Advancements in Agricultural Development
Volume 4, Issue 4, 2023
agdevresearch.org

Conservation Agriculture and Cover Crop Adoption by Smallholder Farmers in Cambodia: Understanding Perceptions, Challenges, and Opportunities for Soil Improvement

P. Nickens[1], D. R. Ader[2], M. Miller[3], P. Srean[4], T. Gill[5], S. Huot[6]

Abstract

Practical solutions for soil conservation are needed to ensure sustainable food production. Conservation agriculture and the use of cover crops are promising strategies for soil improvement in agricultural systems. These strategies are being promoted in Cambodia to address rapidly declining soil fertility; however, there is a lack of insight into the perceptions of Cambodian smallholders towards cover cropping within a conservation agriculture approach. A greater understanding of the utilization and perceptions of cover crops is needed to increase adoption and prevent further soil degradation. This study utilized a mixed methods approach with quantitative data from a farmer survey and qualitative data gathered from follow-up interviews with farmers. Analysis shows that farmers understand what conservation agriculture is and reported benefits, including increased yields, after practicing conservation agriculture. Conservation agriculture was viewed as a way to protect the environment and increase soil fertility, particularly by using cover crops. However, farmers reported that the use of cover crops as part of a conservation agriculture approach faces challenges, preventing further adoption. Understanding the benefits and challenges for farmers can help improve adoption, leading to improved soil and more resilient agricultural systems. Further research on how to address the challenges presented by farmers is needed.

Article History

Received: August 17, 2023
Accepted: November 21, 2023
Published: December 6, 2023

Keywords

soil fertility; mixed methods; sustainable agriculture

1. Presley Nickens, Graduate Research Assistant, University of Tennessee, 101 McCord Hall, 2640 Morgan Circle Dr., Knoxville, TN 37996, pnickens@vols.utk.edu, https://orcid.org/0009-0002-3030-370X
2. David R. Ader, Assistant Director of the Smith Center for International Sustainable Agriculture, University of Tennessee, 101 McCord Hall, 2640 Morgan Circle Dr., Knoxville, TN 37996, dader@utk.edu, https://orcid.org/0000-0003-3360-5017
3. Max C. Miller II, Graduate Research Assistant, Department of Agricultural and Environmental Sciences, Tennessee State University, mmille60@my.tnstate.edu, https://orcid.org/0009-0003-3667-3063
4. Pao Srean, Dean of the Faculty of Agriculture & Food Processing, National University of Battambang, Road 5 Krong, Battambang, sreanpao@gmail.com, https://orcid.org/0000-0003-2330-9660
5. Tom Gill, Director of the Smith Center for International Sustainable Agriculture, University of Tennessee, 101 McCord Hall, 2640 Morgan Circle Dr., Knoxville, TN 37996, tgill4@utk.edu, https://orcid.org/0000-0002-1367-8684
6. Sovanneary Huot, Graduate Research Assistant, Pennsylvania State University, Armsby Building University Park, PA 16801, neary.psu@gmail.com, https://orcid.org/0000-0002-3214-256X

Introduction and Problem Statement

Cambodia, with its agricultural-based economy, is at risk of depleting one of their most precious resources —soil. Cambodian soils are being lost at a tremendous rate due to continuous cultivation and rainfall patterns (Le et al., 2018). A loss of soil fertility is a limiting factor for rice production, the largest agricultural sector in Cambodia; thus, environmentally-conscious strategies that do not risk rice production are needed (Suong et al., 2019). To address this issue, a climate-smart approach that takes conservation agricultural practices into account has been suggested. Conservation agriculture (CA) aims to minimize soil disturbances, diversify cropping systems, and improve soil fertility through the addition of cover cropping and crop rotation practices (Chapuis et al., 2019). Cover crops are an essential part of a CA approach, offering soil health benefits and assisting in carbon sequestration. Cover crops are associated with improvements in soil physical, chemical, and biological properties (Adetunji et al., 2020). Benefits such as increased organic matter, yield, and available nutrients (Adetunji et al., 2020) have the potential to positively impact depleted soils in Cambodia. A greater understanding of the utilization and perceptions of cover crop production by smallholders is needed to further expand the adoption of cover crops under a CA approach. The problem we seek to address is the lack of insight into the perceptions of Cambodian smallholders towards cover cropping and what factors motivate them to adopt cover crops and conservation agriculture practices into their agricultural systems. The knowledge gained from this research can help increase cover crop adoption to remedy depleted Cambodian soils, consequently boosting fertility to meet the forty-two percent production increase needed to meet rice demands by the year 2050 (Ray et al., 2013).

