Cover crops and Nitrogen
A Fun, Interactive Game Quiz to See What You Know

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Cover crops are critical to develop sustainable soil fertility management strategies in organic vegetable and strawberry production. Why? Well… because cover crops can affect everything from fertilizer inputs, to soil health, weeding costs, soil diseases, insects (good and bad), and how much a farm is polluting the environment (i.e. ground water, rivers, ocean, the changing climate we are leaving our kids). But, integrating cover crops into high-value, high-input systems for vegetable and strawberry production can be challenging. Understanding how cover crops work is a first step to figuring out how to use them effectively on a farm.

To try to keep us all engaged, interested, and awake (☺) I'll use a fun and interactive quizzing game called Kahoot to see how much you and others in the course know about cover crops and nitrogen. Kahoot is a game-based learning App that we'll access from our mobile phones. As we play the game through our mobile phones we'll learn how much we know about cover crops (don't worry you can be anonymous if you want) and areas where there's confusion or a need for discussion.

Below is a list of online resources I produced that you might find useful to learn more about cover crops and ways to integrate them into your farm or the farms that you work with. The information from some of these resources was used in the Kahoot game that was designed for the course. Because cover crops are a component of climate-smart farming, I also included some helpful links on climate change. Enjoy, Eric

Videos on cover crops and organic soil fertility management

-Brennan, E.B., S.B. Mirsky, and M. Cavigelli, 2014, Cover cropping is like juggling
www.youtube.com/watch?v=Z8yVDphBm78
-Brennan, E.B., 2014, Are legume-cereal mixtures a good fit for organic vegetable production?
www.youtube.com/watch?v=WREmHa-jFbc
-Brennan, E.B., 2016, Sustainability problems with 'repackaged' synthetic nitrogen in organic agriculture,
www.youtube.com/watch?v=3GjbnchPhl8
-Brennan, E.B., 2017, Cover cropping on vegetable beds: Novel equipment and ideas
www.youtube.com/watch?v=Qm56xkBu8-s
-Brennan, E.B., 2017, Furrow cover crops for 'Greener' strawberries and other plastic mulched crops
www.youtube.com/watch?v=fesxbH03diY
-Brennan, E.B., 2017, To Till or Not to Till.... That is the Question. www.youtube.com/watch?v=zgWNY3k7Ucw
-Brennan, E.B., 2018, Juicing cover crops.... Are you Nuts? Maybe but hear me out!
www.youtube.com/watch?v=H1GfRurgqKI
-Brennan, E.B., 2018, Lessons from long-term cover crop research in the "Salad Bowl of the World"
www.youtube.com/watch?v=JurC4pJ7Lb4

