CIMMYT
International Maize and Wheat Improvement Center

Give and Take: Tackling trade-offs in crop residue use for conservation agriculture in Kenya

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According to the Food and Agriculture Organization of the United Nations (FAO), conservation agriculture (CA) is "a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment."

One of the key pillars of CA is practicing minimum mechanical soil disturbance which is essential to maintaining minerals within the soil, stopping erosion and preventing water loss from occurring within the soil. Historically, soil tillage was a key process in the introduction of new crops to an area. It was believed that tilling the soil would increase soil fertility through mineralization. But tilling of soil can cause severe erosion and crusting which will decrease soil fertility. Today, minimum or no tillage farming is practiced to save the soil's organic levels for a longer period and still allow the soil to be productive for longer periods.

When no-till practices are followed, the producer reduces crop production costs and saves time and labor. Tilling ground requires more money (fuel for tractors or feed for animals pulling the plow). The producer's labor time is reduced because he or she is not in the fields as long as a conventional farmer.

The second pillar of CA also protects the soil. Managing the top soil to create a permanent organic soil cover allows organisms to grow within the soil structure. This growth breaks down the mulch that is left on the soil surface, producing a high organic matter level which serves as a fertilizer for the soil surface. The mulch layer that builds up over time becomes a buffer zone, helping to reduce wind and water erosion. This ground cover also helps keep the temperature and moisture levels of the soil at a higher level rather than if it was tilled every year (FAO 2007).

The third CA pillar is the practice of crop association (intercropping) and/or rotation with more than two species. According to "The role of conservation agriculture and sustainable agriculture," published in the *Physiological Transactions of the Royal Society*, rotational crops act as a natural insecticide and herbicide. Not allowing insects or weeds to establish a pattern will help to eliminate problems with yield reduction and infestations within fields (FAO 2007). Crop rotation can also help build the soil infrastructure. In addition, establishing crops in a rotation allows for an extensive build-up of rooting zones which allow better water infiltration (Hobbs et al. 2007).

In summary, the CA system (minimum or no tillage, permanent soil cover of at least 30 percent of the soil surface and crop rotations/associations) helps reduce surface run-offs, improves rainwater infiltration, suppresses and controls weed growth.

The recommended soil cover of 30 percent can reduce erosion by 80 percent. Other factors such as agro-ecology could also affect the amount and diversity of crop biomass.

While conservation agriculture was introduced in some Sub-Saharan African countries about 20 years ago its adoption at scale has been slow. Because of CA's advantages, the slow adoption may be surprising. However, a closer look at the trade-offs needed to make CA successful reveals a different picture. In mixed crop-livestock systems, crop residue (stover) is useful as livestock feed. Stover is also used for fuel, fencing, building storage barns and other structures as well as being a source of income when sold. As a land preparation measure, some households burn stover to control pests and weeds.

Given that permanent soil cover is one of the pillars of CA, these trade-offs can determine the success (or lack of success) of CA under farmers' conditions. For example, farmers who operate on rented land may have reduced incentives to implement CA and use crop residue in the ways suggested. This is because their short-term objectives may not provide incentives to build long-term soil capital. In this brief, we highlight an important but seldom analyzed issue concerning these trade-offs. Little information is available on how to deal with these trade-offs.

Data, methods and analysis

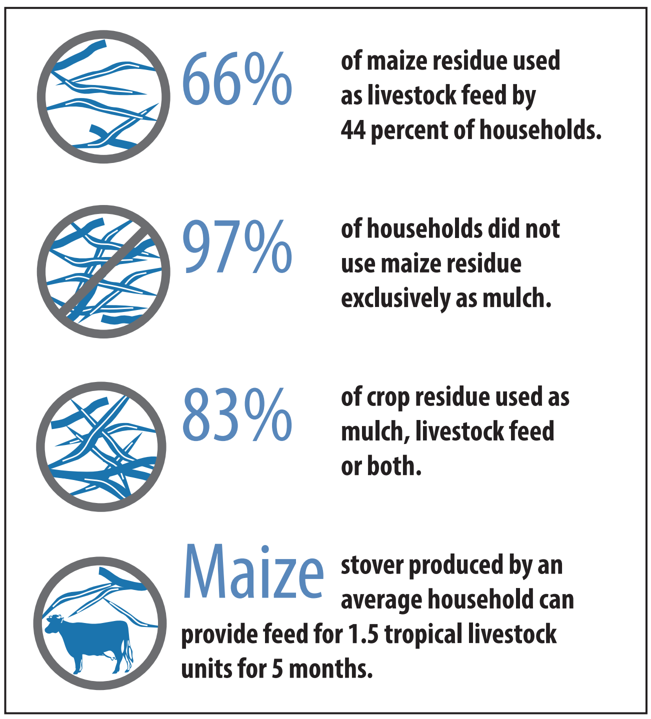
This study was conducted by scientists of the International Maize and Wheat Improvement Center (CIMMYT). It was part of a wider collaborative research involving the World Agroforestry Center (ICRAF) and the Kenya Agricultural Research Institute (KARI). The data came from 613 sample households in five districts in western Kenya (Siaya and Bungoma) and in eastern Kenya (Embu, Meru South and Imenti South). Personal interviews were supervised by researchers from CIMMYT and KARI (Embu and Kakamega). Statistical random sampling was used to select divisions and villages. Sample households were randomly selected proportionately based on total households (from household census records) in the villages. Production and crop residue use data were obtained by recall methods using structured questionnaires to elicit data for the 2010 agricultural calendar.

