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POSTER ABSTRACTS

Poster session 11: Integrating Livestock with Crops

Low-Grade Weirs: An Innovative Drainage Management Conservation Practice with Global Applicability

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Widespread concern for nutrient enrichment of freshwater and marine environments led to the formation Mississippi River/Gulf of Mexico Hypoxia Task Force (HTF), under the US Environmental Protection Agency (USEPA) and the United States Department of Agriculture (USDA). The HTF aims to reduce riverine loads of total nitrogen and total phosphorus from the Mississippi and Atchafalaya River Basins by 45% by 2015. Recent studies highlighted advantages of using low-grade weirs situated in drainage ditches, to reduce effluent nutrient loads, as opposed to traditional control drainage practices such as variable height risers. Weirs have been found to facilitate more efficient management of systems via flexible spatial configurations rather than stationary outflow control structures (Kröger et al. 2008). Implementation of weirs for controlled drainage has proved to be advantageous in semi-controlled experiments by increasing hydraulic residence time (HRT) (Kröger et al. 2008), reducing NO_3^{-}−N concentrations (Kröger et al. 2011) and mitigation of storm water and sedimentation (Kröger et al. 2008). Results of a field-scale investigations of a single drainage ditch also demonstrate that weirs have similar effects on HRT and nutrient reductions (Littlejohn et al. 2014), although, research has yet to demonstrate how spatial and temporal variations of weirs effect nutrient reductions within drainage ditches. Furthermore, traditional agricultural drainage practices in the Mississippi River Basin are limited in that innovative practices for management of water resources have traditionally not been supported by quantifiable data. The overall objective of this study is to quantify the effects of low-grade weir frequency and spatial arrangement on nutrient reduction efficiencies of agriculture runoff using field-based experimental design in the Mississippi Delta.

Study sites are located in the Yazoo Delta Region of Northwestern Mississippi. Sub-watersheds were chosen because of their priority status (MRBI priority watershed former 319(h) watersheds and listing on the 303(d) list) within the Mississippi Delta watershed due to impaired waters (Upper Yazoo – Hydrologic unit code 08030206) and are located on Spruill Farm near Tchula, MS and on Wolf Lake near Yazoo City, MS. Experimental sites, at Spruill Farm and Wolf Lake, total six agricultural drainage ditches, four with multiple weirs installed along their length and two that were not manipulated, serving as reference sites. In addition to data collected from reference sites, base-flow monitoring of drainage ditches prior to weir installation also serves as reference data. Baseflow grab samples were collected if water was flowing every three weeks during the growing season (March-October) and every six weeks during the dormant season (November-February), while storm flow samples were collected on a per rain event basis. Both baseflow and storm flow samples were collected from January 2011 through July 2013.

Results of the nutrient reduction efficiencies of low-grade weirs showed variable nutrient reductions within individual systems before and after weir implementation, with significant indication of post-weir nutrient reductions. Variability of nutrient reductions during both baseflow and storm flow conditions along the length of individual channels also showed within ditch nutrient concentration variability, highlighting heterogeneous inputs and environments for nutrient reductions. To remediate this issue, permutational multivariate analysis of variance (PERMANOVA) was used to account for and identify confounding variables that may be influencing differences observed (or not observed) between sites. Variables included in the analysis were site (for random effects), crop type, rainfall, drainage acreage, season, and weir frequency. Nitrogen species were analyzed with variables separately from phosphorus and total suspended solids. Results showed that drainage acreage and site were found to significantly influence nitrogen loads and analysis of phosphorus species and total suspended solids revealed that crop type, drainage acreage, and season all had a significant influence on loads. In a final analysis to determine overall driving forces of nutrient loads in these systems, a permutational analysis of variance determined drainage acreage, crop type, and site to be the significant driving forces.

Weirs as a best management practice have global applicability to create uniform hydrological and biogeochemical conditions for nutrient removal and can integrate into any agricultural landscape through the ubiquitous use of drainage ditches worldwide. Low-grade weirs are an innovative, relatively low-cost and low-technology best management practice in comparison to large water reservoir systems or bioreactors, making them a more suitable option for large and small-scale farmers alike.

