Organic Transition in Dual-Purpose Wheat Systems

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Introduction

Organic agriculture offers producers the potential to access alternative markets and price premiums for their products, while using beneficial conservation management practices. But adding organic to a production portfolio requires adherence to strict standards, operational accommodations for alternative markets, and a certification process for the land, which requires a three-year transition period. For many producers, any of these factors can be a roadblock. Recognizing the opportunities and challenges in organic agriculture, our team conducted research and outreach activities for interested producers. Field research was conducted near Vernon, TX from 2018 to 2021 to evaluate the three-year organic transition period in dual-purpose wheat systems. This publication provides background information on organic agriculture, a description of our research project, project outcomes, our experiences managing the organic system, as well as links to additional resources.

Organic Standards & Certification

The standards for organic agriculture in the U.S. are established and enforced by the U.S. Department of Agriculture – National Organic Program (NOP), which was authorized by the Organic Food Production Act in 1990. The NOP maintains a handbook that includes guidance, instructions, policies, and other documents that communicate organic standards, including a list of allowed and prohibited substances for use in organic production and handling. Substances that are prohibited include conventional herbicides, pesticides, and other synthetic chemicals; petroleum-based fertilizers; and genetically engineered organisms. Products that are approved for use in organic production are labeled as "OMRI Listed," which means they have been certified by the Organic Materials Review Institute (OMRI). Land used for organic crop production must not have any prohibited substances applied to it for at least three years before the harvest and sale of a certified organic crop. This three-year period is the "organic transition" period that is the primary focus of this document. But before even beginning to transition a parcel of land to organic, a producer should create an Organic System Plan or OSP describing how the land will be managed and create a system for record keeping. The OSP and records will be supplied to a certifier in the organic certification process. Relevant and helpful links on organic standards, certification, incentives, and assistance are given in the "Additional Resources" section near the bottom of this document.

Priorities for an Organic Wheat Producer

Priorities for organic wheat producers are not the same as they are for conventional. Compared to conventional producers, organic producers face very different crop management considerations in meeting organic standards. And rather than delivering a product to a local co-op for pooled marketing and sale, organic producers typically establish direct relationships with buyers and customize the product to their needs. These dynamics turn the focus of organic producers in different directions than they may be accustomed to. To synthetize these considerations, Heartland Plant Innovations hosted an Organic Wheat Conference in Kansas in 2019. The conference brought together researchers, producers, industry stakeholders, and others to discuss production of organic wheat in the Great Plains region. The primary output of the conference was a White Paper (https://kswheat.com/sites/default/files/hpi_organic_conference_white_paper.pdf), which includes, among other material, a ranking of top traits for organic hard red winter wheat varieties.

Among the traits of wheat varieties desirable for organic production, high protein content was listed as the number one priority, while yield ranked much lower as priority number five. These rankings may seem unusual to a conventional producer, but protein concentration in hard red winter wheat must meet a threshold for the wheat to be sold in the high-value organic food market. Wheat with protein below the threshold can only be sold in the lower-value conventional wheat market or the organic feed market. Predictably, robust plant disease resistance was a top priority, because organic farmers cannot deploy chemical agents to control diseases. Baking and other end-use quality traits likewise ranked highly, because organic grain markets are often specialty markets of premium products. Wheat variety selection and other crop management decisions are made with consideration of the needs of buyers and adherence to organic standards, while aiming for agronomic success in the local environment.

Organic Transition Research on Dual-Purpose Wheat Systems

Study Overview

A three-year experiment was conducted on a 100-acre field site near Vernon, TX from 2018 – 2021 to compare a dual-purpose wheat system in organic transition to a conventional system (Figure 1). The conventional system was operated with typical management practices for the region (i.e. winter wheat production each year, fallow summer period, herbicides and tillage for weed control, synthetic fertilizers). The organic system was operated with certifiable organic management practices that were tailored to the region (i.e. rotation of cash crop, incorporating legumes for N fixation, cultivation of summer cover crops, tillage for weed control, and compost to supply additional nutrients). Table 1 outlines the experimental treatments for the study and the planned cropping sequence for both systems each season. As indicated in Table 1, dry conditions caused changes to the plan, including not grazing the wheat pasture and lack of good cover crop establishment or growth in some seasons.

