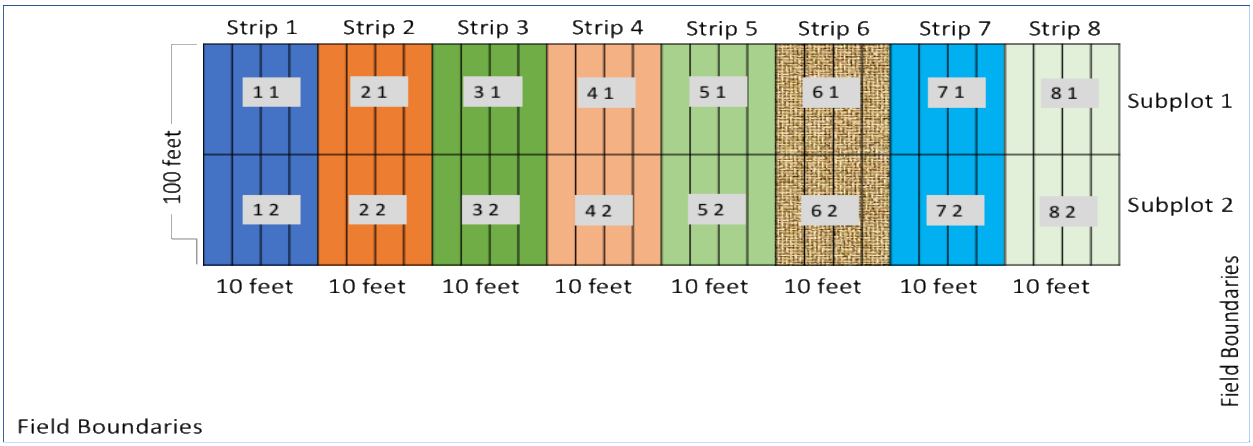


Figure 1. General 4-row by 100 feet strip trial design. Numbers in gray boxes indicate codes for soil samples obtained from each strip. One composite sample of two subsamples would be taken from within each rectangle (eg: from Strip one 1-subplot 1). See Appendix 1 and Appendix A3b for more detail.

Data collection, data sharing, and time estimates

An overview of sampling and data collection includes pre-season, within-season, and harvest activities that are summarized in Table 2. Detailed information and data collection sheets are provided as appendices and online. Please review time requirements and responsibilities with Graduate students or coordinators to verify what you can and cannot do. We can collect samples and assist with plot layout, etc. when arrangements are made. Good communication of planting dates and row spacing is needed so we can complete activities summarized in Table 2. Due to time sensitivity we would greatly appreciate it if farmers could help with the phenotyping activities shown in bold.

Table 2. Summary of data to be collected from each on-farm strip trial. Activities identified by an asterisk are of highest priority so let researchers know if they must collect the data.

Data type	Time needed	Typical date collected	Who does
Planning and record keeping			
Strip Trial Plan of action	2-hr	Winter	Farmer and researchers
Plan and Management History	1-hr	Winter	Farmer and researchers
Within Season Management	2-hr	During the season	Farmer
Field operations			
Planting	4 - 6hr	In season	Farmer and researchers
Cultivation	1-hr	In season	Farmer
Amendments		In season	Farmer
Equipment		In season	Farmer
Plot establishment			
Cover Crop Sampling	<1-hr	March-May	Farmer or Researchers
Plot Layout and Soil Sampling	5-hr	March-May	Researchers
Phenotyping			
[IL] **Date to plant emergence**	10 min/cultivar	Within a week after planting	Farmers or Researchers
[IL] **Date to male flowering (Anthesis) ***	20 min	9 to 10 weeks after planting	Farmers or Researchers
[IL] **Date to female flowering (Silking)**	20 min	9 to 10 weeks after planning	Farmers or Researchers
*Weed pressure rating	20 min	9-10 weeks after planting	Researchers
Ear height	40 min	After flowering before harvest	Researchers
Plant height	40 min	After flowering before harvest	Researchers
*Disease rating		After flowering	Researchers
[WI] **Silage quality**	40 min	Before senescence	Researchers
**Root and stalk lodging*	*30 min*	*Before harvest*	*Researchers*
**Yield (Strip weight)*	90 min	At harvest	Researchers
**Grain moisture*		At harvest	Researchers
**Test weight*		At harvest	Researchers

*Identifies highest priority measurements that may differ by region. Italicized measures are essential.