Theoretical and Conceptual Framework

Cambodia has experienced mass deforestation as a result of the conversion of agricultural land driven by market demand for cash crops (Kong et al., 2019). Deforestation paired with degradative farming practices such as conventional tillage has negatively impacted soil health, with 5.93 million tons per hectare per year of soil lost in 2018 (Sourn et al., 2022). The resulting erosion has a negative effect on agricultural productivity, soil fertility, and biodiversity, thereby affecting the livelihoods and economies of those residing in degraded areas (Sourn et al., 2022). To remedy this spiral of events, a conservation agriculture approach is needed to restore soil health and fertility. A study by Le et al. (2018) found that conservation agricultural practices implemented in Cambodia had four times less sediment loss and an increase in soil organic carbon (SOC) stocks compared to conventional tillage methods. Conservation agriculture is associated with an increase in yields, reduced labor, and conservation of natural resources on Cambodian farms (Edralin et al., 2017).

Previous studies have investigated the decision-making process and perceptions of Cambodian smallholders on the topic of conservation agriculture. Kong et al. (2021) created a simulation game to better understand why Cambodian farmers would adopt conservation agriculture. The results suggested that farmers would choose CA approaches in the absence of cash crops when

crop productivity declined. Sumner et al. (2017) used a mixed methods approach to understand the perceptions of CA through the lens of gender. The study found that CA was perceived to reduce labor for both genders; however, the decision to adopt was dependent on access to resources, the ability to make decisions within the home, and available space. Women were more involved in the household finances while men had greater control over input selection and agricultural production; however, the decision to transition to CA was largely a joint decision (Sumner et al., 2017).

A specific focus on the farmer perceptions of cover cropping, a practice implemented in CA, is absent from the related literature. It has been well established that cover crops implemented under a CA system improve soil health (Hin et al., 2021; Suong et al., 2019). After an analysis of field data, Miller (2022) found a positive correlation between cover crop biomass and maize yield in Cambodian field trials. Farmers who had practiced CA for more than one year reported advancements in soil health, yield, or profitability (Miller, 2022). Unfortunately, the adoption of cover cropping technology has lagged among Cambodian smallholders (Hin et al., 2021). An understanding of the perceived advantages, disadvantages, barriers, and production practices can help researchers better understand the underlying causes of the lack of adoption. Thus, this study utilized the Theory of Planned Behavior (Ajzen, 1991) for the conceptual framework.

Purpose

The purpose of this research is to explore smallholder perceptions of cover crops within conservation agriculture in Cambodia. An increased understanding of the research questions can better inform future strategies to increase adoption, thus leading to improved soil health. The research questions presented for this study are:

1. What are the conservation agriculture practices, particularly cover crop practices, being implemented by the farmers surveyed and what is their perception of the results?
2. Why do Cambodian farmers choose to implement cover cropping on their farms? What are the perceived advantages and disadvantages of cover cropping for a Cambodian farmer?
3. What are the perceived impacts of conservation agriculture, and in particular, cover cropping, on soil health and fertility?
4. What are the perceived challenges preventing Cambodian farmers from practicing cover cropping?

Methods

This research follows a mixed method approach, using both quantitative and qualitative data gathering techniques (Creswell, 2014; Creswell & Plano Clark, 2018). Mixed methods research in agriculture, by using both quantitative and qualitative data collection and analysis techniques, allows researchers to gain a more comprehensive understanding of agricultural issues by exploring both the measurable and subjective aspects of a phenomenon (Harrison & Getz, 2015). Mixed methods can improve the robustness and triangulation of results (Leedy & Ormrod, 2012) and can provide insights into the attitudes and experiences of farmers, which

may not be captured through one method alone. Mixed methods research in agriculture can lead to a more nuanced understanding of complex agricultural issues and can inform policies and improve the efficiency of extension and outreach programs. In this research, the intent was to gather information from farmers to understand the situation of conservation agricultural practices and help inform policies and extension programs that are promoting soil health and conservation agriculture in Cambodia. The farmers were selected because they chose to participate in a cover cropping project led by the local government center known as The Cambodian Conservation Agriculture Research for Development Center (CARDEC). These farmers have been engaging with CARDEC in Battambang Province to increase the adoption of conservation agricultural practices, specifically cover cropping, with mainly the use of the crotalaria species.