Table 1: Experimental treatments for the study, including the cropping and livestock sequence details for the treatments in winter and summer growing seasons for the three-year organic transition period.

Treatment	*S ’18	W ’18/’19	S ’19	W ’19/’20	S ’20	W ’20/’21
Conventional Dual-Purpose	Fallow	Wheat/Cows	Fallow	Wheat†	Fallow	Wheat†
Organic Dual-Purpose	Cover Crop⸸	Wheat/Cows	Cover Crop⸸	Mixed Hay Crop	Cover Crop	Wheat†

*S = Summer, W = Winter
†No cattle grazing these seasons due to dry conditions
⸸No or minimal cover crop growth due to dry conditions

Figure 1: An aerial image of the study site, commonly referred to as "West Walker," located southeast of Vernon, TX.

Cash Crop Production

In the first winter season of organic transition (2018/2019), grain yield was greater in the conventional system than in the organic system (Table 2). For a variety of reasons, yields in organic systems are often reported to be lower than comparable conventional systems in scientific studies. In a large analysis of scientific studies, de Ponti et al. (2012) found that organic wheat yields were 26% lower than conventional, on average, though there was a large range. In the first year of our study, the deficit was -20.2%. This was largely driven by a decrease in grain number production in the organic system, which typically means there was less tillering or spike development. Grain protein was low in both systems this season, but especially low in the organic system.

In the second season (2019/2020), there was crop rotation in the organic system, but wheat was still produced in the conventional system. Wheat yield in the conventional system was the lowest among all seasons of the study, but grain protein was the greatest. A mixed hay crop (winter peas/common vetch/wheat, in a ratio of approximately 40/5/20 lbs/ac, respectively) was produced in the organic system (Table 3). There was negligible growth of common vetch, but the peas and wheat mixture were productive (Figure 2). The winter peas fixed 49 lbs N/ac of aboveground N (any fixed N left belowground was not measured). Intercropping the peas with wheat likely promoted N fixation due to plant competition for limited soil N. As evidence of this, the fraction of N in the peas derived from N fixation was very high at 93%. The entire crop (all aboveground biomass) was harvested to be sold; thus the 49 lbs. of fixed N was removed from the system. Any N fixed by the legume that remained in the system was belowground N.

By the third season (2020/2021) of the study, there was no detectable difference between the systems in grain yield, but there were significant differences in yield components (Table 2). Grain number was greater in the conventional system, but the 1000-kernel weight (a measure of the relative grain weight or kernel size) was greater in the organic system, which helped compensate for the reduced grain number. Grain protein was still lower in the organic system than the conventional and was too low to meet the protein threshold for the organic food market, which is usually set at 12%.

Soil moisture is often the dominant factor limiting yield in dryland wheat systems in this region. But soil fertility and plant nutrient analysis (not shown here) provided evidence that N was also limiting to both yield and grain protein in the organic system. This is discussed more in the *Nitrogen Management* section below.

Table 2: Wheat yield, yield components, and grain protein concentration for all three winter seasons of the study. In comparisons of conventional and organic systems each season, values followed by the same letter are not statistically different ($P = 0.05$).

Season	System	Total Biomass Production	Grain Yield	Grain Number	1000-Kernel Wt.	Grain Protein
		(U.S. tons/ac)	(bu/ac)	(grains/yd^2)	(oz/1000 grains)	(%)
2018/2019	Conv.	2.04a	32.1a	6442a	0.99a	10.1a
	Org.	1.60b	25.6b	5171b	0.98a	9.10b
2019/2020	Conv.	2.33	24.1	4606	1.0	12.6
2020/2021	Conv.	2.54a	38.6a	5823a	1.3b	12.2a
	Org.	2.22a	35.9a	5116b	1.4a	10.3b

Table 3: Biomass production and N parameters for the mixed hay crop grown in the second season (2019/2020) in the organic system.

Species	Biomass Production	Total Plant N	Percent N from Fixation	Fixed N
	(tons/ac)	(lbs N/ac)	(%)	(lbs N/ac)
Winter Pea	0.8	52	93	49
Wheat	0.5	13	-	-
Pea + Wheat	1.3	65	75	49

Figure 2: A close-up image of the mixed hay crop (pea and wheat intercrop) produced in the organic system in the second season of the study.

