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Editorial: Conservation agriculture: knowledge frontiers around the world

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Editorial on the Research Topic
Conservation agriculture: knowledge frontiers around the world

1 Introduction

Conservation agriculture (CA) has its roots in the dramatic events which happened in the 1930s caused by wind erosion of agricultural soils, resulting from several years of severe drought on overtilled land in the central plains of the United States (southern Colorado, Kansas, Oklahoma, northern Texas), known as the Dust Bowl. This period was then marked by the destruction of grasslands and crops (covered in a few hours by a thick layer of fine soil), the ruin of farmers, the rural exodus of millions of people and the aggravation of the economic crisis. The direct consequence was the creation of the Soil Conservation Service (now named the Natural Resources Conservation Service). World Soil Day was established in 2014 to highlight the need to improve soil quality and to encourage action for the sustainable management of soil resources. Conservation agriculture (CA) has been proposed as a viable option to enhance soil health and long-term cropping system productivity. It relies on three fundamental principles: minimum soil disturbance (i.e., only the soil disturbance required to sow seeds into the soil), permanent soil cover with crops, cover crop, crop residues and live mulches, and crop diversification in space and time (FAO, 2021), amongst complementary practices (*e.g.* appropriate nutrient management, enhanced groundcover with alternative organic resources) to enhance its functioning under the conditions of the global south (Thierfelder et al., 2018). Initiated primarily by farmers to reduce soil degradation and production costs, this crop management system now targets different goals and the simultaneous implementation of the three main CA principles intend to contribute to the delivery of multiple ecosystem services (Hobbs et al., 2008; Chabert and Sarthou, 2020): gradual improvements in soil health (Nunes et al., 2020); increased soil fertility (Bohoussou et al., 2022); reduced soil degradation caused by soil erosion (Van Pelt et al., 2017); improved soil structure (Datta et al., 2022); enhanced water infiltration and available soil moisture (Basche and DeLonge, 2019); reduced reliance on pesticide use through coherent crop diversification (Adeux et al.;

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Petit et al., 2018; Cordeau, 2022); mitigating climate change through carbon sequestration (Powlson et al., 2016; Nicoloso and Rice, 2021); increasing returns on investment while reducing production costs (Pittelkow et al., 2015; Knapp and van der Heijden, 2018); enhancing farmers' reconnection to their biotic and abiotic environment of production (Knowler, 2015). CA has been developed by pioneer farmers and its importance in the world is growing by 10M ha/year (Kassam et al., 2019). It is implemented on a wide array of pedoclimates and production systems primarily in field crops (but also vegetables, vineyard, fruit trees, etc.). However, depending on the region of the world, CA also faces different challenges limiting its development, adaptation, and widespread uptake.

Recent advances have highlighted how research and implementation of CA can benefit from the nexus between multiple disciplines including agronomy, ecology, social sciences, and economics among others. We have constructed this Research Topic to highlight new research avenues and practical actions to improve and promote CA worldwide. We have proposed to scientists who are conducted research on CA for years to bring together their expertise in a wide range of disciplines. Among the manuscripts from around the world that have been selected (Figure 1), several overarching themes emerged: (i) assessment of biological processes occurring in CA fields (Binacchi et al., Behnke et al.), (ii) multicriteria analysis of CA performance and identification of levers to increase adoption of CA (Adeux et al., Ngoma et al., Chaudhary et al., and Krishna et al.), and (iii) *in situ* or *in silico* experiments to improve CA-based practices in different contexts (Fonteyne et al., Krupnik et al., Pinnamaneni et al., and Cordeau, 2022).

2 Assessment of biological processes occurring in CA fields

Improving soil fertility is one of the key objectives targeting CA practices, either through increased biological nitrogen fixation by an increased proportion of legumes in the rotation or reduced N loss through leaching (Nouri et al., 2022) or gas emission (Corsi et al., 2012). Binacchi et al. assessed the capacity of cowpea to biologically fix nitrogen in no-till systems with crop residue and cover intercropping with maize during 6 seasons in Kenya (Figure 1). They reported no positive effect of CA compared to conventional tillage-based plots and suggested future work should explore alternative spatial arrangement and variety selection to intercrop cowpea with maize. Behnke et al. assessed the effects of crop rotation, no-till, and cover cropping as a means to limit N losses, through their effect on microbes involved in the N cycle. They showed that maize monoculture increased nitrous oxide emissions by 44% compared to soybean monoculture mainly due to N fertilization (246 in maize vs 0 kg N/ha in soybean), that cereal rye/hairy vetch cover crop mixture reduced soil nitrate levels, but increased nitrous oxide emissions, likely due to the presence of legume in the cover crop mixture contributing to rapid nitrogen mineralization.