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Getting More Value from Canola (*Brassica napus*)—Opportunities for Mixed Farming Enterprises in Southern Australia's High Rainfall Cropping Regions

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Background

Diversification in a farming enterprise is an essential risk management tool that has led to most cropping farmers in southern Australia's high rainfall zone (HRZ) incorporating livestock into their business. With an increasing area of land being sown to canola every year, the ongoing fit for livestock is becoming a juggle. The introduction of European long season winter type canola varieties into Australia has enabled growers to take advantage of the strong vernalisation requirement in these varieties by sowing earlier, in some cases out of season and effectively getting two crops from the one sowing pass.

Sowing in spring and treating the canola as a forage rape over the summer and autumn months, providing large amounts of high quality feed, before removing livestock and carrying the crop through to harvest with no yield penalty, has a niche fit in many mixed farming operations in the region.

Results

Several field experiments have demonstrated that European winter canola types have suitable phenological characteristics to allow for their use as biennial spring-sown crops, providing significant forage (2500 to 4000 kg/dry matter per ha) for grazing while remaining vegetative through the summer and autumn and recovering following vernalisation in winter to produce high seed yield (2.5 to 5.0 t/ha). Results for one replicated trial sown at Dunkeld in Victoria's south west are presented below (Table 1).

Table 1. Dry matter production and grain yield for spring sown Taurus canola at Dunkeld in 2012

Grazing (no).	Intensity of grazing	Grazing times	Days grazed	DM consumed cumulative (kg/ha)	Grain yield (t/ha)
1	Light	31 Jan - 22 Feb	22	494	2.8
	Heavy	31 - Jan - 5 Mar	34	2316	2.5
2	Light	31 Jan - 22 Feb 29 Mar - 5 Apr	29	2763	2.9
	Heavy	31 - Jan - 5 Mar 29 Mar - 10 Apr	46	2944	2.5
3	Light	31 Jan - 22 Feb 29 Mar - 5 Apr 26 Apr - 3 May	36	3488	2.7
	Heavy	31 - Jan - 5 Mar 29 Mar - 10 Apr 26 Apr - 7 May	55	4031	2.4
		LSD $_{(p=0.05)}$			NS
		Sown in Spring, ungrazed			1.9
		Sown in Autumn, ungrazed			2.3

In 2012, grazing over summer increased grain yield compared to no grazing. Sowing in spring with no grazing yielded 1.9 t/ha with optimal grazing yielding 2.7 t/ha. Taurus sown at the conventional time (April) yielded 2.3 t/ha. Observations were that plants that were grazed had branched more and produced a denser canopy with all stems producing pods for grain. Over 4000kg of high quality dry matter was removed through the heaviest grazing, whilst still producing a grain yield of 2.4t/ha which would be considered adequate for a commercial crop.

Applications and Implications for Conservation Agriculture
Conservation agriculture in southern Australia's high rainfall cropping region is quickly becoming the rule rather than the exception as intensity of farming systems increases. Controlled traffic farming along with minimum till practices have seen large gains in what is a relatively new cropping district. Interest in soil health, particularly minimising soil disturbance and cover cropping is growing at a rapid rate as the benefits of a conservation farming systems are becoming more obvious.

One crop providing a forage and grain component from only one sowing pass, as well as providing a resilient and active crop over the hot, dry summer months is what makes this novel rotation one that has attracted interest from conservation farming groups in southern Australia. Whilst cover cropping has clear benefits, farmers in this unique cropping region are struggling to find opportunities for summer cover crops that are productive and profitable whilst still minimising risk in their business. From an economic perspective, the forage value, which is comparable to most commercially available dedicated forage rapes, has seen the canola paying for itself before it is locked up for grain production.