Forage Production, Quality, and Cattle Gains

The amount of standing forage was measured in the systems monthly (Table 4). The dual-purpose grazing period typically lasts from roughly December to March, but data was collected beyond this period to also represent a "graze out" scenario. The amount of standing crop never differed between systems in any month. Forage nutritive value parameters were also measured. There were generally no differences between systems in these parameters, except crude protein (Table 5). The data shows that crude protein was lower in the organic system in February in the 2018/2019 season, and again in April in the 2020/2021 season. Like grain yield and protein, soil fertility and plant nutrient analysis (not shown here) provided evidence that N limitation was the primary factor causing low forage protein in the organic system.

Grazing of wheat forage only occurred in the 2018/2019. There was no difference between systems in cattle gains (data not shown), similar to the lack of differences between systems in forage standing crop and nutritive value. In the 2019/2020 and 2020/2021 seasons, early-season forage production was insufficient to support cattle grazing, primarily due to limited precipitation.

Table 4: Monthly standing crop (forage) in both systems for all three winter seasons of the study. In comparisons of conventional and organic systems each season (across all months), values followed by the same letter are not statistically different ($P = 0.05$).

			Monthly Standing Crop				
Season	System	Crop	Jan.	Feb.	Mar.	Apr.	May
					(lbs./ac)		
2018/2019	Conv.	Wheat	759c	934c	1179c	2602b	3392a
	Org.	Wheat	680c	886c	1108c	2150b	2749ab
2019/2020	Conv.	Wheat	179bc	310bc	584b	3020a	–
	Org.	Mixed Hay	121c	319bc	670b	2686a	–
2020/2021	Conv.	Wheat	544c	715c	766c	1574b	3018a
	Org.	Wheat	509c	687c	729c	1437b	2679a

Table 5: Crude protein concentration in wheat forage measured monthly in both systems in the first and last seasons of the study (2018/2019 and 2020/2021). In comparisons of conventional and organic systems each season (across all months), values followed by the same letter are not statistically different ($P = 0.05$).

		Crude Protein				
Season	System	Jan.	Feb.	Mar.	Apr.	May
				(%)		
2018/2019	Con.	18.8a	17.3ab	14.7c	15.6bc	4.38d
	Org.	16.9ab	14.2c	13.6c	13.3c	3.79d
2020/2021	Con.	19.4a	16.2bc	14.8cbd	13.3cd	7.56ef
	Org.	17.5ab	14.2cd	13.1cd	9.09e	5.29f

Nutrient Management

Nitrogen is often the most limiting nutrient in conventional cropping systems, but management of N is particularly challenging in organic systems. Without the option to apply synthetic N fertilizers, organic producers are limited in sources of N for their crops. In wheat production, N limitation will reduce yield and especially grain protein. In addition to or in lieu of synthetic fertilizers, N can be introduced through legume cash and cover crops by the process of biological N fixation. Exogenous sources of organic N can also be applied, such as manures, composts, and organic digests, with some restrictions. There are also some OMRI-approved inorganic sources of N with relatively low solubility, but these options have limited availability and are often high in cost. In our three-year study, soil fertility and plant nutrient analysis showed that N was limiting to yield and grain protein in the organic system. The various sources of N for organic systems are discussed below in conjunction with our experiences relying on them in the study.

Introducing N through legume-based fixation was a key component of our organic system nutrient management plan, but we had varied success. Legumes were cultivated in the organic system as a rotational cash crop and as cover crops, each time with OMRI-approved, species-specific rhizobium inoculants. The mixed hay crop, grown as a cash crop over the winter season, was productive and the winter peas fixed N, as hoped (Table 3). In contrast, dry conditions prevented successful establishment and/or growth of summer cover crops in two out of three seasons (Table 1). Our experience suggests that the winter season may be the prime opportunity for achieving legume-based N fixation in a wheat-based cropping system in the Texas Rolling Plains. The summer season is often hot and dry in the region and, when wheat is the cash crop, soil moisture is usually depleted early in the summer. Nitrogen fixation by legumes depends on plant roots successfully associating with rhizobia bacteria and this process can be impeded by harsh environmental conditions. In general, the conditions that favor plant growth also favor N fixation, though N fixation can be particularly sensitive to water deficit and heat stress. An Extension publication available at the following link provides more information on how N fixation can be managed in agronomic systems: https://agrilifelearn.tamu.edu/s/product/nitrogen-fixation-by-coolseason-legumes-in-agronomic-systems/01t4x000002dewT.