Field management

Strip trials should ideally be planted within a day or two of the adjacent corn-area. Farmers will control weeds and complete any field operations normally applied to corn they produce. The dates of field operations, quantities and sources of materials applied and, description of equipment used should be recorded in data sheets available in **Appendix A1c**. Field management history should be collected before planting, ideally during the planning stage using the **Field History and Management Information** form (Appendix A1b.).

Cover crop sampling

Should be done just before a cover or green manure is terminated. **Details are in Appendix 2**. One sample should be taken for every two strips to be planted (4 subsamples if planting 8 cultivars) distributed evenly across the area where the plots will be laid out. These should be distributed to represent the plot area and capture differences in biomass that are noteworthy. It is very important to record the location where samples are taken using a method that will allow us to link 1) a photo taken from above using a cell phone with 2) the above ground biomass sample taken from that area after the photo was snapped, and 3) high resolution satellite imagery. Biomass samples will need to be picked up by graduate students or coordinator.

Soil sampling

If farmers can collect samples so these can be taken on a timely basis it would be greatly appreciated. If you can't do this let us know. Ideally, samples should be taken before planting after sources of fertility have been applied, but before secondary tillage (cultivation and seed bed preparation) have occurred. Farmers will collect two composite subsamples per strip as identified by the numbers within strips in Figure 1. Subsamples will be composites of two cores taken to a 12-inch depth. If farmers do not have a sampling probe one will be provided along with labeled mailing bags. After air dying samples, farmers will mail them to the University of Illinois using pre-paid mailers. We will use soils to complete standard tests and soil health assays. Results will be shared as soon as possible. Any additional soil sampling during the growing season will be arranged with the farmer and cooperators. More detailed instructions are provided in **Appendices A3a and A3b**.

Crop phenotyping

After planting, participating farmers with interest in this and research coordinators will visually track crop growth and development, assess pressure from weeds and pests, and measure a small set of important plant characteristics (see Table 2). Detailed instructions are provided in the phenotyping guide in **Appendix A3c**. Trainings for rating and summaries of data produced by these efforts will be carried out through the educational network. Phenotyping forms for trait evaluation will be provided.

At harvest, cooperators will work with the farmer to ensure harvest is done in a timely manner. In some instances, cooperators will come to the farm to evaluate yield using a plot combine to harvest the two center rows of each strip. In some places, the investigators will work with the farmer to manually harvest strips. In all cases, grain samples from each strip will be sent to the University of Illinois for grain and processing quality analysis using pre-paid mailers.

Data sharing

Farmers participating in the strip trials will receive results from soil testing, agronomic performance of cultivars and grain quality evaluations. Soil variables include soil pH, available N, P, K, base cations, soil structural assessment, biologically active soil organic matter and plant growth promoting activity. The agronomic performance data will comprise grain yield, maturity, tolerance to weed pressure, and resistance to diseases and pests. Grain quality assessment includes quantification of % protein, minerals, and starch, tocopherols, phenolics, and amino acids. Results will be expressed as raw data, but also as a percentage relative to a commonly utilized control hybrid for the Central and Northern Corn Belt. Completion of the sharing agreement will permit participants to determine how they want their information to be labeled. Data summary and sharing will be facilitated by the project coordinator.

Participant responsibilities

Maintaining good communications, providing needed information and resources, and obtaining and providing seed to the farmer is the responsibility of coordinators (Marriott and Goldstein). The project will cover the cost for sample mailing and materials needed for data collection and compensate farmers for losses according to the compensation agreement **(Appendix 4).**

Joint responsibilities include participation in planning, and possibly in planting and harvest.