-Link to all my videos

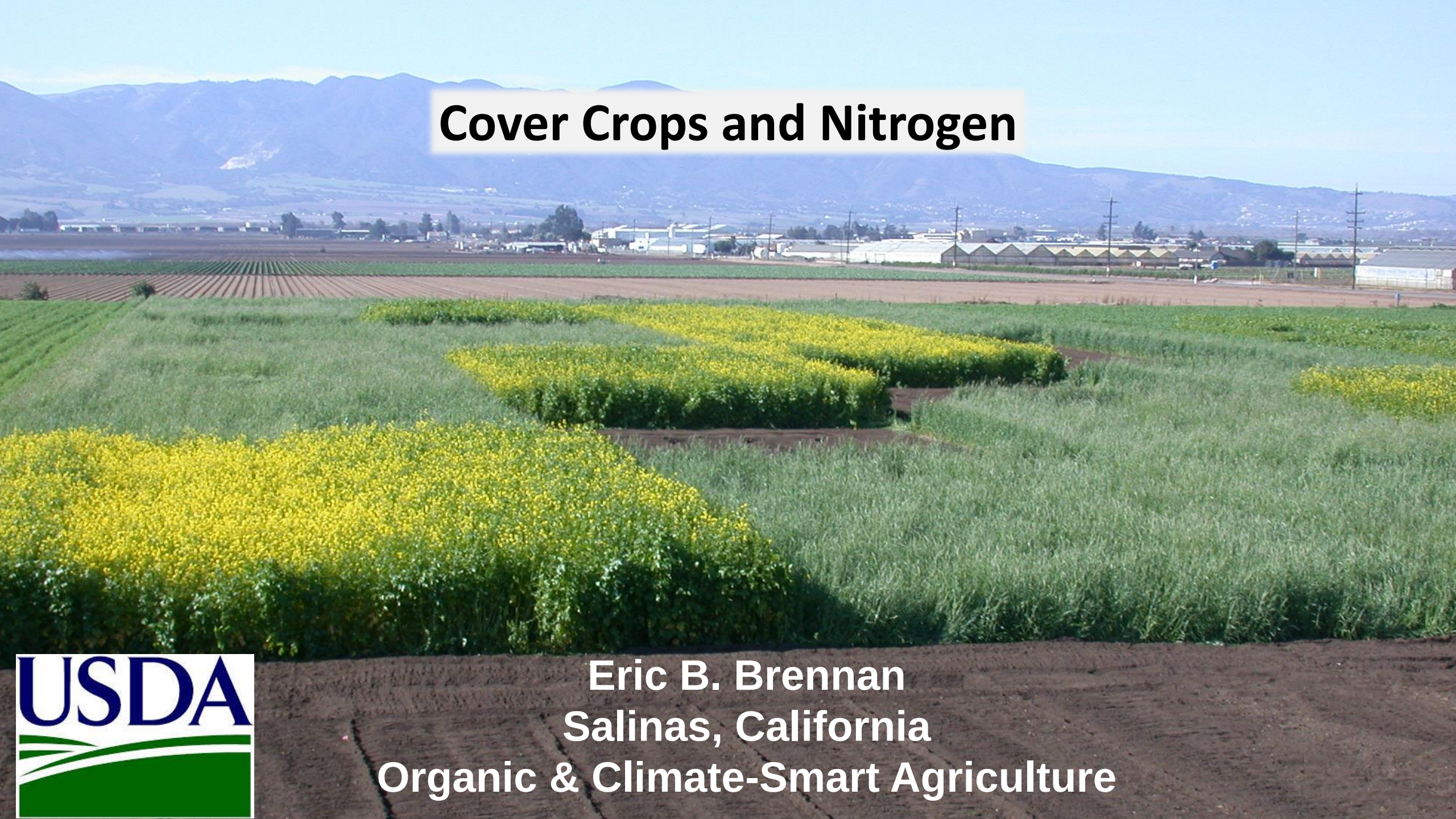
Publications

Brennan, E.B. 2017. Can we grow organic or conventional vegetables sustainably without cover crops? HortTechnology 27:151-161.
-Link to free PDF copies of all my cover crop research publications

Climate change

-How do we know this climate change thing is even real? https://www.youtube.com/watch?v=m50bYJX2i6I
-Just how long have we known about climate change anyways? https://www.youtube.com/watch?v=XpqBto89i38
-What's warming the world (Interactive graphic).