Experimental Approach
In spring 2011, a replicated field trial was sown at Dunkeld in Victoria's south west to investigate the best management for a spring sown dual purpose canola. Plots were 12m by 2m and sown into an area of failed barley (waterlogged). Grazing management for the lowest impact on grain yield was investigated in this first year of trialling, resulting in three grazing durations and two grazing intensities (light and heavy). Grazing management of the crop is outlined in Table 1, detailing the dates of the three grazings as well as the dry matter consumed during this time. All up, there was just over 4000 kg/ha of DM removed over 55 days of grazing.

Grazing commenced at the end of January 2012 following some decent rainfall in the summer to enable the crop to get up and away, with 3000 kg/ha of good quality dry matter available when most of the area was lacking feed. The area was grazed by dry ewes at a stocking rate of 26 DSE/ha. After grazing was completed, the gate was closed and the trial was left to grow into a grain producing crop and direct headed at crop maturity.

Results and Discussion
Deciding how hard to push the crop at grazing depends on the value of the feed, how the season is going and an individual's attitude to risk. Every grower will have a point at which they feel the benefits and risks are balanced. We aimed to push the crop at different levels to find a 'best bet' and also have a 'worst case' scenario.

The number of times the crop was grazed had a small effect on yield. Grazing twice produced the best result, yielding 0.1 t/ha more than grazing once and 0.2 t/ha more than grazing three times. Although there was a yield penalty by grazing three times compared to two times, the third grazing supplied an additional 1000 kg/DM/ha of high quality feed at the beginning of May. Heavy grazing reduced yield compared to light grazing irrespective of the number of times it was grazed. However the reduction in yield was small and the heavy grazing produced 4000 kg/DM/ha of feed compared to 1400kg/DM/ha when lightly grazed. When deciding on stocking rate and grazing intensity, it can be a trade-off between the value of the feed over summer and autumn and final grain yield suggesting that attitude and preference will vary between growers.

Crop stands thinned by 20 to 30% during summer, and this was exacerbated by grazing, but surviving stands of around 30 plants /m^2 were sufficient to support high yields. The spring-sowing approach has potential to replace the existing forage rape-spring cereal sequence, or to add a further option to the existing autumn-sown winter canola in areas such as southern Victoria, where early autumn establishment can be problematic and spring-sown crops can better withstand attack by pests and winter water-logging that limits yield of autumn-sown crops.

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None

Sustaining Livelihood Security with Village Cluster Approach for Resource Conservation

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Key words*:* Farm income, Participatory approach, Resource conservation technology, Resource use efficiency, Village cluster approach

Abstract

The total number of food insecure people in the globe is probably half the population of the world and is mainly attributed to the direct or indirect consequence of inadequate nutrition. This reveals the enormous magnitude of the vicious cycle of agriculture production systems that operate in the backdrop of rural areas which generate income for livelihood security from the scarce resources. And the most concern one is the huge degradation of our scarce resources such as land, water and livestock as a consequence of over- exploitation and improper technologies coupled with inadequate infrastructure to transfer appropriate technologies. The concerned social issue is multiplication in the status of unemployment, low income, food insecurity, loss of bio-diversity and above all, environmental pollution affecting human & animal health.

In Southeast Asia including India, over 50% of the poor (including the landless & small farmers) have <0.4 hectare land holding and have very limited access to irrigation. They can neither maintain large herds of livestock nor are they able to earn a livelihood from agriculture or any other single activity. Therefore, providing sustainable livelihood and gainful employment to the rural masses through developmental research, appropriate use of regional resources, expansion of suitable technologies and skill development is of prime concern now than ever before (Rafael 2008).

It is crucial to promote a *development Programme* for all the sections in a society through an approach commonly known as *Village Group (VGA) or Cluster Approach* (VCA). A need is felt in our thinking process focusing on a concept called "*viable unit areas of development in rural space"*. It is in this context that an understanding of a cluster of villages comes as a useful grassroots level unit for setting up and organizing rural development programmes at micro-level planning (Shamsul 1999). It is more relevant now-a-days in the case of many agricultural crops as the commodities where farmers face uncertainty with respect to their requirement for planning materials (seed), production, productivity and finally marketing. For example, 'VCA' is established to be a gain to cotton farmers for getting them agriculturally sustainable and economically sound. Similarly, keeping in view the economic significance of insects and pests for example in pulses, important decision for a control measures can be adopted.