Planting, weed control, and overall maintenance of plots before and after harvest is the responsibility of the farmer. Ideally, weed control will be done with harrowing and inter-row cultivation. The farmer is also responsible for signing and sending back material transfer agreements to the individual collaborators that supply the seed. Agreements are provided in **Appendix 4.**

Advisory Board and Project Participants

Goals

Advisory board guides project research and outreach activities and engages in the Educational Network. Their experience in participatory breeding and familiarity with aspects of the organic seed industry will guide us developing resources and educational content that will be of help to the organic sector. Advisory board members will contribute through meetings, on-line survey and discussion and, possibly participation in a writing retreat designed to develop content for eOrganic. Information on eOrganic will help members of the organic sector develop viable business partnerships, understand intellectual property issues, and engage in selection and testing activities on their farms. Contributions would be acknowledged through co-authorship or attribution as appropriate. Advisory board members interested in participating in a maize-based case study will contribute through focus groups and workshops investigating the structures and relationships needed for networks that support the development of successful organic feed- and food-based products.

Members

Table 3. Advisory members and contact information

Name	E-mail	Institution
Jim Myers	James.Myers@oregonstate.edu	Oregon State University
Philipp Simon	psimon@wisc.edu	USDA-ARS
Mark Sorrells	mes12@cornell.edu	Cornell University
Bill Tracey	wftracy@wisc.edu	University of Wisconsin Cliff Bar
Claire Luby	cluby@wisc.edu	University of Wisconsin
Michela Colley	micaela@seedalliance.org	Organic Seed Alliance
Julie Dawson	dawson@hort.wisc.edu	University of Wisconsin
Paul Scott	paul.scott@ars.usda.gov	USDA-ARS Ames, IA
Chris Reberg-Horton	chris_reberg-horton@ncsu.edu	North Carolina State University
Ken Dallmier	ken.dallmier@clarksongrain.com	Clarkson Grain
Merle Kramer	merle@midwestorganic.com	Midwest Organic Farmers Cooperative
Craig Adams	craig@greatrivermilling.com	Great River Milling
Sherry Tanumihardjo	sherry@nutrisci.wisc.edu	University of Wisconsin

Appendix 1 Record Keeping Guide and Forms

This section collects field-specific information we need. Links to online forms are detailed in the sections below or can be accessed in the project's eOrganic workspace (http://eorganic.info/CASH). Please use the online forms if you can because it would save us time and prevent any transcription errors.

A1a. Strip Trial Plan of Action

This is used for strip trial design and should be completed each year after you have completed your winter planning meeting. Please submit by mid-March. Please click the following link to access the form online: Strip Trail Plan of Action and Field History & Management Records or type in your computer browser: http://bit.ly/2YhC3qq.

Name and Contact Information	
Farm name:	Farmer name:
Address:	
Phone:	E-mail:
Preferred mode of contact:	

Please list cultivars to be planted including those chosen from the core set (table 1). Participants will be able to choose additional cultivars starting in 2019. Please identify additional seeds needed and any deviations from the basic plan in the comments section.

Cultivar list: describes the number, type, and identity of cultivars to be planted on your farm.

Cultivars to be planted	Anticipated date seed is needed	Comments

Plot Plan		
Number of rows per cultivar:	Row length (ft):	Row width (in):
Anticipated weed control methods:		
Anticipated harvest methods:		

Pre-Plant Tillage	
Date:	Implement:
Date:	Implement:

Pre-Plant Fertilizer/Manure Applications		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		

Planting Protocol	
Planting date:	Row spacing:
Plant density:	
Equipment:	
Cultural practices:	

Strip-Trial Area Description
Describe any known problems in this area of the field.
Weed pressure:
Water logging:
Soil fertility:
Other:

A1b. Field History and Management Information

This should be complete before field operations begin if at all possible, but only needs to be completed once for each field you use. It will provide information about the field's history of management and the typical tillage and fertilization practices you have used. Please skim the questions and decide whether it would be easier to provide us with materials you prepare for certification. The same information we are asking about should be covered in your organic system plan and field inputs documentation. This form is also linked to the previous form and available online at Strip Trail Plan of Action and Field History & Management Records or type in your computer browser: http://bit.ly/2YhC3qq. This form is also easily found through our eOrganic workspace.