Cover Crops and Nitrogen



Eric B. Brennan
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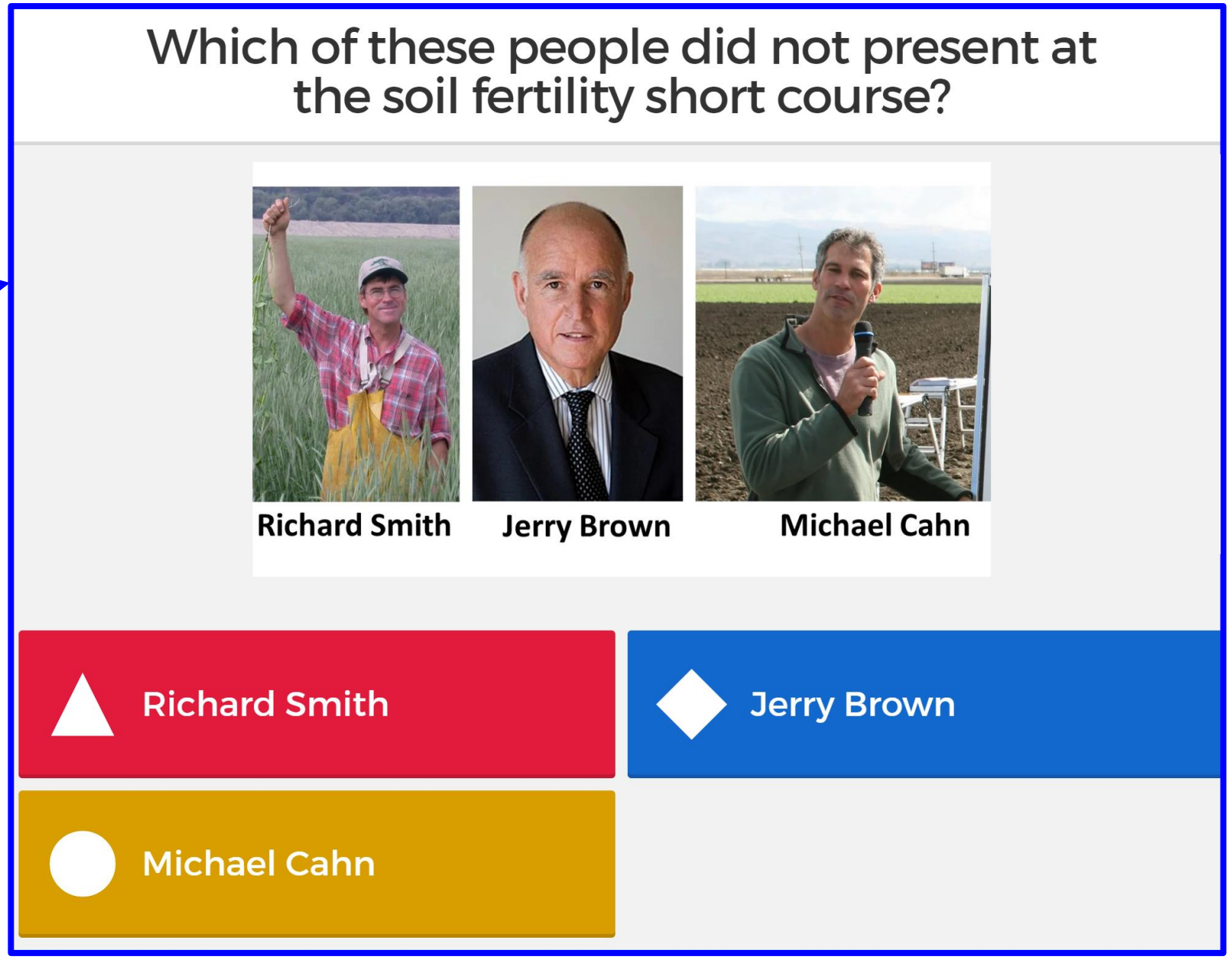
This presentation used a fun & interactive game-based learning platform called Kahoot . This was the last presentation during the Organic Soil Fertility Short Course.

The cover crop game included 13 questions.

The first 3 questions (about the speakers, public health & planetary health) were intended to get the players engaged and familiar with the game. The next 10 questions are focused on cover crops. Players had 20 to 30 seconds to choose an answer using their cell phone & then we talked about the answers using additional relevant information shown next to each question.

The following slides show screen shots (in blue boxes) of the questions & relevant links to learn more. The correct answers (based on the latest science) are in the second to last slide. To check your knowledge, try playing the game, & after that use the relevant links to learn more. If you have follow up questions or comments email eric.brennan@usda.gov The last slide has a link to Eric's cover crops videos and publications. Enjoy ☺.

1.



20 seconds

This is how much time the players had to choose.

This blue box is all that the game players saw before they chose an answer

Click on the photograph of each person to learn more about them and their work.

2.

20 seconds

Click here to learn about vaccine safety, and click here to learn about anti-science information on vaccines and other important topics.

3.