The mixed methods approach was executed by utilizing quantitative data from a farmer survey (N = 57), and qualitative data gathered from in-depth interviews with a subset of the farmers surveyed (n = 14). Cambodian enumerators, from the National University of Battambang, who have experience with farmer surveys, were contracted to implement the survey in the Khmer language. Trustworthiness was established with the interviewees by using in-country enumerators from a local university. In-depth interviews were conducted by the authors with the use of Khmer translators.

A simple survey instrument was developed to gather basic information about the current CA and cover crop use by the farmers. The survey was tested at the National University of Battambang on a group of faculty and graduate students to ensure its validity. The survey consists of close-ended questions to capture data on the farmer themselves (age, years farming, etc.), their resources (land, irrigation etc.), and their practices (tillage, planting, etc.). The survey also contained questions about their use and perceptions of CA and cover crops. The survey responses were collected on paper and then input into Excel. All research protocols were approved by the university Institutional Review Board (16-03351-XP). IBM SPSS Statistics (Version 24) was used to analyze the survey data.

The qualitative methodology for this study employed a semi-structured interview format. A total of 14 on-farm, in-depth interviews were conducted between the dates of December 16, 2022 and December 25, 2022. Interviews lasted on average 40 minutes and included questions pertaining to farmer perceptions, experiences, and observations of CA and cover crops. Farmers were selected to represent individuals who have been practicing CA for varying lengths of time, which ranged from first year to veteran practitioners. Interviewees were also chosen to include farmers with operations under diverse crop rotations and in multiple agro-ecological contexts (upland and lowland). Field notes and interview guides were used to collect the interview data. The qualitative data was analyzed by reviewing the responses and organizing them based on themes. We present both findings from the farmer survey and the interviews.

Findings

Survey results show that respondents have an understanding of what both cover cropping and conservation agriculture are and the benefits they can provide (Table 1). Reported CA practices included growing cover crops, crop rotation, implementing no-till, and reducing fertilizer usage. Smallholders reported that cover cropping information came from projects provided by the Provincial Department of Agriculture, CARDEC, Smart Agro (private sector seed company), machine service providers, and other farmers. 93% of smallholders reported that they grew cover crops once a year (Table 1). Juncea (or Sun Hemp) was the primary type of cover crop grown. Farmers reported their motivation for growing cover crops: to improve soil, feed animals, produce seeds for sale, or improve diversity on their land. On average, farmers had been practicing CA for 3.1 years. 61.4% of respondents reported that their yields increased after practicing conservation agriculture (Table 2). After planting a cover crop, 28.1% of smallholders reported that they plowed the land.

Table 1

Smallholder Profile, N=57

Parameter	*%* or *M*	*f*
Demographics		
Male	86.0	49
Age	48.5	
Hectares farmed	11.5	
Hectares of cover crops	2.8	
Farming Practices/ Experience		
Experienced past rice harvest loss (due to pest, weather, etc.)	77.2	44
Knows about cover crops	100.0	57
Knows about conservation agriculture	94.7	54
Gets cover crop seed from project	33.0	19
Grows a cover crop once per year	93.0	53
Broadcasts cover crop seed	77.2	44

Table 2

Percent of Farmers, Perceived Impacts of CA, N=57

Parameter	*%*	*f*
Increased water-holding capacity	86.0	49
Increased drought resistance	70.2	40
Increased insect resistance	40.4	23
Increased yield	61.4	35

In the interview portion, many farmers said that they began practicing CA after observing the results of other farmers who practice CA or after attending a CA demonstration. In one interview a farmer stated, “Other farmers have noticed my improvements as a result of CA and have asked me about my practices. I have side-by-side plots to show other farmers to promote CA.”

Respondents suggested the following reasons prevent farmers from adopting CA: lack of information, concerns about machinery availability, budgetary restrictions, and negative preconceptions about CA. Preconceptions stem from a belief that plowing multiple times is required to obtain high yields, with concerns about insects residing in soil surface residue, difficulties plowing after cover crops, timing of commodity crop harvest, and tillage requirements for certain commodity crops. “I believe many farmers still do not understand CA, which may make others hesitant to adopt it, despite many seeing positive results of farmers practicing CA,” the same smallholder said. Ensuring farmers are well-informed is integral to the adoption of CA, as a retired government official also stated, “I believe widespread adoption of CA is important, but may not take place unless the government makes a more concerted effort to promote it.”