Application of organic fertilizer sources is commonplace in organic systems. Raw manure can be used, but there are more drawbacks and limitations to this. Organic regulations restrict the timing of raw manure applications and, if it comes from non-organic sources, it should not contain excessive contaminants. Additionally, raw manure is heavy (high water content) and thus expensive to transport, it can contain live weed seeds and pathogens, and can have variable and unstable nutrient content. As a result, composted manure is more commonly used. In our organic system, composted cattle manure was applied at a rate of 2 tons/ac prior to planting wheat in the first and third winter seasons of the study. This supplied averages of 87 lbs N/ac, 43 lbs P/ac, 71 lbs K/ac, plus micronutrients in each of those seasons. But since compost is a complex organic source of nutrients, most of these nutrients were only slowly available for crop uptake. The ratio of the nutrients was also not ideal for plant growth, with the material being relatively rich in P and poor in N, which is typical for most manure-based composts. The rate of compost we applied (2 tons/ac) was relatively low to avoid overapplication of P and to control costs, with the hope that legume N fixation would make up the N deficit. In water-limited agronomic systems, composts are usually applied at rates ranging from about 2 to 8 tons/ac, depending on compost nutrient concentrations and expected yields. Higher concentrations are often applied in higher-yielding systems. Best management practices should always be used for manure and compost applications to avoid nutrient loading (ATTRA Sustainable Agriculture, 2015).

Although yield was equivalent between systems by the third year of the study, the grain protein concentration in the organic system was still insufficient for sale to the organic food market. Compost application and legume N fixation, as managed in the study, were not enough. A wheat variety was chosen (Green Hammer) for the third year of the study that is known to perform well in N-poor conditions, including having a propensity for elevated grain protein. We believe this choice helped to close the yield gap between systems, but the robust grain filling in the organic system (i.e. high 1000-kernel weight, as shown in Table 2) likely diluted grain protein. For a producer to optimize both yield and grain protein, adjustments are needed to the nutrient management we used. Steps could be taken to increase the frequency of winter legumes in the crop rotation or to reduce export of legume N through harvest and removal of crop biomass. A more readily plant-available and concentrated source of OMRI-approved N could also be applied. If this type of N is applied particularly after the jointing stage of wheat development, it will have little or no effect on yield, but would be expected to boost grain protein concentration.

Weed Management and Crop Rotation

Weed management is typically a key challenge in organic production systems. Tillage is the most common weed control measure employed, but creative and labor-intensive weed control approaches are also used in various organic systems. In our study, we fallowed the system for an entire year prior to organic transition to fight weeds and reduce the soil weed seed bank. Considering existing weed pressure is critical for producers who would like to transition any piece of ground to organic. After reducing weed pressure in our system, we achieved good in-season weed control with just two tillage operations per year. We tilled prior to fall planting and just after harvest using a sweep plow or a field cultivator. In tilling before planting, we were able to start with a weed-free seed bed each year and the cash crop (wheat or mixed-species hay) effectively competed with weeds during the season. Some weeds emerged between wheat rows in the spring, especially in the first study season (2018/2019), but the wheat was harvested before significant weed growth occurred. Tilling shortly after harvest helped to terminate spring-germinated weeds such as marestail, which typically did not return after tillage. However, the field site had a substantial seed bank of red sprangletop, a vigorous warm-season annual grass that occupies the area during the summer. This species is prevalent in the Southern Great Plains region, especially in winter cropping systems, and is difficult to control without herbicides. Even in the summer of 2020 when a cover crop (cowpea) was successfully established in the organic system, red sprangletop outcompeted the cowpea by mid-season. Embraced as a volunteer cover crop itself, however, red sprangletop may provide benefits to the organic system and the producer. These benefits could include reducing high summer soil temperatures, decreasing surface water runoff and controlling erosion, sequestering carbon and nutrients in the soil, and reducing soil compaction. Sprangletop has been reported to be palatable to livestock and thus could also provide an opportunity for grazing. If more noxious summer weeds were present in the system, such as amaranth species like pig weeds, more aggressive weed controls actions would have been needed.