3 Multicriteria analysis of CA performance to increase adoption

It remains difficult and risky for farmers to give up ploughing which is a paradigm rooted in their cultural backgrounds (Lahmar, 2010) since we lack knowledge on conservation agriculture systems on some regions of the globe and particularly on its impacts on fuel and agrochemical use and economic profitability. Adeux et al. analyzed 13 indicators on a multicriteria basis across 3000 farms involved in the French DEPHY farm network in France to assess CA performance including environmental, economic and societal aspects (Craheix et al., 2016; Chabert and Sarthou, 2020). Adeux et al. showed that CA required more herbicides (significant) but slightly less insecticides (even not significant), and decreased time of traction in the field, fuel consumption, as well as mechanization costs. However, CA tended to slightly decrease profitability due to slightly lower productivity but resulted in better profitability per hour of field traction. As in many studies, Adeux et al. encourage further investigation to identify the diversity of responses across a diversity of production situations and to track down the rare systems solving apparent trade-offs (i.e. increased profitability with reduced pesticide use while following CA principles). Ngoma et al. reviewed the evidences that CA is climate smart systems for Eastern and Southern African farming conditions. They identified the reasons why adoption rates by smallholders in this region

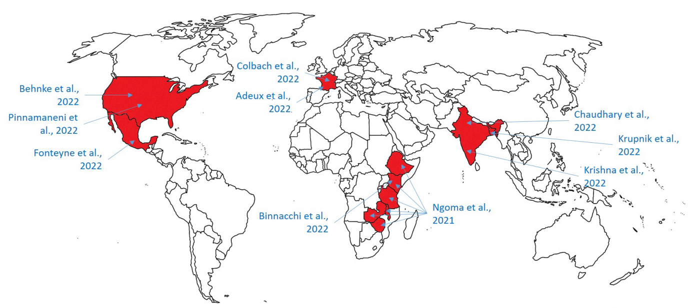

FIGURE 1
Distribution map of the published articles included in the Research Topic.

remains low. They found that CA can contribute positively to productivity and resilience of the farming systems. However, they identified that the degree of success can considerably varies if implemented in farm or household.

Chaudhary et al. explored farmers experiences and the drivers of CA adoption in the Eastern Gangetic Plains of South Asia through 57 qualitative and semi-structured individual interviews. These farmers faced a variety of hurdles and adopted various strategies such as assuming the role of an educator by sharing their knowledge with other farmers in the community, changing mindsets for stover retention, adoption through self-investment. This led farmers to identify a range of benefits such as increased respect in the community, improved socio-economic conditions, and increased free time. Krishna et al. focused on the constraints to adopting zero tillage in rice and wheat irrigated farming systems of the Indo-Gangetic Plains. They showed that farmer adoption was low among smallholders (with less than 2 ha of land). Nevertheless, the benefits are the same for small and large farmers, both in terms of reduced variable costs and improved yields.