Smallholder Perceptions

Cambodian smallholder farmers stated advantages of practicing CA included improved soil properties, erosion mitigation, added soil organic matter, reduced chemical inputs, added soil moisture retention, and reduced input costs. One farmer stated, “CA is an essential practice, especially for annual crops. It should be widely adopted for the sake of crop diversity and the improvement of soil quality.” Another farmer who had been practicing CA for three years said, “I am more comfortable with CA, because of its reduced impact on the environment and it is a healthier way of life for my family.” Disadvantages of practicing CA included climate, drought, difficulty in implementing CA practices, lack of equipment, difficulty in obtaining cover crop seeds, uneven land, associated pests, and a high cost to initiate CA practices. When asked what could be done to improve current CA practices in the survey portion of the study, many respondents suggested increased advertisement of CA techniques (35.1%) followed by more machinery (14%), water systems improvement (8.8%), and greater farmer participation (7%). An overwhelming majority of 94.7% of survey respondents stated that CA protects the environment (see Table 3). During an interview, one smallholder who has been farming since childhood said, “If Cambodian farmers can implement CA it would benefit their land and the environment while helping them adapt to climatic changes in the future.” To adapt to climate change, other smallholders stated that they implemented growing cover crops, crop rotations, or disease/weather-resistant varieties.

Table 3

CA Perceptions, N=57

Parameter	*% Agree*	*f*
Improves soil fertility	96.5	55
Protects the environment	94.7	54
Requires low production costs and increases crop yield	75.4	43
Sustainably improves soil	94.7	54
Provides higher income than conventional tillage	78.9	45
Reduces soil erosion	93.0	53
Controls pests	64.9	37

Barriers

Smallholder responses suggested that seed and machinery accessibility were barriers to production. However, when asked about cover crop seeds, farmers reported that seed was reasonably priced (100%) and easy to find (82.5%). Respondents reported that their farms were accessible by large agricultural machines (100%). Clear barriers to CA implementation were unsuccessful cover crop reproduction and crop failure due to a lack of water (Table 4). "Seed germination," one farmer stated about both cover crops and corn, "depends on rainfall under CA more than conventional tillage, as the soil is not as fine and the seed is not covered as well upon broadcasting or planting. This is the primary challenge of practicing CA."

Table 4

Barriers to Cover Crop Implementation, N=57

Parameter	*%*	*f*
Cover crop reproduction unsuccessful	64.9	37
Cover crop failure due to water	64.9	37
Not enough water to grow cover crops	42.1	24
No water system	17.5	10

Conclusions, Discussion, and Recommendations

This article sought to address the lack of insight into the perceptions of Cambodian smallholders towards cover cropping and what factors motivate them to adopt cover crops and conservation agriculture practices into their agricultural systems. These practices are vital components of the efforts to restore soil health and fertility in depleted Cambodian soils. A greater understanding of the utilization and perceptions of cover crop production by smallholders is needed to further expand the adoption of cover crops under a CA approach.

Most farmers surveyed both understood and implemented cover cropping and CA practices. Increased yield, water holding capacity, soil fertility, and income were favorable outcomes of implementation reported by smallholders. CA was cited as a way to protect the environment, adapt to climate change, and sustainably improve the soil in Cambodia. Clear barriers to implementation were negative preconceived notions about cover cropping, cover crop failure due to water (whether an excess or deficit), and unsuccessful cover crop reproduction. Farmers stated a disadvantage to CA was difficulty in finding cover crop seeds (see smallholder perception); however, when specifically asked about seed availability, a large majority of respondents said seeds were easy to find (see barriers).

Recommendations for future research in this area should seek to delineate CA practices from cover cropping, since survey responses indicated that at times CA was used interchangeably with the term cover cropping. While closely associated, cover cropping falls under the umbrella of CA. Smallholder responses indicated there is an evident need to address cover crop seed reproduction, water-related barriers, and increased government support of cover cropping. Based on the presented benefits of CA and cover crops, we recommend that practitioners continue to increase CA adoption and communicate their experience with their communities. The insights into smallholder perceptions, motivations to adopt, challenges, and opportunities presented by this study can provide guidance on where to focus future soil health related research and programs in Cambodia.

Acknowledgements

This research was supported by the USAID Bureau for Food Security and Resilience and the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification managed by the Kansas State University and was led by the University of Tennessee Institute of Agriculture (USAID Federal Award No.: AID-OAA-L-14-00006; Subaward No.: 5587-UT-KSU-6056). The contents of this article are the responsibility of The University of Tennessee and do not necessarily reflect the views of USAID or the United States Government.

