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Implementing Demonstration to Promote the Sustainable Farming Practice of Using Cover Cropping Systems

Abstract

Use of cover cropping systems has multiple benefits for agriculture. To convince vegetable growers to adopt such systems, we applied a field demonstration in which we grew selected cover crops during the off-season and then tomatoes. We focused on implementation of a science-based demonstration design and attended to the usefulness of the demonstration and audience timing preferences. As a result, growers grasped the advantages of growing cover crops and, consequently, have extensively adopted cover cropping systems, thereby applying a critically important practice for crop management and agricultural sustainability. Our method and findings can help Extension educators better implement programs to convince agricultural producers to adopt desirable farming practices that improve sustainable agriculture.

Keywords: cover cropping system, demonstration, tomato, sustainable agriculture

Qingren Wang
Extension Agent in Commercial Vegetables and Pesticide Application Training
Institute of Food and Agricultural Sciences Extension Miami-Dade County
University of Florida
Homestead, Florida
qrwang@ufl.edu

Christian F. Miller
Extension Agent in Commercial Vegetables and Tropical Fruit
Institute of Food and Agricultural Sciences Extension Palm Beach County
University of Florida
West Palm Beach, Florida
cfmiller@ufl.edu

Shouan Zhang
Associate Professor and State Extension Specialist in Plant Pathology
Tropical Research and Education Center
Institute of Food and Agricultural Sciences
University of Florida
Homestead, Florida
szhang0007@ufl.edu

Introduction

Growing cover crops has numerous benefits to growers, including yield increase and quality improvement plus weed and soil pest control (Clark, 2007; Wang, Li, Handoo, & Klassen, 2007; Wang, Li, & Klassen, 2005). Selection of an appropriate cover crop is site specific and depends on climate and cropping systems adopted in a given region. For example, to help growers in the northern Great Plains select suitable cover crop species, U.S. Department of Agriculture (USDA) scientists developed a cover crop chart for their region (Liebig et al., 2013). Additionally, Extension specialists at Michigan State University have published a state-specific decision tool Midwest farmers can use to select their optimal cover crops (Baas, Mutch, & Ackroyd, 2011).

Growing cover crops also can contribute to sustainable agriculture. In south Florida, growing fresh market vegetables during winter is an important industry because of the state's favorable subtropical climate. During the hot and rainy summer off-season, soil nutrient leaching is a major concern. This concern is especially critical in south Florida, where the Everglades, a giant wetland, is adjacent to an agricultural area with a shallow aquifer. To explore ways to reduce the potential leaching of soil nutrients applied in fertilizers during the growing season, scientists at the University of Florida have conducted a number of studies on growing various cover crops during the summer off-season (Wang, Klassen, Li, & Codallo, 2009; Wang, Klassen, Li, Codallo, & Abdul-Baki, 2005; Wang et al., 2007; Wang, Li et al., 2005). The cover crops are then incorporated into the soil as a green manure for growing subsequent vegetable crops (Wang et al., 2018). Results from these studies have shown that growing certain cover crops is promising for improving vegetable yield and quality (Wang, Klassen et al., 2005) while also conserving soil and water by reducing nutrient leaching (Wang, Li et al., 2005) to benefit the environment. Although use of the cover cropping systems has been identified as a Florida best management practice (BMP) (Florida Department of Agriculture and Consumer Services, 2015), most growers still need a better understanding of the cropping systems, the performance of different cover crops, and the benefits of implementing them as BMPs.

Pursuing an effective approach for stimulating growers' motivation and convincing them to adopt cover cropping systems is of great importance. Although field demonstration, initiated by Knapp as early as 1903, has been applied successfully in Extension programming (Cline, 1970; Hancock, 1992; Rasmussen, 1989), reports on successful use of field demonstration to improve the adoption of cover cropping systems are sparse. Our interactions with local vegetable growers in south Florida revealed that most prefer to see a system on a large scale in a local grower's field prior to adopting it. Therefore, to convince growers to adopt cover cropping systems in vegetable production, we implemented a field demonstration. Working closely with a local vegetable grower, we demonstrated two promising cover crops at the grower's field to showcase the results for our clientele. Our study has implications for Extension professionals seeking to promote sustainable agriculture best practices by efficiently convincing local growers to adopt cover cropping systems.

Materials and Methods

We followed traditional demonstration guidelines (Kittrell, 1974) by selecting a conspicuously located vegetable field of a well-known grower in Miami-Dade County, Florida. The 40-ac field was used for an on-site demonstration to evaluate the performance of two cover crops and their effects on tomato yield and quality. The grower disked and leveled the land and planted seeds of sunn hemp (*Crotalaria juncea* L.), a legume cover crop, and sorghum sudangrass (*Sorghum bicolor* x *S. bicolor* var. *sudanense* [Piper] Stapf.), a nonlegume cover crop, with a tye-drill planter at a rate of 25 lb/ac and 50 lb/ac, respectively, in 10 ac each. The remaining land was left naturally fallow as a control. We divided each treatment, including the fallow, into three replicates for subsequent sampling, biomass quantity evaluation, and tomato yield determination. The growth period of the cover crops was May 24 to July 1, 2016. The grower incorporated the cover crop residues into the soil as green manure. We collected plant biomass samples randomly from each replicate of both cover crops and dried them to determine the biomass weights.