Crop Rotation 2014-2018
Rotation:

2018		
Crops		
Main crop:	Planting date:	Harvest date:
Cover crop:	Planting date:	Termination date:
Cover crop termination method:		
Tillage		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Cultivation		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Fertilization		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		

2017		
Crops		
Main crop:	Planting date:	Harvest date:
Cover crop:	Planting date:	Termination date:
Cover crop termination method:		
Tillage		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Cultivation		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Fertilization		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		

2016		
Crops		
Main crop:	Planting date:	Harvest date:
Cover crop:	Planting date:	Termination date:
Cover crop termination method:		
Tillage		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Cultivation		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Fertilization		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		

2015		
Crops		
Main crop:	Planting date:	Harvest date:
Cover crop:	Planting date:	Termination date:
Cover crop termination method:		
Tillage		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Cultivation		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Fertilization		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		

2014		
Crops		
Main crop:	Planting date:	Harvest date:
Cover crop:	Planting date:	Termination date:
Cover crop termination method:		
Tillage		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Cultivation		
Date:	Implement:	
Date:	Implement:	
Date:	Implement:	
Fertilization		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		
Date:	Type:	
Rate:	% dry matter:	N-P-K:
Application method:		

A1c. Strip Trial Management Record Sheet

This form records field inputs and operations used during the strip trial. The form is also available online at Management Record Sheet or type the following URL in your computer browser: http://bit.ly/2nRuOVF. This form is also easily found through our eOrganic workspace.

Having the form available online should make this record keeping easy for you and you can do in the field with the help of a smartphone. Please submit paper records or online form by the end of December.

Farm and field name:_____

Please record all field operations and any field observations that might influence your trial. Alternatively, the Organic Systems Plan can be provided.

Field Operation	Equipment or material used	Date	Comments

Appendix 2. Cover Crop Sampling Instructions

General guidelines:

Collect measurements and samples **just before cover crop is terminated**. Carry out measurements and sampling **at 4 representative sites** within the strip trial area. Label sampling sites with an S followed by consecutive numbers (S1, S2, S3, S4). Only measure typical areas; avoid areas of poor germination, unusually weedy patches, etc. unless these represent the area.

Equipment checklist if farmers are sampling and mailing:

Paper bags for collecting and mailing cover crop samples	We will supply
A mailing box and return label	We will supply
Instructions and data sheets	We will supply
Yardstick, ruler, or measuring tape to measure height and size sampling quadrat	You supply
Digital camera	You supply
Sharp knife or clippers	You supply
Stakes and string for laying out a sampling quadrat that is 9" by 9" minimum	We can provide if you let us know
Android or iOS device (iPhone) to determine location	*You supply*

Please complete the evaluations in order at each sampling site so that results can be compared.

Step 1: Record sampling site locations.

For each sampling site, record latitude and longitude using the Gaia GPS app downloaded on your cell phone. Make sure that in settings under units, datum selected is WGS84, which is what Google Earth uses. Select trip and write down the longitude and latitude shown at the top center of the screen associated with each sampling location in case photographs get lost or separated from the physical samples.

Hit 'trips' then take a level, downward-facing photo ***at least 2 feet above*** the top of the canopy and select "use photo." Do this for each site and then go to the saved folder and share photos with emarriot@illinois.edu. (See PHOTO in step 2 for additional information.)

Step 2: Record cover crop measurements.

Collect cover crop height, composition, growth stage measurements, and photo for % groundcover analysis. These measurements will be used to estimate biomass. The data sheet can be accessed online here: Cover Crop Sampling Data Form or type the following URL in your computer browser: http://bit.ly/2HgQhkA.

A. WEED TYPE AND ABUNDANCE: Record the most common weed species in the field. Note if weeds are few (cover <5% of the field), common (cover 5-30% of the field), or many (cover >30% of the field).