Key results

On residue use, the data showed that 44 percent of the households used more than 66 percent of their maize residue as livestock feed. Conversely, only 23 percent of the households retained more than 66 percent of maize residue as mulch. Maize stover was the main crop residue because it (maize) covered 67 percent of the cultivated area. Nearly all maize growers (97 percent) used crop residues for alternative uses but not exclusively as mulch. These uses included fuel, animal feed, construction, sale or burning *in-situ*.

Crop residue retention helps reduce surface run-offs, improves rainwater infiltration, suppresses and controls weed growth.

For the most part, livestock feed is the predominant use, followed by soil mulch. This is not surprising because 84 percent of the households keep livestock. The average household in the entire sample owned 1.5 tropical livestock units (TLUs) of cattle plus 2 small ruminants. In total, 83 percent of maize residue is used either as mulch, livestock feed or both. The average amount of maize stover produced per household per year (1.1 tons) can feed a 300 kilogram cow (consuming at a rate of 4.72 kg dry matter/day) for about 7.8 months.



> **The soil fertility impacts of maize stover are also significant. The average maize stover production during the major season was 655kg/household. Recycling this stover as soil mulch potentially provides an equivalent amount of nitrogen and phosphorus available in 33 kg of diammonium phosphate (DAP).**

In cases where maize is produced twice a year, if maize stover is the sole source of animal feed, it can easily provide more than six months of feed for a typical dairy cow. From this study, with an average household owning 1.5 TLUs, the maize stover when harvested and preserved properly can easily feed a dairy cow for five months (a substantial supply of feed).

The soil fertility impacts of maize stover are also significant given the average maize stover production of 655 kg per household (during the main season). This could easily add 6 kg of nitrogen (N), 1.3 kg phosphorus (P) and 9.2 kg K (potassium) to the soil. Therefore, the 655 kg of maize residue can potentially provide the N and P equivalent of 33 kg of DAP (valued at $30 using prices that prevailed at the time the study was conducted). It is clear that depending on the household's preferences and circumstances, a household allocates stover to the use that will best save on costs or yield the highest returns.

Maize stover collected for feed (Embu).

In the relatively livestock-abundant eastern districts, a higher proportion of residue is used as feed. In western Kenya, most of the residue is used as mulch with Siaya district having the highest proportion left in the fields. The key results are as follows:

- Households that had more family labor used lower levels of residue as mulch – family labor being an enabling factor in transporting residue from the fields to the livestock pens or feeding points. In most cases, it is more efficient to harvest the crop residue and feed it to livestock in heaps as opposed to *in-situ* grazing.
- Fields that were far from the homestead had larger portions of residue retained as mulch. This again illustrates the central role of labor in determining how residue is used. In fact, the proportion of maize residue used for soil mulch decreases with an increasing level of family labor available for agricultural use. Family labor contributes to the farmer's ability to transport maize stover from the plot to the homestead for use as livestock feed and other alternative purposes.
- The proportions of residue use both as feed and soil mulch strongly depended on the size of livestock owned and particularly the number of dairy cows. All the three dairy cow types (indigenous, cross-bred and exotic) have a positive and significant effect on the proportion of maize stover used as livestock feed in both seasons. Similarly, the number of trained oxen and bulls owned positively affected the proportion of residue used for feed in both seasons.
- In regard to soil mulch, households which received extension and/or training services on the importance of retaining crop residue on plots left larger proportions of maize residue during both seasons.
- Households which produced more residue due to having larger maize plots used more residue as mulch. The increased residue supply has the potential to reduce competition between the use of residue as livestock feed or mulch.
- A larger quantity of maize residue is retained by households using relatively fertile plots to grow maize. This could be a result of increased biomass production on fertile plots and the produced biomass exceeds the households' livestock feed requirement.

Policy lessons and suggestions for the way forward

- Crop residue is a critical element of CA. Therefore, under mixed crop-livestock systems where livestock (especially dairy cattle) is an integral part of the farming system, CA will succeed only if alternative feed sources are found in order to shift residue use from livestock feed to soil mulch. Alternative fodder crops such as napier grass must be critical components of CA in mixed crop-livestock systems. Hopefully, this suggestion of introducing extra feed crops will still make CA a viable proposition given the cost savings from CA.

Alternative feed sources are important to resolve the trade-offs in crop residue use.

- In cases where introducing a new fodder crop may be economically infeasible (due to small farm sizes for example), then increasing biomass production of maize residue could also help to reduce the competition between animal feed and soil mulch. Giving focus to maize varieties with higher potential of biomass production (without compromising grain yield) and the introduction of alternative feed sources could be crucial.
- When it comes to the extension system, there is need to have a program of Training of Trainers on CA. This should concentrate on creating awareness of farmers on the long-term benefits of CA-based practices. The results of this study show that farmers who had had extension training on the use of residue used a larger proportion as mulch.
- Finally, any strategies designed to retain more crop residue on farm plots should be context-specific based on agro-ecology, cropping systems and the existing level of crop-livestock integration.

This brief is based on Jaleta, M., Kassie, M., and Shiferaw, B. (2013) Trade-offs in crop residue utilization in mixed crop-livestock systems and implications for conservation agriculture, Agricultural Systems, 121: 96-101.

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