Typically, a cluster is a contiguous group of 12-15 village *Panchyats* (group of villages) comprising of 5000 to 6000 families where farmers in a cluster of villages are goaded to take part in holistic development for livelihood opportunities through resource conservation based on interventions involving multiple disciplines (Baif 2006). The underlying principle of mutual trust is the basic element of such a partnership among all the stakeholders. The objectives of such a group approach include solving common felt needs, formulation and execution of action plan through participatory approach involving all the stakeholders. Innovative approaches like contract farming, farmer field school (FFS) and other participatory mode help farmers to enhance their income. FFS is a group-based learning process that has been used by a number of governments, NGOs and international agencies to promote certain goal like integrated pest management (IPM). There is always a possibility of incurring additional costs due to human resources and backward integration operations, yet that could be covered in long run. Therefore, VCA for conserving resource has the key role in enhancing farm income and *upliftment* of rural masses that will in turn help enhancing overall productivity and resource use efficiency (Praharaj et al. 2013).

VCA activities encompasses in the outset, the extension personnel interact with the local community to identify the local problems without any pre-conceived ideas/activities. The community is then encouraged to interact closely and organize the participant families into 3-4 economic categories based on their income and access to various resources. Mostly families that are homogeneous on socio-economic status interact regularly to identify resources and opportunities for individual families belonging to different categories to earn the livelihood. Thus, while the marginally poor and small farmers get smaller support through 3-4 developmental interventions, the poorest families having limited resources are participating in several activities and thus, the chance of failure is less. Moreover, it enables in maintaining transparency and promotes harmony among the members although major challenges encountered in the programme is related to finding an appropriate long term solution (Adrian 2002) for farmers requiring a suitable off-farm production and service activities such as cottage industry, hire-service and civil construction etc. for them (Silvestre 2006).

Potential outputs of VGA includes a) *Livelihood security* involving access to technology, information and market, increase in productivity of crops, livestock including that of natural resources, access to micro- finance, banking and critical inputs etc.; and b) *Community welfares* concerning availability of safe drinking water, drainage and sanitation facilities, health care/nutrition and literacy, gender equity and higher social values etc. The overall impact of such programmes will be capacity improvement for improved livelihood opportunities and self governance. The target oriented impacts mostly include motivation to all round development, substantial increase in agricultural produce, boosting income through Best Management Practices (BMPs), formation of Self-Help Groups (with participation of women), awareness to technical skill development, improvement in milk/meat yielding herds, increased awareness for soil & water conservation practices, efficient use of water and reclamation of degraded lands for agri- horti-forestry & mixed farming systems etc.

Applications of cluster approach through resource conservation finds place in seed village, integrated pest (resistance) management, farm mechanization, higher efficiency in share of common resources (land & water) and watershed development, organic farming, precision farming, reduced cost of cultivation, increased margins through higher production efficiency, risk & uncertainty avoidance, agro-services and entrepreneurship, effective integration with other institutions (banks) for mutual benefits, logistic arrangement, capacity building and skill development (Praharaj et al. 2013). Various case studies involving village cluster approach for enhancing farm income through resource conservation such as crop revolution in Punjab State, *BAIF programme* for sustainable development, Tamil *Nadu* precision farming project, *Periyar PURA* (Provision of urban amenities in rural areas), summer mungbean farming in *Fatehpur, Uttar* Pradesh State and Project *Siruthuli* (revitalizing water bodies) are some of the successful examples.