4 Improving CA-based practices in different contexts

CA systems combine a diverse set of farming practices, which may evolve since CA adoption (Derrouch et al., 2020). In addition, to improve the benefits and limit the drawbacks of certain practices, research is required to adapt CA to changing climate (Pisante et al., 2015) and pest pressure (Cordeau, 2022). In other regions, CA acreage is increasing where soil erosion and degradation jeopardize the sustainability of agriculture. In Mexico, maize is the staple crop of the country Mexico and often produced by smallholder farmers on sloping terrains. Fonteyne et al. tested conservation agriculture and agroforestry practices, *i.e.* crop diversification through crop rotations, multicropping, relay cropping or agroforestry, in collaboration with local farmers in two states of Mexico (Figure 1). They showed that combining agroforestry with conservation agriculture resulted in a profitable and productive system that also reduced the economic risks for farmers by allowing them to obtain several crops per year. Pinnamaneni et al. tested the effect of a winter rye cover crop on soybean growth and yield, weed control, and profitability under no-till conditions in Mississippi, USA. They showed that CA-based soybean production with rye cover crops could be viable after the first year, since they found positive impact on soybean yield while potential for carbon sequestration and weed suppression. However, it has to be noticed that net returns were lower in year one. More importantly, they identified that conditions are required to succeed, such as deep planting of soybean seeds due to a thick layer of rye residue on the soil surface and additional effort in irrigation to avoid residue blocking water movement, particularly during the first irrigation.

Irrigation is indeed a facilitating practice for CA implementation and crop performance in certain regions of the globe, as mentioned by Krupnik et al. in Coastal Bangladesh. In this region, farmers are interested in growing a second crop in order to increase income and ensure food security following the predominant monsoon season rice crop. However, energy costs, labor, and investment constraints limit their ability to do so. Krupnik et al. concluded that both strip-tilled maize followed by unpuddled transplanted rice and strip-tilled maize followed by fully-tilled, puddled rice with residues retained can result in positive economic, agronomic and environmental outcomes compared to farmers' practice or conventional full-tillage. However, discussions with farmers after the trials revealed that farmers remained more interested in their adapted practices than in the CA practices. The discussions revealed strong practical aversion to using the full suite of CA practices due to logistical constraints in negotiating the hire of laborers for unpuddled manual transplanting.

In order to explore a wider array of farming practices and combinations across different pedoclimates in France and Spain, Colbach and Cordeau investigated *in silico* how much tillage (type, depth and number of passes/year) reduces weed infestation and yield loss due to weeds, and which systems and weed species are the most affected by reductions in tillage. They showed that herbicide treatment frequency index increased when tillage frequency decreased, that no recorded no-till system was herbicide-free, and that long and diverse rotations and cover crops were associated with a reduction in tillage, herbicides, and yield loss. They concluded that no-till cropping systems must be more investigated to determine whether sustainable no-till herbicide-free systems are indeed feasible and sustainable.

Author contributions

SC, LG, MJ, CP, CT wrote and edited the article. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The handling editor EJ declared a past co-authorship with the authors.

Publisher's note

References

Basche, A. D., and Delonge, M. S. (2019). Comparing infiltration rates in soils managed with conventional and alternative farming methods: a meta-analysis. *PloS One* 14, 1–22. doi: 10.1371/journal.pone.0215702

Bohoussou, Y. N. D., Kou, Y. H., Yu, W. B., Lin, B. J., Virk, A. L., Zhao, X., et al. (2022). Impacts of the components of conservation agriculture on soil organic carbon and total nitrogen storage: a global meta-analysis. *Sci. Total Environ.* 842, 156822–156822. doi: 10.1016/j.scitotenv.2022.156822

Chabert, A., and Sarthou, J.-P. (2020). Conservation agriculture as a promising trade-off between conventional and organic agriculture in bundling ecosystem services. *Agricult. Ecosyst. Environ.* 292, 106815. doi: 10.1016/j.agee.2019.106815

Cordeau, S. (2022). Conservation agriculture and agroecological weed management. *Agronomy* 12, 867. doi: 10.3390/agronomy12040867

Corsi, S., Friedrich, T., Kassam, A., Pisante, M., and Sà, J. D. M. (2012). *Soil organic carbon accumulation and greenhouse gas emission reductions from conservation agriculture: a literature review*. Food and Agriculture Organization of the United Nations (FAO). pp 89

Craheix, D., Angevin, F., Doré, T., and De Tourdonnet, S. (2016). Using a multicriteria assessment model to evaluate the sustainability of conservation agriculture at the cropping system level in France. *Eur. J. Agron.* 76, 75–86. doi: 10.1016/j.eja.2016.02.002

Datta, A., Choudhury, M., Sharma, P. C., Jat, H. S., Jat, M. L., and Kar, S. (2022). Stability of humic acid carbon under conservation agriculture practices. *Soil Tillage Res.* 216, 105240. doi: 10.1016/j.still.2021.105240

Derrouch, D., Chauvel, B., Felten, E., and Dessaint, F. (2020). Weed management in the transition to conservation agriculture: farmers' response. *Agronomy* 10, 843. doi: 10.3390/agronomy10060843

FAO (2021) *Conservation agriculture principles*. Available at: https://www.fao.org/conservation-agriculture/overview/principles-of-ca/en/ (Accessed 13th December 2021).