B. HEIGHT: Measure and record standing average cover crop height (metric preferred to the nearest centimeter) using tape measure, ruler, or similar. Place the end on the ground and hold measuring stick vertical to the ground. Estimate the average height of the top of the canopy. If the crop is a mix of species of different heights, estimate the height of the tallest species. If the crop has lodged, raise and hold plants along the vertical edge of the yardstick or ruler and measure height.

C. COMPOSITION: Determine proportion of grasses, legumes, and broadleaf weeds (not legumes). Grab handful of plants and cut off at base of plants (10-20 stems) and report number of stems in each category. Discard the stems after you have recorded the number in each category.

D. GROWTH STAGE: Assess growth stage and record the letter for the most representative stage for each type of cover crop present.

Grasses:
V = vegetative, just leaves, no stem elongation
B = boot stage, developing head is detectable in flag leaf sheath, but has not fully emerged
F = flowering/antithesis, head has emerged and flowers are in bloom (no percentage of head needs to be in bloom to qualify for flowering)

Legumes:
V = vegetative, just leaves, no flowers, pods, or seeds
B = bud, flower buds detectable
F = flowering, flowers are in bloom

E. PHOTO: Take a downward facing photo of the cover crop, keeping phone or camera parallel to the ground and ***at least 2 feet above the top of the canopy***. Keep other items – sampling frame, tools, feet, etc., out of the photo. Check to make sure that the photo is not over-exposed and that colors are accurate. We will use the photo to assess % ground cover and greenness. Email the photo to emarriot@illinois.edu and include your name, field name, and sampling site number (e.g. S1, S2, etc.). On the data sheet record the dominant type of cover crop in the photo.

Step 3: Clip biomass samples.

For background on sampling methods please consult: "Estimating Plant-Available Nitrogen Release from Cover Crops" by D.M. Sullivan and N.D. Andrews, provided.

A. Prepare a rigid sampling frame using ½" PVC pipe and 4 elbow joints or stakes and string to encompass an area containing enough above ground biomass to fill a 2-gallon plastic bag or 2/3 of a standard paper grocery bag. The size of the area will range from about 1 square foot (¼ square meter) to 3 square feet (1 square meter). Record the dimensions of the frame on the data sheet.

B. Select a representative area of the cover crop (Fig. A). Place flags in a square shape using the dimension determined in A. The flags will be at the 4 corners. Wrap the string around the outside of the flags to create a square. Or work a rigid frame through the canopy to the ground (Fig. B). It may be easier to leave one side off the frame while working the frame through the canopy and then reattach the fourth side. For a very tall or entangled crops, push plants over in one direction and place frame or the flags and string on top of the "rolled" cover (Fig. F).

C. Using a knife or clippers, cut or clip all plants within the frame just above ground level, making sure to only include ***living*** plants that originate within the frame (Fig. C and D). For tall, entangled covers that have been pushed over, use a knife to cut through and collect all the biomass under and within the frame (Fig. F). Remove any soil from the sample. Do not collect dead residue from previous crops.

D. Label bag with your name, field name, and sampling site number. Close and seal bag. To keep samples in good shape, please store in a shady, cool, dry place while you collect additional samples and mail as soon as possible.

Figures A-D from Cover Crop Sampling Instructions by N. Andrews, D. Sullivan, J. Julian and K. Pool. Figures E and F from Estimating Plant-Available Nitrogen Release from Cover Crops by D.M. Sullivan and N.D. Andrews. Photos by K. Pool.

Step 4: Deliver samples:

Immediately after you take cover crop samples verify that they are properly labelled with your name, the name of the field (if you are sampling more than one field), and the sampling site number. E-mail sampling site photos to emarriot@illinois.edu. Contact the coordinator to have them pick samples up or place all the samples and the data sheet into the box we have provided, affix the label and contact UPS to have these picked up for next day delivery.