Two model system are described here. *Cultivation of summer mungbean programme in Fatehpur(U.P.), India* where a model seed system implemented by Indian Institute of Pulses Research, Kanpur and sponsored by ISOPOM. It has started in the year 2006-10 in Fatehpur District of Uttar Pradesh, India. The main focus of this programme is to produce quality seed of chickpea and pigeonpea in the background of traditional rice-wheat cropping system. Latest introduction of *Meha* and *Samrat* mungbean genotypes has resulted in realization of net profit of ₹ 1000/- per day for a period of 60 days (of crop duration).Besides this, there is an increase of yield, net profit and BCR following adoption of modern practices including containing of insects pests in many pulses through viable IPM approach. Thus, the technology expanded to an area of 150 hectares in Malwan block of Fatehpur District in U.P. Development of infrastructure like tube well was also included in the cluster of villages (Singh 2011, IIPR 2010).

Consortium for Sustainable Village-Based Development - Village Earth: This model is outside India and publicly supported by non-profit, non-governmental organization (NGO) based in Fort Collins, Colorado (Teigland *et al.* 2005). The organization works for the empowerment of rural and indigenous communities around the world with active projects with the Oglala Lakota on the Pine Ridge Indian Reservation in South Dakota, the Shipibo-Konibo of the Amazon region of Peru, India, Cambodia and Guatemala (Solvell, 2009). It is associated with the International Institute for Sustainable Development at Colorado State University. The Village Earth includes a sustainable livelihoods approach that recognizes the multi- layered and interrelated survival strategies of rural families and communities and seeks to build on assets and eliminate underlying constraints through an ongoing process of participatory reflection and action (Teigland and Lindquist, 2007). It also includes the clustering and networking of local institutions to promote regional self-reliance without compromising local autonomy (Silvestre and Dalcol, 2009). The development of multi-sector service centers to link local institutions to local, regional, and global resources is also its one of goals.

To conclude, some of the typical resource conservation mediated VGA applications are observed and evident worldwide. Thus, it is now pertinent to highlight them following their importance in resource conservation and enhancing livelihood securities of rural masses. Clusters are a striking and common feature in today's economy as it aids in conservation and judicious utilization of scarce resources. Therefore, an understanding of clusters adds an important dimension to the more commonly debated role of personal contact networks in the success of entrepreneurial farming. This will enable increase in livelihood and farm income of rural masses/farmers through resource conservation.

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An Economic Evaluation of Short Rotation Crop and Crop/Pasture Systems at Tygerhoek in the Southern Cape

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Background

The rural economy of the southern Cape is driven by dryland agricultural production. Deregulation and the withdrawal of state subsidies for commercial agricultural production since 1994 have exposed commercial agriculture to competitive international markets causing producers of agricultural products in South Africa (particularly the grain markets) to compete with products that have been highly subsidized in their countries of origin. These negative economic forces together with the increasing input costs, as well as highly variable and unpredictable climatic conditions have had severe negative impacts on the southern Cape. In this poster we undertook an economic analysis (to the gross margin level considering gross income, and direct and indirect allocatable variable input costs) of a large-scale, long-term experiment that compares several crop and crop/ annual legume pasture rotation systems (Peterson & Varvel 1989). This was done in an attempt to determine the potential economic implications of the most feasible rotation systems for the southern Cape.

Results

The gross margins obtained were the most stable in the continuous lucerne and the two continuous cropping systems. The data obtained from the Tygerhoek trial support the common practice of combining a 6 year cropping phase with a 6-year lucerne phase on farm.