In early September 2016, the grower disked the land again, formed raised beds, applied dry fertilizers, set up driplines, fumigated the soil, and covered the beds with plastic mulch. After 3–4 weeks of fumigation, he transplanted tomato (*Solanum lycopersicum* L. Sanibel) seedlings and implemented regular farming practices, including irrigation, fertigation, pest control, rebar installation, and string tying of plants, according to his farming plan.

To determine the tomato yield with different cover crops as compared with fallow, we harvested tomato fruits three times from January to February 2017, graded them with an automatic machine according to USDA standards (i.e., extra large, large, medium, and small sizes). The combined weights of these grades, except the small size fruit, were taken into account as a total marketable yield. We used fruit size as a criterion for evaluating tomato quality according to the USDA standards. In fact, tomato growers expect higher yields of extra large and large fruits because of customer preferences and a higher price for the round type of tomatoes. We subjected the data to statistical analysis for the least significant difference test at $p \leq .05$ using SAS software (Version 9.4, Cary, NC).

We organized two grower field day events by inviting vegetable growers, stakeholders, and industrial representatives to participate via our email list. At the first one, in June 2016, participants evaluated the performance of the cover crops by walking through various plots with the crops. At the second field day, in February 2017 during a tomato harvest season, participants took the same approach to observe the tomato growth and fruit yield increase that had resulted from growing the cover crops as compared with fallow. We also provided handouts, fact sheets, and other related Extension publications addressing tomato crops grown on land where cover crops had grown in comparison with fallow. To improve participation rates, we conducted both field day events at noontime and provided a lunch of fast food and drinks, with a voluntary sponsorship each time. In addition, continuing education units (CEUs) for pesticide applicators were applied for and approved by the state and were issued to licensed participants at the end of the events.

To assess growers' knowledge gain and willingness to change practices, we carried out an on-site survey. All participants were invited to visit the demonstration plots with various replicates and provided with fact sheets of treatments and results. We also addressed the statewide strategies for and potential impacts of promoting BMPs by implementing cover cropping systems for sustainable development of agriculture. Questionnaires with multiple-choice items addressing knowledge improvement, practice change, program usefulness, and so on were distributed to every participant at the beginning and collected at the end of each event. In addition, we conducted a follow-up survey using multiple approaches, including the Qualtrics online platform, telephone calls, email, and face-to-face on-site visits, 3 months after the program to determine actual behavior changes of vegetable growers regarding adoption of the cover cropping systems in their farming practices.

Results and Discussion

The field demonstration resulted in success, with a large number of participants and impressive feedback. A total of 81 people attended the two field day events. An on-site postevent survey showed that 86% of participants had knowledge gain, with a weighted average rating of 4.3 on a scale of 1 (*low*) to 5 (*high*); 84% were willing to change their practices in vegetable production, with a weighted average rating of 3.8 on the same scale; and 91% were satisfied with the program, with a weighted average rating of 4.3 on the same scale.

For the follow-up surveys we conducted through various means 3 months after the program, there were 63 available participants. Of those participants, we collected responses from 20 (32.3%). This response rate is comparable with the 33.5% response rate MacGowan et al. (2018) achieved with a mail-in survey. Among the 20 participants, 90% thought the field demonstration was helpful, 85% understood the benefits of growing cover crops, and 75% actually had adopted a cover cropping system. Further information revealed that those who had adopted cover cropping systems were major local vegetable growers. Due to their leading roles, more and more growers have followed them and changed their practices. As a matter of fact, our demonstration has consequently resulted in approximately 3,000 ac of the cover crops grown each year, constituting a dramatic practice change toward development of sustainable agriculture in the region.

Our success with the field demonstration resulted from a number of factors. We believe that our demonstration clearly showcased the entire procedure of implementing cover cropping systems via a scientific field design. For example, participants could compare different cover crops with fallow for biomass production and consequently witnessed tomato yield and quality improvement, thereby assuaging critical concerns they had about system adoption. The usefulness of the demonstration centered on the ability of participants to observe the performance of both cover crops with regard to improved tomato yield and quality, which resulted from the nutrient contribution from the cover crops (see appendix).

Logistics also contributed to the success of the field day events. We seriously considered the preferences of our participants and chose a time most appropriate to their needs (12:00–1:30 p.m.) and provided a free lunch. In addition, certified pesticide applicators were able to obtain CEUs to renew their licenses. Our results align with those identified in a previous report, in which the researchers concluded from a massive survey that a successful demonstration depends on how best to design it, its usefulness, and awareness of preferences of the audience (MacGowan et al., 2018).

Field demonstration has had a long history in Extension programming, with a number of success stories (Hancock, 1992; Rasmussen, 1989). As reported (Kittrell, 1974), demonstration projects have been shown to influence a cooperating producer's decision for his or her farm management. More importantly, such a project can persuade other growers in the community to look at the facts and can provide an opportunity for them to communicate with each other and exchange information about their experiences. In fact, MacGowan et al. (2018) found that among different types of sources, respondents ranked the option "in-person communication with family, friends, or neighbors" the highest. In another survey, Wang, Kasu, Jacquet, and Kumar (2019) concluded that most respondents ranked other farmers or their peers as the top preferred information source.