COVER CROP SAMPLNG DATA SHEET

Farm name: Field name:

What are the dominant weed species in the field?:

Which best describes weed abundance in the field? Weeds are **few** (covering <5% of field), **common** (covering 5-30% of field), or **many** (covering >30% of field)?:

Size of sampling frame or quadrat used for biomass clipping (cm x cm):

In-field Assessment

Site	Sampling site location (latitude and longitude)	Height (centimeter)	# Stems			Growth Stage	
			Grass	**Legume**	**Weed**	**Grass**	**Legume**
ex.	*42.549520, -72.855174*	*27*	*7*	*4*	*2*	*V*	*F*
S1							
S2							
S3							
S4							
S5							
S6							
S7							
S8							

Appendix 3 - Field Data Collection Guide

A3a. Marking the Location of Your Trial and Laying Out the Plot

Materials needed

- Plot map
- Measuring tape or measuring wheel
- 20-30 flags

Please adapt our basic design (Figure 1) to identify how you will lay out the study on your farm and in a field going into the corn phase of the rotation. Identify the corner where you will start planting strip #1 and where you plan to stop planting and record the basic planting direction you will use (EW or NS). For example, you could say Strip 1 will be planted in the corner of field X (the name you use) at longitude _____ latitude _____.

	Strip 1 (Add # of rows)	Strip 2 (Add # of rows)	Strip 3 (Add # of rows)	…
Subplot 1	1 1	2 1	3 1	
Subplot 2	1 2	2 2	3 2	

Longitude and latitudes can be determined using Google maps or Apple's Compass app on a smart phone.

> **Android device:** In Google maps, touch and **hold** your current location (zoom in to increase accuracy), this will drop a pin. The coordinates should appear in the search box at the top.
>
> **Apple device:** Location services must be turned on in privacy settings. Open the Compass app to get coordinates of your current location. Alternatively, in Google maps, touch and **hold** the blue dot that represents your current location (zoom in to increase accuracy). This will drop a pin at your location. At the bottom of the screen, tap "Dropped Pin" to see the coordinates.

While we would prefer the coordinates of the sampling sites, it is also okay to send us the coordinates of two field corners collected using a fixed location and estimated distance to the spot. You could estimate the number of paces you use, distance covered in 10 paces, and record this. After selecting your sampling site, pace off the distance to a known location, for example a corner of the field. Count how many paces you walk in each direction (e.g. to the west and to the south to get to the SW corner of the field) to get to your sampling location. Record these numbers for the corner where you will start and stop planting. When we visit the field we can get the exact location.

To lay out the plot and if you are working alone, put a flag into the end of a measuring tape that is at least 100 feet long if you are using our standard design. You will need one measuring tape that is as long as the plot length you plan. Pull out the tape perpendicular to the direction you will plant and fasten the end by wrapping it around another flag. Mark out every 10 feet (or adjust to match your planter and the row width) with a flag to identify the different strips. To help you take soil samples place flags to indicate the midpoint along the 100 feet strip (50 feet segments) as explained in Figure 1.

A3b. Taking Soil Samples

This is ideally done right after you flag the plots.

Materials needed

- Plot map, paper bags, and labels provided
- Soil sampling tube (0.75-2" diameter), 12 inches deep.
- Bucket to combine soil cores to make a composite sample
- Flags

Before you start, take a core or two to make sure it is not too wet to sample. If soils are too wet it will be difficult to get them out of the sampling tube. If soils are in good shape then date the sampling bags and organize them so that you are sure that the numbers on the bags match the plots and subplots you are sampling (Figure 1).

Total number of samples per strip n = 2 composite samples per strip × number of strips.
Total number of cores taken c = 4 cores per strip × number of strips (e.g., 40 cores for 10 strips).

Within each half of the strip ("subplots") collect two 12-inch cores using a soil tube that is at least 0.75" in diameter. Please distribute sample locations within subplot to represent fairly soil variability. Place the two cores per subplot into a bucket and mix and crush cores to form a composite sample. Transfer the composite sample to the appropriately labeled bag. Once you are done you should have 2 bags representing each strip.