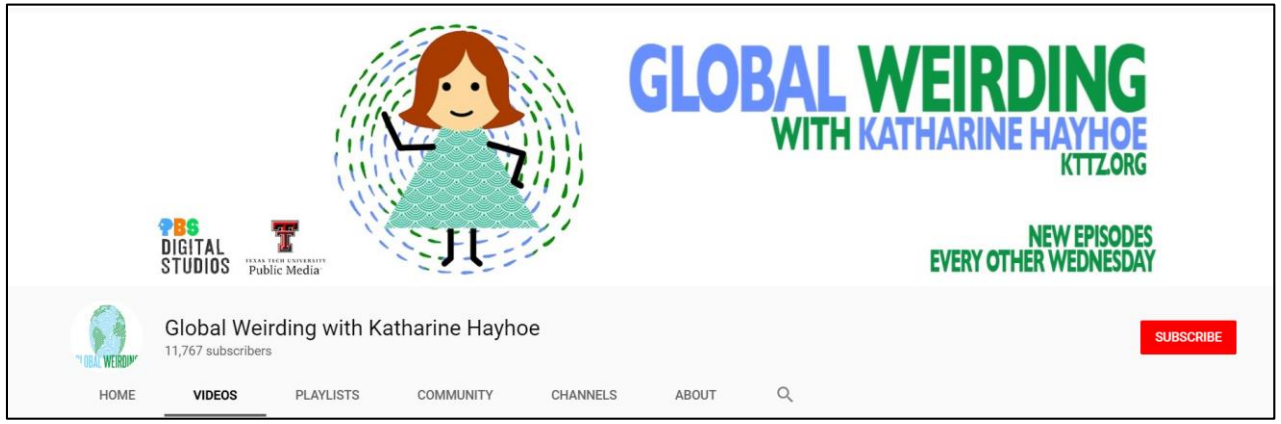
20 seconds

Is there lots of scientific evidence that humans are causing climate change?

Maybe

Yes

No



Click here to watch a short video on the causes of climate change, or the box above for several related videos.

4.

30 seconds

Here are links to 2 papers on nitrate leaching with various cover crops and best management practices to reduce leaching in vegetables.

5.

20 seconds

Legume cover crops can capture nitrogen from the air due to a symbiotic relationship with what:

- ▲ Mycorrhizal fungi & Rhizobium bacteria
- ◆ Rhizobium bacteria
- ● Collembola
- ■ Mycorrhizal fungi

Here's a link to good overview of this symbiosis.

6.

20 seconds

What is the internal color of a legume root nodule that is fixing nitrogen?

- Red or pink
- Green
- White
- Grey

Here's a link showing legume color.

7.

30 seconds

Legume cover crops get their nitrogen from:

- Biological nitrogen fixation
- Leftover nitrogen in the soil
- It depends on the amount of nitrogen in the soil

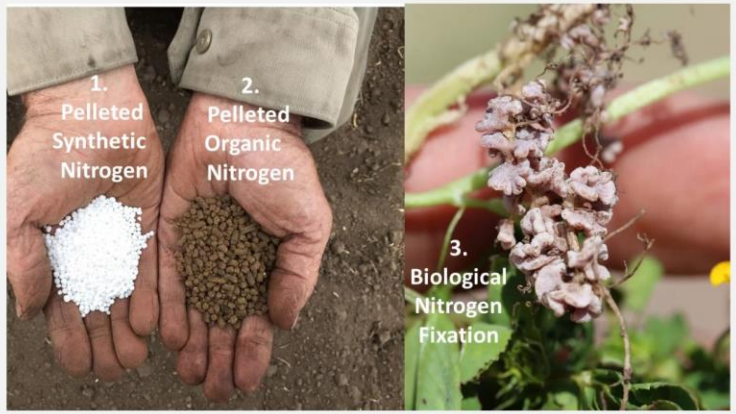
-Click this link to see this paper (*Pampana et al. 2018. Nitrogen fixation of grain legumes differs in response to nitrogen fertilisation. Exp. Agric. 54:66-82*). Figure 4 in the paper shows the relationship between nitrogen fixation and soil nitrogen. Soil nitrogen was varied by applying different levels of fertilizer.

-Click here for paper (Brennan and Boyd. 2012. Winter cover crop seeding rate and variety affects during eight years of organic vegetables: II. Cover crop nitrogen accumulation. Agron. J. 104:799-806) where we estimated N fixation in a legume-rye mixture (see page 803).

8.