Crop rotation is essential in organic production systems. Crop rotation breaks disease cycles, diversifies soil microbial communities, promotes soil nutrient cycling, offers an opportunity for N fixation, and provides other benefits. There are few options for cool-season crops to rotate with wheat in the Southern Great Plains region and even fewer with crop insurance available. In our study, we rotated wheat with a mixed-species hay crop that was heavy in legumes. The crop was productive, nutritive value was desirable, and we were able to market the crop to local cattle producers. Following the transition period and organic certification, this hay would be of greater value to organic livestock producers who rely completely on organic feed sources for their animals. Winter peas, forage collards, vetch species (note that some have animal toxicity issues and should be monitored), triticale, and other species may be good options for hay in an organic system in the region. Production of cool-season legumes as seed crops may also be possible, depending on marketability of the seed. Rotation of winter wheat with summer crops is also possible, depending on moisture availability and long-term system management plans. In our system, the soil seed bank of red sprangletop would create a large barrier to doing this.

The Economics of Organic Transition and Management

The economics of the organic transition period can sometimes be a roadblock to producers making organic part of their portfolio. It is a time when producers must adhere to organic management practices and pay certification costs, but they generally cannot yet access organic price premiums for their products. It can also be a period with many unknowns. Our primary purpose in conducting our research project was to create a possible roadmap for management of dual-purpose wheat systems during organic transition, removing some of the unknowns and risks in that area. There are other resources available to help. Various government incentives exist that can offset organic certification costs or assist in other ways. Links describing some of these programs can be found in the "Additional Resources" section below. Sometimes buyers of organic crops have programs or incentives they offer producers who contract with them to ease economic challenges of organic transition (e.g. https://www.kashi.com/en_US/what-is-certified-transitional.html and https://www.ardentmills.com/organic-hub/). It is also common for producers to hire a qualified professional consultant who can give detailed advice and assistance on issues ranging from record keeping to crop management and marketing.

In management of organic farming enterprises, costs incurred for individual inputs can vary considerably from comparable conventional operations. Organic farmers typically rely much more on on-farm resources (e.g. composted manure application to crops in an organic grain-livestock operation) and specialized management practices instead of synthetic pesticides and fertilizers. Organic operations may also have some novel expenses, such as on-farm grain storage capacity to enable direct marketing. The Center for Integrated Agricultural Systems at the University of Wisconsin-Madison published an informative discussion of some economic management tradeoffs organic producers might encounter, available at this link: https://cias.wisc.edu/curriculum-new/module-v/module-v-section-d/. It is often assumed that operating costs are higher for organic than conventional, but a comparative analysis of numerous studies by the Food and Agriculture Organization (FAO) have shown that is often not true and that organic operations are typically more profitable (https://www.fao.org/3/ak355e/ak355e.pdf). The potential for increased economic profitability is one incentive for producers to consider organic.

AgriLife Organic Workshop

Our team hosted the Texas A&M AgriLife Organic Workshop on 25 April 2020. The virtual event is available to producers as a permanent online resource. The purpose of the workshop was to provide information on how to successfully transition into organic production and manage an organic operation. Experts in the Texas Rolling Plains and High Plains regions were recruited to speak on the following topics: organic certification, crop insurance and USDA Farm Service Agency (FSA) programs for organic production, marketing of organic products, considerations in becoming an organic farmer, integrating goats into organic systems, integrated pest management (mites, nematodes, and Bt resistance), and an update on the progress of our transitional organic dual-purpose wheat systems research (before it was completed). Following are individual links to the presentations:

- Chandler, B. 2020. *Texas Department of Agriculture Organic Certification Program*: https://www.youtube.com/watch?v=VYVUuxBMQBA&list=PLQeRtwVwL1DNmiHH8jsVgOfHgACk0JVzL&index=1.

- Jones, D., Cook, A. 2020. *Crop insurance and FSA programs for organic production*: https://www.youtube.com/watch?v=eei6am_l7-w&list=PLQeRtwVwL1DNmiHH8jsVgOfHgACk0JVzL&index=7.

- Abello, F. 2020. *Organic production marketing*. https://www.youtube.com/watch?v=aJpb7J-w2fM&list=PLQeRtwVwL1DNmiHH8jsVgOfHgACk0JVzL&index=9.