Place sample bags in an area that protects them from rain and direct sun for drying. After they have dried (usually within 7 days), mail them to Carmen Ugarte using the return labels provided. Make sure to include basic field information and any notes or corrections in the return envelope.

A3c. Phenotyping

Priority traits (see Table 2) will be evaluated using the following procedures.

Materials needed

- Plot map
- Record sheets
- Measuring stick in some cases

Farm and field name:_____

Please use the following table to record data collected during your evaluations. This form is also available online and can be accessed by clicking Phenotyping or typing the following URL in your computer browser http://bit.ly/2nOUu56 . Please send these records by December of each year. This form is also easily found through our eOrganic workspace.

Trait	Date recorded	Strip 1	Strip 2	Strip 3	Strip 4	Strip 5	Strip 6	Strip 7	Strip 8	Strip 9	Strip 10
Date to plant emergence											
Date to male flowering (Anthesis)											
Date to female flowering (Silking)											
Plant height (cm)											
Ear height (cm)											
Root lodging											
Stalk lodging											
Weed pressure rating (can send photos)											
Disease rating											
Stand count in 1/1000th of acre											
Any noteworthy observation prior to harvesting											
Yield (Strip weight)											
Grain moisture (%)											
Test weight											

Date to Emergence

Description/Procedure:

Date to corn emergence is recorded as [MM/DD/YY]
Time: Two visits within 7 to 10 days after planting.
N: 2 dates per strip
Unit: [MM/DD/YY]

Note: Record a visual estimate of the percent emergence during each of your visits.

Anthesis (DMF)

Description/Procedure:

Taken as [MM/DD/YY] to 50 percent of a plot exhibiting anther exertion on greater than half of main tassel spike. Day of anthesis recording is shown in *Picture 1,* whereas the day after is shown *Picture 2*.

Timing: At Flowering

n = 1 date per plot

Unit: [MM/DD/YY]

Picture 1

Picture 2

Image Credit:
- 2004, 2006; Purdue University, RL Nielsen
- http://www.mississippi-crops.com/2013/06/26/identifying-corn-reproductive-growth-stages-and-management-implications/

Silking (DFF)

Description/Procedure:

Taken as [MM/DD/YY] to 50 percent of plot exhibiting silk emergence (*Picture 1*). Following day is shown in *Picture 2*.

Timing: At Flowering

n = 1 date per plot

Unit: [MM/DD/YY]

Picture 1

Picture 2

Plant Height (PHT)

Description/Procedure:

Placing measuring stick on ground next to the root crown, "plant height" is measured at the ligule of the flag leaf.

See *Picture 1*

Timing: At plant maturity

n = 1 representative plant per plot

Unit: centimeter [cm]

Notes: One plant is considered suffient since these are inbreds and hybids and are not segregating for traits. Please record date measured.

Picture 1

Ear Height (EHT)

13

Description/Procedure:

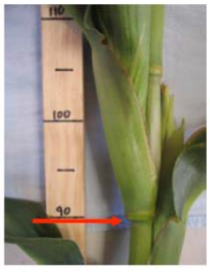
Placing measuring stick on ground next to the root crown, "ear height" is measured at the primary ear bearing node. See *Picture 1*.

Timing: At plant maturity

n = 1 representative plant per plot

Unit: centimeter [cm]

Notes: One plant is considered suffient since these are inbreds and hybids and are not segregating for traits.



Picture 1

Stalk Lodging (SLD)
Green Snap (GSP) (optional)

Stalk Lodging Description/Procedure:

Number of plants broken between the ground level and the top ear node (picture 1).

Timing: Before Harvest

n = 1 count per plot

Unit: number of plants with SLD

Notes: Emphasis is on the number of plants, not the %, which does not tell us much. Accurate stand counts and lodging counts are essential and will be used to calculate a % lodging in later analyses.

Picture 1

Green Snap (optional) Description/Procedure:

Number of plants broken between the ground level and the top ear node **before flowering** (picture 2).