On the basis of our outcomes, we believe that implementing the field demonstration on adopting a cover cropping system was an effective approach for educating local vegetable growers. Of course, an optimal cover crop selection must be site specific. However, replication or adaptation of our approach may help Extension educators better facilitate adoption of cover cropping systems or other desirable farming practices to improve the development of sustainable agriculture.

Conclusions

Using a field demonstration in a grower's field on a large scale is a successful way to convince local growers to adopt a cover cropping system. Applying the field demonstration can showcase the success, the reality, and the benefit to growers of changing their farming practices. It is a straightforward scenario for persuading growers to accept the targeted strategy because they are able to witness the fact that growing cover crops during a crop off-season can improve soil fertility, scavenge soil nutrients, suppress weeds and soil pests, and conserve soil and water due to the large amount of biomass accumulated in cover crop plant tissues. As a result, they understand that growing cover crops, particularly growing legume cover crops, can improve crop yield and quality. However, an efficient demonstration needs a science-based design, comprehensive consideration of the usefulness of the demonstration, and appreciation of the timing preferences of the audience. We recommend that Extension educators implement field demonstration programming as an efficient approach to eliciting producer behavior changes in similar areas, such as crop rotation, soil conservation, use of other cover crops, pest control, and nutrient and water management.

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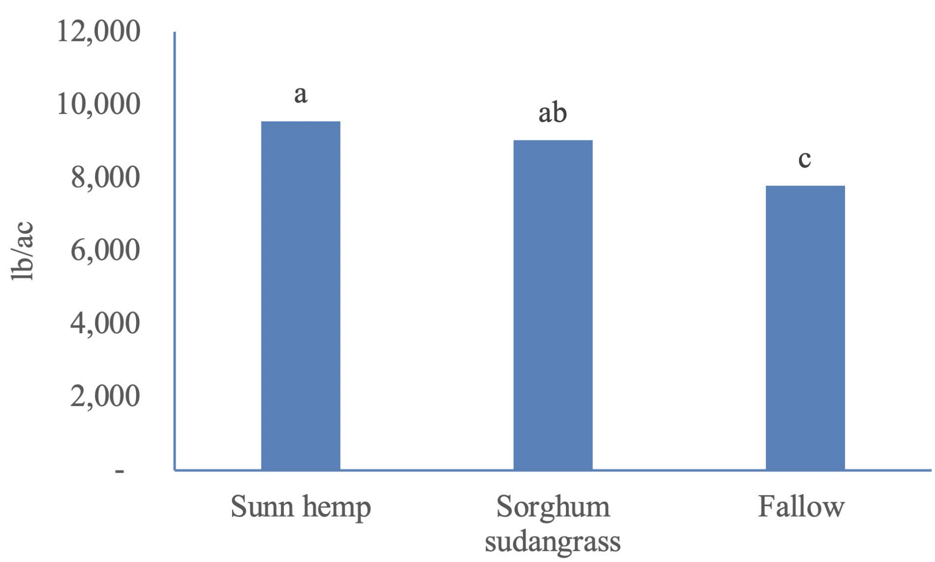
Appendix

Cover Crop Biomass Production Associated with Tomato Yield and Quality

Both cover crops grew well in the field. For instance, the total amount of biomass of sunn hemp and sorghum sudangrass was 7.2 ton/ac and 4.4 ton/ac, respectively, in a growth period of 63 days. Sunn hemp produced a significantly ($p \leq .05$) greater amount of biomass as compared to sorghum sudangrass. As a result, growing both cover crops improved the tomato yield compared to fallow. The tomato yield was increased by 22.1% and 13.5%, respectively. The tomato fruit quality was improved as well with the cover crops grown. For example, the tomato yield of extra large size fruit was increased by 23% and 16% from the fields previously growing sunn hemp and sorghum sudangrass, respectively, as compared to that from the fallow control (Figure 1).

Figure 1.

Tomato Extra Large Fruit Yield After Growing Sunn Hemp and Sorghum Sudangrass as Compared with Fallow



Note. The same letter(s) on the bars indicates insignificant difference at $p \leq .05$.

As we explained to our field day audiences, the significant increases in tomato yield and quality after the cover crops grown are mainly attributed to the nutrients released from the decomposition of cover crop tissues. For example, as much as 410 lb/ac of nitrogen accumulated in plant tissues of sunn hemp could be released gradually as the plant tissues are decomposed by soil microbes. In addition to nitrogen, other macro nutrients such as phosphorus and potassium also accumulated in the cover crop tissues. For instance, as much as 25 lb/ac and 56 lb/ac of phosphorus and 190 lb/ac and 187 lb/ac of potassium could accumulate in the tissues of sunn hemp and sorghum sudangrass, respectively (Wang et al., 2009). Therefore, nutrient contribution from cover crop tissues may play an important role in increasing the tomato yield.