Presley Nickens - writing-original draft, writing-review and editing, formal analysis; **David R. Ader** - writing-original draft, writing-review and editing, investigation, conceptualization, data curation, funding acquisition, supervision; **Max Miller** - writing-original draft, investigation, data curation; **Pao Srean** - funding acquisition, supervision; **Tom Gill** - funding acquisition, supervision; **Sovanneary Huot** - funding acquisition, conceptualization

References

Adetunji, A. T., Ncube, B., Mulidzi, R., & Lewu, F. B. (2020). Management impact and benefit of cover crops on soil quality: A review. *Soil & Tillage Research, 204*, 104717. https://doi.org/10.1016/j.still.2020.104717

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision*

Processes, *50*(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-T.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods Approaches (*4th ed.). SAGE.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods Research* (3rd ed.). SAGE.

Edralin, D. A., Sigua, G. C., Reyes, M. R., Mulvaney, M. J., & Andrews, S. S. (2017). Conservation agriculture improves yield and reduces weeding activity in sandy soils of Cambodia. *Agronomy for Sustainable Development, 37*(52)*,* 1–11. https://doi.org/10.1007/s13593-017-0461-7

Harrison, J. L., & Getz, C. (2015). Farm size and job quality: Mixed-methods studies of hired farm work in California and Wisconsin. *Agriculture and Human Values, 32*, 617–634. https://doi.org/10.1007/s10460-014-9575-6

Hin, L., Kornecki, T. S., Reyes, M. R., Bunthong, B., Hok, L., Lor, L., Tivet, F., Leng, V., Suos, V., & Clemmons, H. (2021). Effects of different management methods for Sunn-Hemp cover crop on corn production in a no-till system in Cambodia. *Applied Engineering in Agriculture, 37*(5), 805–818. https://doi.org/10.13031/aea.14345

Kong, R., Castella, J. C., Suos, V., Leng, V., Pat, S., Diepart, J. C., Sen, R., & Tivet, F. (2021). Investigating farmers' decision-making in adoption of conservation agriculture in the Northwestern uplands of Cambodia. *Land Use Policy*, *105*, 105404. https://doi.org/https://doi.org/10.1016/j.landusepol.2021.105404

Kong, R., Diepart, J., Castella, J., Lestrelin, G., Tivet, F., Belmain, E., & Bégué, A. (2019). Understanding the drivers of deforestation and agricultural transformations in the Northwestern uplands of Cambodia. *Applied Geography (Sevenoaks), 102*, 84–98. https://doi.org/10.1016/j.apgeog.2018.12.006

Le, K. N., Jha, M. K., Reyes, M. R., Jeong, J., Doro, L., Gassman, P. W., Hok, L., Sá, J. C. de M., & Boulakia, S. (2018). Evaluating carbon sequestration for conservation agriculture and tillage systems in Cambodia using the EPIC model*. Agriculture, Ecosystems & Environment, 251*, 37–47. https://doi.org/10.1016/j.agee.2017.09.009

Leedy, P., & Ormrod, J. (2012). *Practical Research: Planning and Design* (10th ed.) Pearson.

Miller, M. (2022, December 26). *Data analysis of research plots, farmer interviews, and suggestions for future research and farmer assistance* [Presentation]. Department of Agricultural and Environmental Sciences, Crop Genomics Lab, Tennessee State University. https://drive.google.com/file/d/10PTeiTACR-ks4VQI2bjuxyClGWXsTtCQ/view?usp=share_link

Ray, D. K., Mueller, N. D., West, P. C., & Foley, J. A. (2013). Yield trends are insufficient to double global crop production by 2050. *PloS One, 8*(6), e66428–e66428. https://doi.org/10.1371/journal.pone.0066428

Suong, M., Chapuis, E., Leng, V., Tivet, F., De Waele, D., Thị, H. N., & Bellafiore, S. (2019). Impact of a conservation agriculture system on soil characteristics, rice yield, and root-parasitic nematodes in a Cambodian lowland rice field. *Journal of Nematology, 51*(1), 1–15. https://doi.org/10.21307/jofnem-2019-085

Sourn, T., Pok, S., Chou, P., Nut, N., Theng, D., & Vara Prasad, P. V. (2022). Assessment of land use and land cover changes on soil erosion using remote sensing, GIS and RUSLE model: A case study of Battambang Province, Cambodia. *Sustainability, 14*(7), 4066. https://doi.org/10.3390/su14074066

Sumner, D., Christie, M.E., & Boulakia, S. (2017). Conservation agriculture and gendered livelihoods in Northwestern Cambodia: Decision-making, space and access. *Agriculture and Human Values, 34*, 347–362. https://doi.org/10.1007/s10460-016-9718-z