Applications and Implications for Conservation agriculture

The largest effects that crops/pastures grown in one year have on the subsequent crops are usually those on soil-borne pests and diseases, on nutrition and on opportunities to control weeds (McEwen et al 1989). In addition to breaking disease cycles the beneficial effects of legumes in cereal grain rotations are to reduce N inputs in the subsequent grain crop (Herridge 1982, McEwen et al 1989, Petersen & Varvel 1989). Since the southern Cape receives a proportion of its annual rainfall during the summer months, lucerne pastures have the potential to provide high quality green forage in the summer and the winter. Seasonal production of lucerne depends on rainfall and grazing management. Stocking rates of five to six Merino ewe units (one ewe plus one lamb) per hectare are recommended in a rotational grazing system for lucerne pastures (Van Heerden and Tainton 1987). Medic and medic/clover pastures provide excellent quality fodder (seasonal CP% of diet between 15.4 and 30.8) to sheep (Brand et al 1991) during the winter months. Stocking rates of four to five Merino ewe units per hectare are recommended in a continuous grazing system for medic pastures (Van Heerden and Tainton 1987). In addition to providing high quality winter grazing, medic dry matter residues and mature pods (where more than 500kgha-1 DM of pods could remain on the pasture at the start of summer) are well used by sheep during the summer months (Wasserman 1980). Pasture based systems showed the highest total soil carbon accumulation, with 2 consecutive years of annual legume pastures having the highest accumulation. Since this study was conducted the last three seasons have seen massive increases in yield.

Experimental Approach

Long-rotations refer to the establishment of lucerne pastures that are grazed for 5 to 7 years followed by a cropping phase of 5 to 7 years before the next lucerne phase is established for a further 5 to 7 years, and so on. In these long-rotations the proportion of the farm planted to pasture will usually vary from less than 50% in areas with high crop production potential to 60 or 75% in areas where the risk of crop failure is high. Short rotations refer to the situation where a land is planted to an annual legume pasture in annual or biannual rotation with wheat or other cereal crops.

No-till production practices (AUWplow) were used for all crops in the experiment. Data from the 2002 to 2010 seasons were included in the analysis. Five rotation systems were compared, viz. 1-pure lucerne pasture (Luc), 2-PPC , 3- PCPC, 4- PPCC, 5- pure cash crop sequences (where P = pasture (medic/clover mixture), C = cash crop). System 2 and 4 consisted of 4 different cash crop variations each, system 3 had 5 different cash crop variations and system 5 consisted of two different pure cash crop sequences. Cash crops included wheat, barley, canola, lupin, oats and a variable option (cash crop to be planted decided at start of season). Each rotation system tested was fully represented in each year and replicated twice. The experimental design therefore took into account the short- and long-term crop X climate interaction.

Results and Discussion

Crop yields depend largely on seasonal climatic conditions and on management inputs such as fertilization; weed, pest and disease control; and rotation or crop sequence. Average wheat production tended to be highest in systems where wheat followed a single year of legume pasture, followed by wheat after canola. In the short term gross margins differ among rotation systems both within and between years. This was, in part, due to large variations in allocatable variable costs, in commodity prices and crop yields.

From the results it is clear that a combination of these a lucerne phase followed by a cash cropping phase would potentially show more stable gross margins than the systems tested in the trial. Individually, the gross margin obtained from a particular crop or livestock product may look far superior to another product thus discouraging the inclusion of the product which has a low gross margin potential in the production system (Jordan et al, 1997). However, the true benefits of including legume pastures into the cropping system are seen only when the gross margins of all crop and livestock produced from the farming system are taken as a whole.

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Conservation Agriculture in African Mixed Crop-Livestock Systems: Expanding the Niche.

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Introduction
Due to the multiple benefits livestock generates, feeding crop residues to livestock is particularly common in the developing world, where 75% of the milk and 60% of the meat are produced in mixed crop-livestock systems (Herrero et al., 2010; Valbuena et al., 2012). When insufficient quantities of crop residues are retained as surface mulch, minimum tillage alone may lead to lower yields compared with the current farm practices, particularly on soils that are prone to crusting and compaction (Baudron et al., 2012). Based on those observations, some authors have concluded that conservation agriculture (CA) would only fit in a limited set of socio-ecological niches in Africa, which is dominated by mixed crop-livestock systems (Giller et al., 2009; Andersson and Giller, 2012). The objective of this study was to quantify crop residue use (and soil-livestock trade-offs) and explore alternatives to increase the quantity of cereal residues available as soil amendment in two study sites characterized by mixed crop-livestock farming systems: Western Kenya and the Ethiopian Rift Valley.