30 seconds

Where does most of the nitrogen in Salinas Valley organic systems come from?

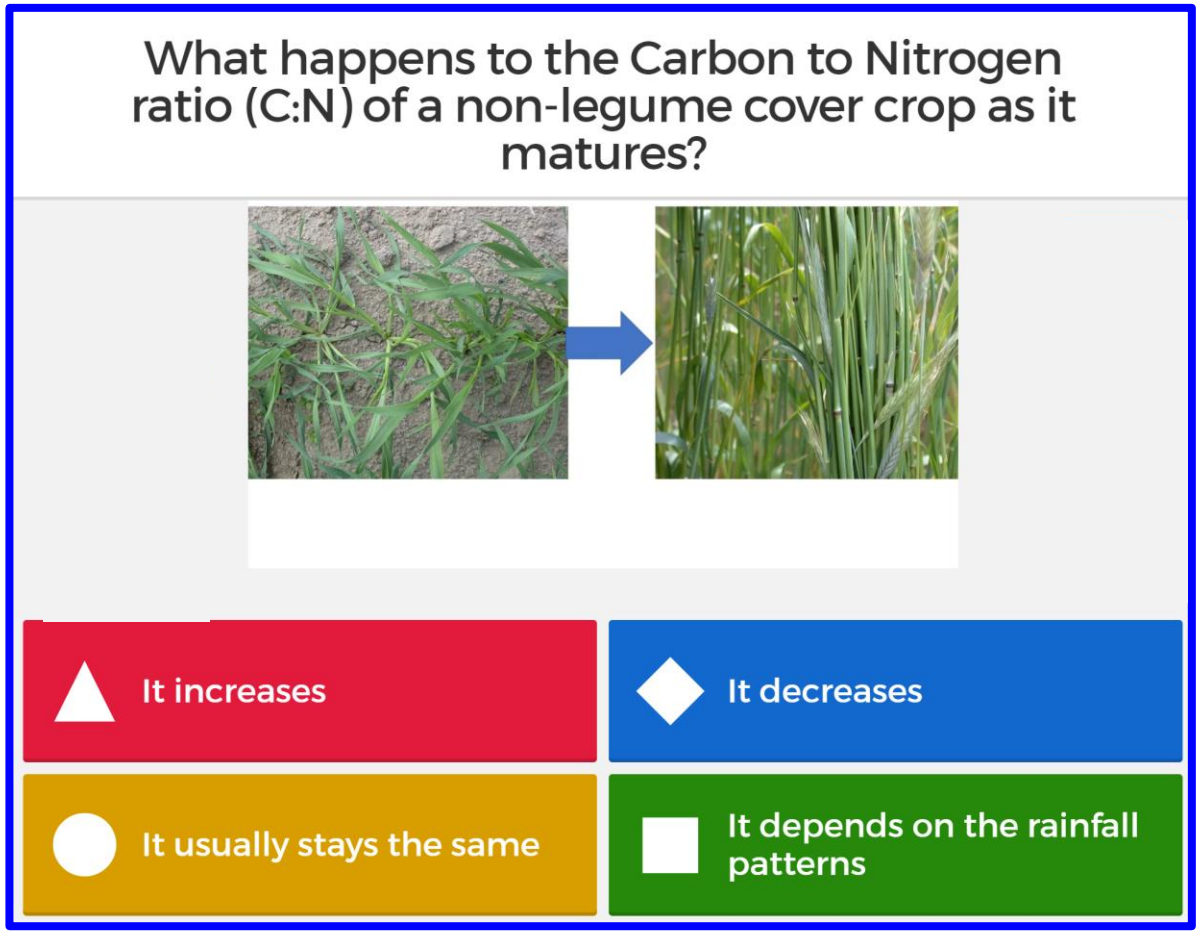


- Synthetic nitrogen fertilizers
- Pelleted organic nitrogen fertilizers
- Biological nitrogen fixation
- 1 and 2

Click here to watch this Eric Brennan's 5 minute video (*Sustainability problems with 'repackaged' synthetic nitrogen in organic agriculture*.). It describes the source of most of the nitrogen in these systems.

9.