Timing: Before flowering

n = 1 count per plot

Unit: number of plants with GSP and date of triggering event [MM/DD/YY]

Notes: Collaborators may choose to take counts of green snap following a weather event occurring before flowering that causes substantial numbers of stalks to snap. Please also record date of event.

Emphasis is on the number of plants, not the %, which does not tell us much. Accurate stand counts and lodging counts are essential and will be used to calculate a % lodging in later analyses.

Picture 2

Photo 1 credit: Gordon Johnson, UDel Extension
Photo 2 credit: UGA Cooperative Extension

Root Lodging (RLD)

Description/Procedure:

Number of plants that show root lodging per plot, i.e., those stems that lean substantially to one side (≥ 15% from vertical) (picture 2). Count includes "goosenecked" plants that have "straightened up" after becoming lodged earlier in the season (Picture 1).

Timing: Before Harvest

n = 1 count per plot

Unit: number of plants with RLD

Notes: Emphasis is on the number of plants, not the %, which does not tell us much. Accurate stand counts and lodging counts are essential and will be used to calculate a % lodging in later analyses.

Picture 1

Picture 2

Weed Pressure Rating

A visual estimate of percent ground cover by weeds is used to assess weed pressure.

Description/procedure:

Estimate percent ground cover in 17.5 ft of one of the two center rows. Photos indicating weed pressure can be sent to Claire Luby (651-343-5180) to help determine the percent of ground cover.

Time: After flowering
n: 1 count per plot
Unit: Percent cover
Note: Please also record the commonly seen weed species in each plot.

Disease Rating

A number of fungal and bacterial diseases are common to corn. We hope to monitor these as they impact crop fitness and yield.

Description/procedure:

Scout plots for signs of lesions on leaves, wilting or discoloration. If these signs are evident, count number of plants with signs of disease in a known row length and send a photo to Claire Luby (651-343-5180) for diagnosis.

Time: After flowering

Stand Count

Description/procedure:

Count the number of plants in the two center rows of each cultivar and in row sections equal to 1/1000th of an acre. If the row width is 30 inches, this section would be 17.5 ft.

Time: Before harvest
n: 2 counts per plot
Unit: Number of plants in 1/1000th of an acre.

Appendix 4 - Sharing Agreements

Educational Network participants will be asked to sign and return the following forms in person or by mail to Carmen Ugarte (N-215 Turner Hall, 1102 S. Goodwin Ave., MC-047, Urbana, IL 61801)

A4a. Educational Network Participants

This agreement indicates that participant contributions to meetings can be used to develop project and associated educational materials. By signing this, I acknowledge that recordings and images of meetings and exchanges may be taken and that my participation in these interactions can be used either in anonymous form without consent or in a form that identifies my unique comments or image after receiving consent.

PARTICIPANT:

_____

Date:

_____

A4b.Testing Network Members Agreement

This Agreement is a prerequisite to participate in the Strip Trials.

Participants agree to plant and test seed supplied by the network. Participants will not breed, self, or manipulate seed being tested by the network. Seed cannot be crossed nor can any breeding work be conducted on the seed. Seed not planted should be mailed back to the seed supplier or destroyed. Seed cannot be distributed to a third party.

Farmer members shall use data produced by the network to inform decisions made for their breeding program, seed expansions, or seed sales. Participants shall not re-publish or provide to a third party the official network data, unless the data is marked for public sharing. No network data revealing coded or uncoded pedigree information shall be provided or shared with any non-members of this network or the public, unless the data is specified for public sharing. Participating members shall consult with the project Coordinator before publishing related data.
Participants agree to share data freely with the network in raw and summarized form.

FARMER	**UNIVERSITY OF ILLINOIS**
_____	_____
By:	By:
DATE:	
_____	_____

A4c. Income Loss Compensation

Collaborators participating in strip trials will receive compensation of $250.00 to compensate for any yield loss and access to detailed management records. To receive this compensation collaborators will need to complete the vendor information form https://www.obfs.uillinois.edu/payments-vendors-students/vendor-setup-update/ and register as a "Research Participant" to be paid. A paper version of this form will be mailed with this manual.