Material and Methods
A range of methods were used in this study, to fulfill four interrelated sub-objectives. First, current crop residue uses were quantified, using farm survey data. Second, alternatives were explored to increase the quantity of crop residues retained in the field by (1) increasing the quantity produced and (2) reducing livestock demand. These explorations were made using farm survey data and feed trial data. Third, the impact of crop residue mulching on crop productivity was established using on-station trial data. Data was analyzed by estimating crop residue budget, calculating water-limited yield using the boundary line method, and exploring the consequences of different scenarios of residue production and use.

Results and Discussion
Current cereal residue use. In Western Kenya, although there is little competition between the use of crop residues as soil amendment and other uses such as feed or fuel, most farmers retain quantities of crop residues that may be too low to have a significant impact on soil organic carbon and other soil parameters. CA with low mulching rate may also lead to soil crusting and compaction and be detrimental for crop yield (Baudron et al., 2012). In the Ethiopian Rift Valley, the bulk of the cereal residues produced is fed to livestock: over 80% of all the tef, wheat and barley straw, and about two thirds of the maize and sorghum stover. As a result, the majority of farmers (69%) do not retain any crop residue in their fields. Only 3% of the farmers in this site retain at least one t ha-1 of crop residue.

Closing the yield gap to increase maize stover yields. Maize yield in both sites is limited by N and P. Increasing application rates in these nutrients increases attainable maize yield (up to 2700 and 6700 kg ha-1 in Western Kenya during the short and the long rains, respectively, and up to 8120 kg ha-1 in the Ethiopian Rift Valley). However, the efficiency with which N and P are used is low, as the large majority of farmers (78% in Western Kenya and 68% in the Ethiopian Rift Valley) do not produce half of the yield they are expected to achieve given the quantity of N and P applied. This may be the results of a high incidence of yield-reducing factors such as weeds, pests and diseases, and/or of poor response to N and P (Vanlauwe et al., 2010). Assuming a scenario where all the farmers in Western Kenya 'close the yield gap' – i.e. achieving 90% of the water-limited yield potential – the proportion of farmers not retaining any residue in their fields would decrease from 19% to 3% and the proportion of farmers retaining at least one t ha-1 of crop residue would increase from 36% to 93%. Similarly, assuming a scenario where all the farmers in the Ethiopian Rift Valley would close the yield gap, the proportion of farmers not retaining any residue in their fields would decrease from 69% to 13% and the proportion of farmers retaining at least one t ha-1 of crop residues would increase from 3% to 60%.

Providing incentives to increase livestock productivity. Livestock producers tend to respond to increasing market demand for livestock products by using rations that are poor in cereal residues but rich in energy-dense ingredients, and by selecting for cows that have a high individual productivity and require energy-dense rations to fulfill their genetic potential. If all farmers in Western Kenya were to intensify dairy production to a level where cows would be fed on rations containing no maize residues, the proportion of farmers not retaining any residue in their field is predicted to decrease from 19% to 8%, and the proportion of farmers retaining at least one t ha-1 of crop residue would increase from 36% to 49%.

Providing substitutes to the current functions of livestock. In the Ethiopian Rift Valley, animal traction is an important function played by livestock, as the number of pairs of oxen owned by a farm had a significant influence on the farm productivity. Therefore, it was hypothesized that the adoption of mechanization to replace oxen would significantly increase the quantity of crop residues retained in the field. More than half of the farmers would retain one t ha-1 crop residues or more in their fields if tractors were substituted to oxen in this site.

Conclusion

We argue that the focus on trade-offs and competition for scarce crop residues diverts research efforts away from proposing alternatives: the question should not be ‘if’, but ‘how’ crop residues can fulfill the need of both the soil and the livestock. Modifying the supply-side of crop residues without altering the demand-side is unlikely to increase the quantity of crop residues retained in the fields, particularly in areas where farmers tend to maximize the number of livestock they keep. The promotion of combinations of technologies, rather than single component technologies, would be needed, though this requires a major shift in the way research and development is being conducted.

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