30 seconds



-Click here to see this paper (*Brennan et al. 2013. Winter cover crop seeding rate and variety affects during eight years of organic vegetables: III. Cover crop residue quality and nitrogen mineralization. Agron. J. 105:171-182*). Figure 10 in the paper shows the relationship between the C:N ratio and nitrogen concentration for several cover crops from December, when they were in the early vegetative stage, to maturity in February and March.

10.

30 seconds

The primary benefit of adding compost to the soil is to improve:

- Disease suppression
- Soil health
- Drainage and tilth

Click here to see this paper (*Brennan and Acosta-Martinez. 2017. Cover cropping frequency is the main driver of soil microbial changes during six years of organic vegetable production. Soil Biol. Biochem. 109:188-204.*). In figure 2 of this paper was use microbial biomass carbon (MBC) as one indicator of soil health. In figure 2B we can compare the effect of compost on MBC by comparing system 1 and 2, and the effect of cover crop frequency by comparing systems 2 and 3.

11.

30 seconds

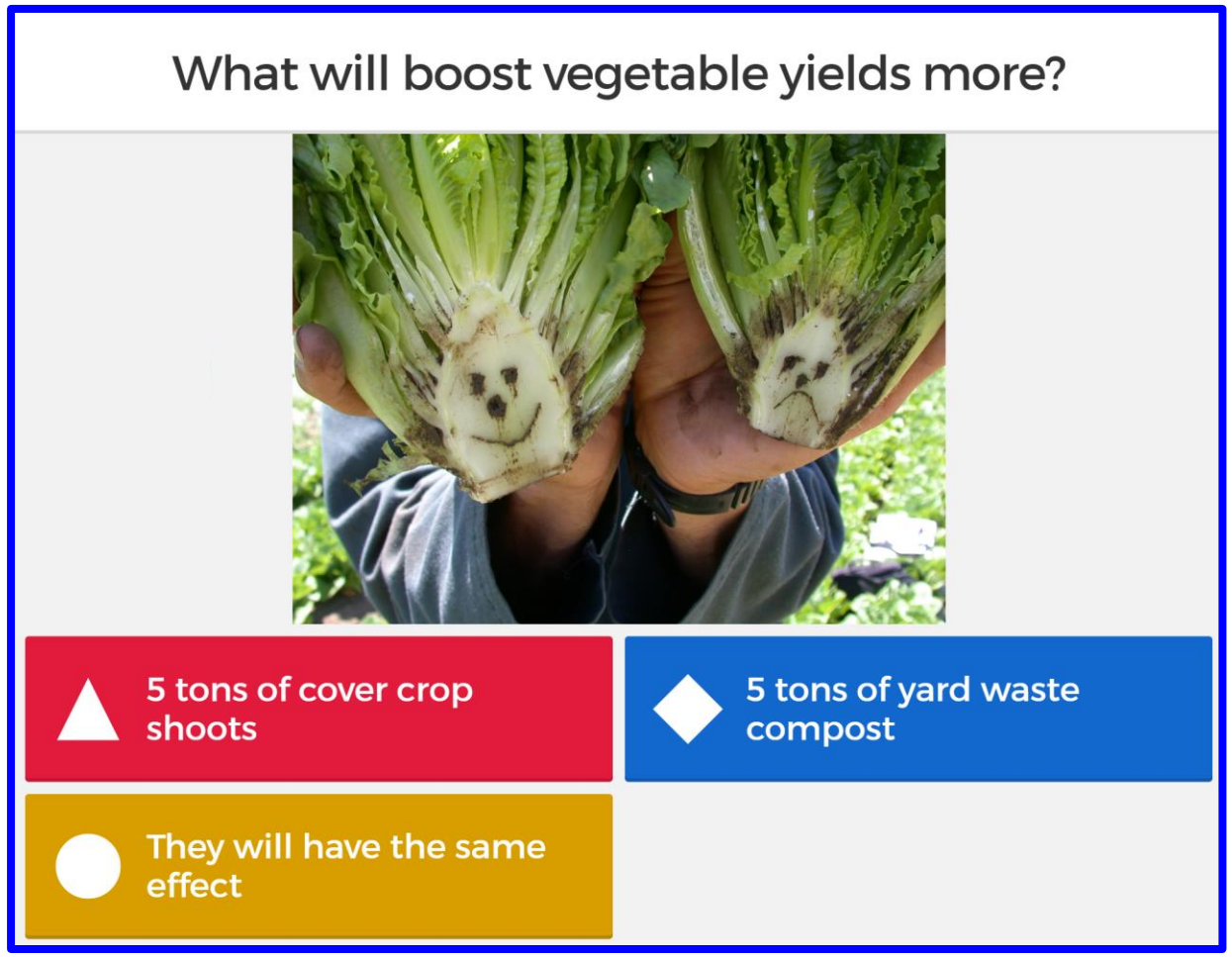
Most of the carbon added to the soil from cover crops is from:

- Roots
- Shoots
- Equal amount from roots and shoots
- Root exudates

Click here to see this paper (*Bolinder et al. 1997. Estimating shoot to root ratios and annual carbon inputs in soils for cereal crops. Agric. Ecosyst. Environ. 63:61-66*).
In table 3 of thie paper provides some interesting information on how much of the carbon in various cereal crops is in above ground tissues (straw and grain), in root biomass and root exudates.
-Click here for another paper (Dittmer H.J. 1937. *A quantitative study of the roots and root hairs of a winter rye plant (Secale cereale). Am. J. Bot. 24:417-420*) that details the incredible number of miles of roots in a rye plant.

12.

30 seconds



Click here to watch this Eric Brennan's 11 minute video (Lessons from long-term cover crop research in the "Salad Bowl of the World"). It provides information on the effects of cover crop and compost on vegetable yields, and other things.

13.

30 seconds

Per $ of seed cost, what's the most cost effective cover crop to add organic matter to soil?

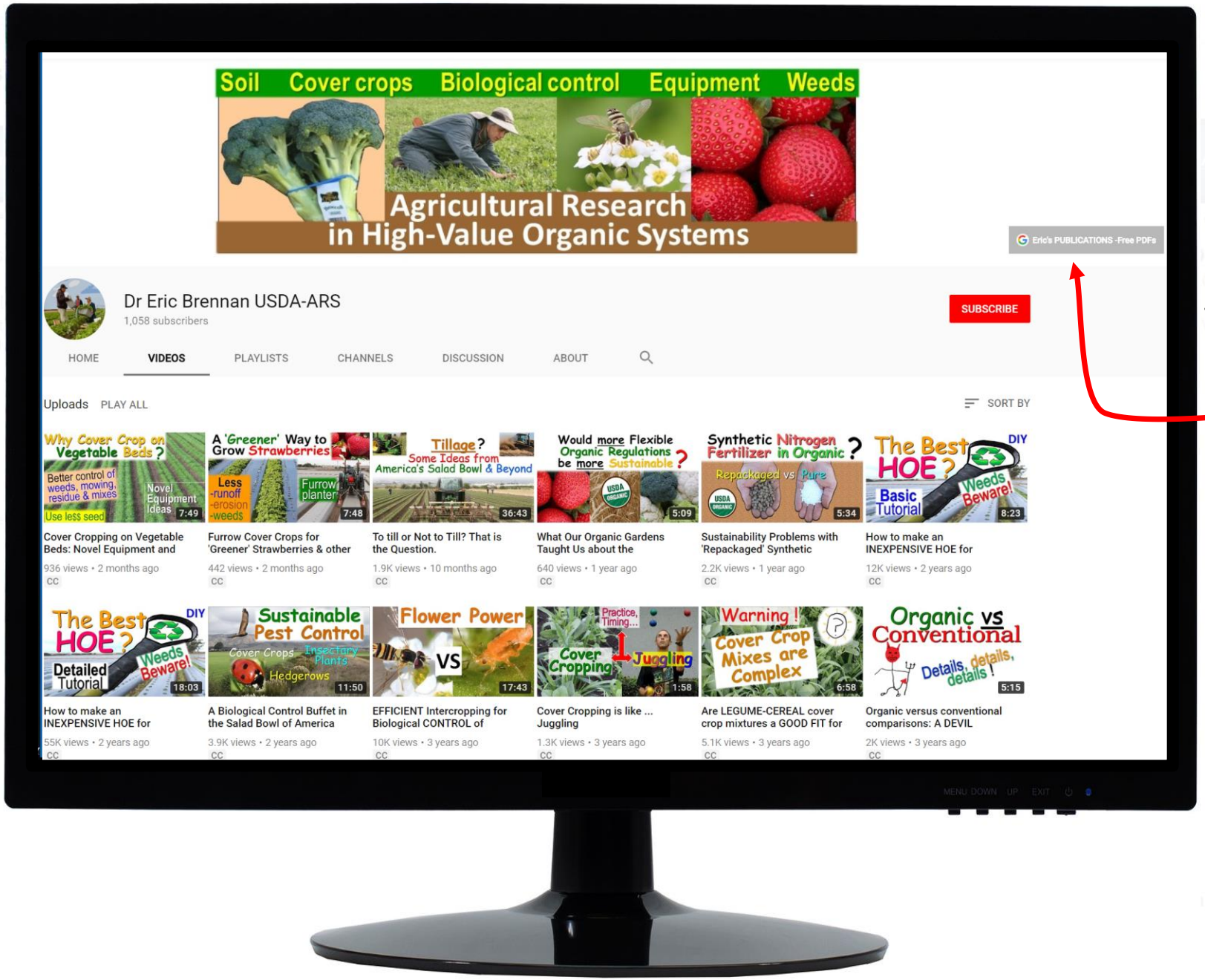
- A mixture of legumes and a cereal
- Pure legumes
- Cereal rye
- Mustard