Hobbs, P. R., Sayre, K., and Gupta, R. (2008). The role of conservation agriculture in sustainable agriculture. *Philos. Trans. R. Soc. B: Biol. Sci.* 363, 543–555. doi: 10.1098/rstb.2007.2169

Kassam, A., Friedrich, T., and Derpsch, R. (2019). Global spread of conservation agriculture. *Int. J. Environ. Stud.* 76, 29–51. doi: 10.1080/00207233.2018.1494927

Knapp, S., and van der Heijden, M. G. A. (2018). A global meta-analysis of yield stability in organic and conservation agriculture. *Nat. Commun.* 9, 1–9. doi: 10.1038/s41467-018-05956-1

Knowler, D. (2015). Farmer adoption of conservation agriculture: a review and update. *Conserv. Agric.*, 621–642. doi: 10.1007/978-3-319-11620-4_23

Lahmar, R. (2010). Adoption of conservation agriculture in Europe: lessons of the KASSA project. *Land Use Policy* 27, 4–10. doi: 10.1016/j.landusepol.2008.02.001

Nicoloso, R. S., and Rice, C. W. (2021). Intensification of no-till agricultural systems: an opportunity for carbon sequestration. *Soil Sci. Soc. America J.* 85, 1395–1409. doi: 10.1002/saj2.20260

Nouri, A., Lukas, S., Singh, S., Singh, S., and Machado, S. (2022). When do cover crops reduce nitrate leaching? a global meta-analysis. *Global Change Biol.* 28, 4736–4749. doi: 10.1111/gcb.16269

Nunes, M. R., Karlen, D. L., Veum, K. S., Moorman, T. B., and Cambardella, C. A. (2020). Biological soil health indicators respond to tillage intensity: a US meta-analysis. *Geoderma* 369, 114335–114335. doi: 10.1016/j.geoderma.2020.114335

Petit, S., Cordeau, S., Chauvel, B., Bohan, D., Guillemin, J.-P., and Steinberg, C. (2018). Biodiversity-based options for arable weed management. a review. *Agron. Sustain. Dev.* 38, 1–21. doi: 10.1007/s13593-018-0525-3

Pisante, M., Stagnari, F., Acutis, M., Bindi, M., Brilli, L., Di Stefano, V., et al. (2015). Conservation agriculture and climate change. *Conserv. Agric.*, 579–620. doi: 10.1007/978-3-319-11620-4_22

Pittelkow, C. M., Liang, X., Linquist, B. A., Van Groenigen, K. J., Lee, J., Lundy, M. E., et al. (2015). Productivity limits and potentials of the principles of conservation agriculture. *Nature* 517, 365–368. doi: 10.1038/nature13809

Powlson, D. S., Stirling, C. M., Thierfelder, C., White, R. P., and Jat, M. L. (2016). Does conservation agriculture deliver climate change mitigation through soil carbon sequestration in tropical agro-ecosystems? *Agricult. Ecosyst. Environ.* 220, 164–174. doi: 10.1016/j.agee.2016.01.005

Thierfelder, C., Baudron, F., Setimela, P., Nyagumbo, I., Mupangwa, W., Mhlanga, B., et al. (2018). Complementary practices supporting conservation agriculture in southern africa. a review. *Agron. Sustain. Dev.* 38, 1–22. doi: 10.1007/s13593-018-0492-8

Van Pelt, R. S., Hushmurodov, S. X., Baumhardt, R. L., Chappell, A., Nearing, M. A., Polyakov, V. O., et al. (2017). The reduction of partitioned wind and water erosion by conservation agriculture. *Catena* 148, 160–167. doi: 10.1016/j.catena.2016.07.004