- Tuggle, J. 2020. *Organic wheat production: Grower considerations for becoming an organic farmer*: https://www.youtube.com/watch?v=EHtBT9E8UAg&list=PLQeRtwVwL1DNmiHH8jsVgOfHgACk0JVzL&index=4.

- Adams, C. 2020. *Organic transition in North Texas wheat systems: Research project update*: https://www.youtube.com/watch?v=uHpQHQbPRX8&list=PLQeRtwVwL1DNmiHH8jsVgOfHgACk0JVzL&index=2.

- Benavidez, J. 2020. *Integrated goat grazing systems*: https://www.youtube.com/watch?v=7UuJxuxUAUc&list=PLQeRtwVwL1DNmiHH8jsVgOfHgACk0JVzL&index=3.

- Bynum, E. 2020. *Predatory mites for control of spider mites in Texas High Plains cotton*: https://www.youtube.com/watch?v=mVKVEK3tlH8&list=PLQeRtwVwL1DNmiHH8jsVgOfHgACk0JVzL&index=5.

- Porter, P., Bynum, E., Shields, E., Kesheimer, K. 2020. *Entomopathogenic nematode studies for control of corn rootworm*: https://www.youtube.com/watch?v=ImjqaPzu7mw&list=PLQeRtwVwL1DNmiHH8jsVgOfHgACk0JVzL&index=6.

- Porter, P. 2020. *Status of corn earworm resistance to Bt corn on the High Plains as we enter the 2020 growing season*: https://www.youtube.com/watch?v=-MppwMgiaRQ&list=PLQeRtwVwL1DNmiHH8jsVgOfHgACk0JVzL&index=8.

Additional Resources

Many resources are published online by NOP, the Texas Department of Agriculture (TDA), and other sources to help producers get started in organic farming. Local USDA Farm Service Agency (FSA) and Natural Resources Conservation Service (NRCS) offices can also provide knowledge, plus information on financial resources that are available to organic producers. Below are links to some helpful websites.

USDA-AMS: “Is organic an option for me?”
https://www.ams.usda.gov/services/organic-certification/is-it-an-optiond
(training modules, guides, and other resources)

USDA-AMS: “A Guide for Conventional Farmers Transitioning to Organic Certification”
https://www.ams.usda.gov/sites/default/files/media/10%20Guide%20to%20Transitional%20Farming%20FINAL%20RGK%20V2.pdf
(a helpful overview and guide through the organic transition process)

Texas Department of Agriculture: “Organics”
https://www.texasagriculture.gov/regulatoryprograms/organics.aspx
(TDA organic certification form, cost share program information, and other resources)

Rodale Institute: “Organic Farm Funding”
https://rodaleinstitute.org/education/organic-farm-funding/
(information on funding initiation, improvement, or expansion of organic farms)

USDA Farmers.gov: “Organic Transition Initiative”
https://www.farmers.gov/organic-transition-initiative
(a producer-focused initiative to build and strengthen organic markets)

USDA-NRCS: “Conservation for Organic Farmers”
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/organic/
(NRCS resources for developing conservation plans in organic systems)

Primary References

For more complete descriptions of our organic transitions research on dual-purpose wheat systems, please see the following peer-reviewed journal articles:

1. Hinson, P., Adams, C.B., Pinchak, B., Jones, D., Rajan, N., Somenahally, A., Kimura, E. 2022. Organic transition in dual-purpose wheat systems: Agronomic performance and soil nitrogen dynamics. *Agronomy Journal* 114:2484-2500.
2. MacMillan, J., Adams, C.B., Hinson, P., DeLaune, P., Rajan, N., Trostle, C. 2022. Biological nitrogen fixation of cool-season legumes in agronomic systems of the Southern Great Plains. *Agrosystems, Geosciences and Environment* 5:e20244.
3. Hinson, P., Pinchak, B., Adams, C.B., Jones, D., Rajan, N., Kimura, E., Somenahally, A. 2023. Forage and cattle production during organic transition in dual-purpose wheat systems. *Agronomy Journal* 115:873-886

Other References

1. ATTRA Sustainable Agriculture. 2015. Tipsheet: Compost. National Center for Appropriate Technology.
2. de Ponti, T., Rijk, B., & Van Ittersum, M. K. 2012. The crop yield gap between organic and conventional agriculture. *Agricultural systems* 108:1-9.