Click here to see this paper (Brennan and Boyd, 2012. Winter cover crop seeding rate and variety affects during eight years of organic vegetables: I. Cover crop biomass production. Agron. J. 104:684-698). Table 1 in the paper shows the seed cost for the various cover crops, & the last paragraph of the *Practical Implications* section of the paper discusses the cost of organic matter added by the cover crops per unit of seed cost.

Correct answers based on the latest scientific evidence

Question (Click a question below to go back to that slide and resources)	**Correct**	**Some Miscellaneous Comments and caveats**
1. Which of these people did not present at the soil fertility short course?	Jerry Brown	
2. Are vaccines safe?	Yes	
3. Is there lots of scientific evidence that humans are causing climate change?	Yes	
4. What's the best way to reduce nitrate leaching into the ground water during winter?	Grow a cereal cover crop during the winter	
5. Legume cover crops can capture nitrogen from the air due to a symbiotic relationship with what:	Rhizobium bacteria	
6. What is the internal color of a legume root nodule that is fixing nitrogen?	Red or pink	
7. Legume cover crops get their nitrogen from:	It depends on the amount of nitrogen in the soil	
8. Where does most of the nitrogen in Salinas Valley organic systems come from?	Synthetic nitrogen fertilizers	This question is a bit tricky because it refers the original source of nitrogen (i.e. , whether it was synthetically or biologically fixed).
9. What happens to the Carbon to Nitrogen ratio (C:N) of a non-legume cover crop as it matures?	It increases	
10. The primary benefit of adding compost to the soil is to improve:	Drainage and tilth	This question is a bit tricky and perhaps misleading because soil health includes many different attributes (physical, chemical and biological). In the study cited, we were focused on biological aspects. But we have other data on soil physical characteristics that will be published in the future. It would would be good to clarify that the compost was from yard waste and thus is likely to decompose relatively slowly compared to fresh material from a cover crop.
11. Most of the carbon added to the soil from cover crops is from:	Shoots	
12. What will boost vegetable yields more?	5 tons of cover crop shoots	We believe that cover crops are providing more yield benefit than compost because as the video shows, yields increased in the two low yielding systems whenevery cover crops were added. However, separating the effects of cover crop from compost is complex because the study lacks systems with frequent cover cropping without compost.
13. Per $ of seed cost, what is the most cost effective cover crop to add organic matter to the soil?	Cereal rye	This question refers to typical Salinas soils with lots of leftover nutrients in the fall.

www.youtube.com/user/EricBrennanOrganic



Eric's publications are available for free here