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RESEARCH ARTICLE

COMPETITIVE USES OF CROP RESIDUES ARE CHALLENGING SOIL FERTILITY MANAGEMENT IN ETHIOPIA

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ABSTRACT

Crop residues, the fibrous by-product of harvested crops has significant implications for current and future socio-economic and environmental outcomes. It is a precious and/or scarce resource that applied for multipurpose use, although competing applications of crop residues has been creating multifaceted challenges in Ethiopia. This review paper aimed to gather and compile scientific findings and facts about crop residues use in different parts of country. Having multiple determinants, the type and use of crop residue is quite different from region to region and place to place. The types of residues used are mostly field crop left overs, legumesand pulse haulms. Smallholders used their crop residues for animal feed, fuel, construction, soil amendment and for sale with varied proportion. Many literatures confirmed that, crop residue use in Ethiopia is mostly for livestock feed and biofuel source. Decline in natural pasture accompanied by loss of its valuable species and shortage of firewood, inaccessibility of alternative energy source at rural areas are the major causes of using crop residues for livestock feed and fuel source at the expense of soil fertility management in Ethiopia. In one way or another, competitive use of crop residues without retaining adequate amount on farm resulted in poorsoil biological, physical, and chemical properties thus; decline in soil nutrient status and aggravated soil erosion which in turn decrease crop productivity and worsening food security at large. Obviously, theproduct of crops and animals as well as energy isconsistentlydemanded. From the sustainability stand point of views, mixed type of farming should be operated in complimentary way. Based on the existing trend in crop residues use in Ethiopia, smallholders should allocate and retain proper share of their crop residues for soil fertility management purpose and above all, theuse of crop residues should be viewed from conservation agriculture (CA) practice.

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INTRODUCTION

Smallholder agriculture in Ethiopia, the back bone of the country economy, is the dominant sector that provides over 85 percent of the total employment and foreign exchange earnings and approximately 55 percent of the GDP (EPA, 2012). In fact, the contribution of agricultural sector to GDP in Ethiopia is above the average contribution of sub-Saharan Africa. This indicates, agriculture in Ethiopia is known to have long lasted historical ties as the livelihood of the majority of communities and country economy are entirely depends on such giant sector. In most parts of the country smallholders operate crop-livestock enterprises with a strong interaction between the two subsectors (Moti and Berhanu, 2010). In mixed farming system/crop-livestock combination, smallholder farmers cultivate variety of crops and rear different livestock species (Bogale *et al.*, 2008).

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Here in the system, crop residues are becoming an important production component and play an important role mainly as feed, fuel, and soil nutrient balancing (Dagnachew *et al.,* 2012). Crop residues are the fibrous by-product of the cultivation of field crops that are grown for purposes other than fodder (Olaf *et al*., 2011). It constitutes cellulose, hemicellulose, lignin, tannin, oil, wax, resin, cutin, protein, and nucleic acid in which the constituents have been affected by types of crops grown, maturity stage and growing condition (Patrick *et al.,* 1964). It is one of the most important natural resources andreadily available and accessible forms of organic resources for mostsmallholder agriculture (Julia *et al.,* 2016).In cereal production, grain is the main product and the crop residues comprise the stems and leaves, the above ground crop biomass produced. In Ethiopia, smallholder farmers used their crop residues for many purposes,*viz.* for feed, fuel, construction and mulching.In recent time,teff straw and sorghum stover have been traded and even being operated by middlemen, thus considered as a source of income. In Ethiopia, organic amendments such as animal dung and crop residues are

largely used for competing uses, especially as household energy sources, instead of being recycled to maintain soil fertility (Getachew *et al.,* 2012). In addition to low biomassproductivity of crops, alternative uses of crop residues are major constraints which contribute to continuous nutrient depletion.The multiple uses and competing applications of crop residues create many challenges (Julia *et al.,* 2016). It was obvious that, ever increasing population would likely result in maximum pressure on existing natural resources. Conversion of grazing land to cultivation causes degradation and declining in natural pasture. These scenarios continuously result in limited supply of animal feed. As evidenced in a number of field researches, in such cases smallholders in Ethiopia forced to use majority of their crop residues for animal feed thus low retention of residues on the farm has likely been occurring (Moti*et al*., 2012; Frederic *et al.,* 2016; Dagnachew *et al.,* 2012; Julia *et al.,* 2016).

Energy demand, particularly in the rural area is another aspect which has been affecting the livelihood of the community and causing ecological crises. For the great majority of population in Ethiopia, a source of energy is from forest and agricultural biomass (EUEI, 2013; Dawit, 2008). Forest degradation mainly for farm land expansion and firewood collectionis becoming a central issue in the discussion of human and natural capital. Increased cost of fuel accompanied by limited supply, absolute poverty at rural area and lack of access to alternative energy source are prominent challenges currently facing majority of the communities in Ethiopia (Chipman, (1999;Dawit, 2008;Dugassa*et al.,*2017). These multiple challenges have led to consumption shift towards crop residue as household fuels.However, the potential large scale use of crop residues for biofuel raises concerns about environmental impacts (Stephanie and Kristine, 2017). The nature and type of crop residues and purposes for which the residues are used vary markedly from region to region and place to place. More importantly, crop residues are diverse and precious resource which requires wise and efficient utilization. It has a strong positive correlation with soil fertility improvement and in turn soil fertility status ensures crop production in sustainable basis. Documenting how farmers of different localities of the country allocate their crop residues among the competing uses is very important in promoting mixed crop-livestock systems. This review paper therefore attempts to gather and compile scientific findings and facts about competitive uses of crop residues at the expense of soil fertility management in Ethiopia.

Crop residues Potential in Ethiopia

According to FAO, (2014), factors for conversion of grains into residues where used. This was also explained by Sheehan *et al. (*2003) that, there is a 1:1 grain-to-residue relationship between the dry matter of crop grain and the dry matter of crop residues. This indicates, availability of crop residue is directly proportional to grain production. However, Butterworth and Mosi (1985) stated that, the relationship between grain yields and that of crop residue depended on many factors particularly rainfall and time of planting. In other way, the availability of crop residues at the farm level depends not just on production levels but also on a variety of social and economic factors. This implies that, there are a number of determinants in crop residue production. According to Tesfaye*et al. (*2006), in Ethiopia, the total annual residue production varies from place to place depending on the production system of the area and hence the type of crops grown.

Daniel, (undated) reported that, based on 2:1 straw to grain ratio estimation, from about 6 million ha of farm land put currently under annual grain crops, about 12 million tons of crop residues produced.According to the report of EUEI, (2013), the estimated total annual production potential of crop residues in Ethiopia is 22.4 million tons (EUEI, 2013). Kassahun*et al. (*2016) have estimated availability of crop residues in highland and mid altitude areas of Horro and Guduru districts and they reported that the total crop residues produced in both agro ecologies were 10.29 tons per household per year. Bogale *et al. (*2008) from their part reported that, 9.0 tons of crop residues per household were obtained from Sinana and Dinsho sub districts of Bale, Ethiopia. Comparable tonnage also reported from AdamiTulluJiddoKombolcha districts in the central Refit Valley of Ethiopia amounted as 9.79 tons of crop residues per household obtained (Dawit*et al.,* 2013). It is noticed that the potential is varied across region, time of the year as well as growing condition.

Contribution of Crop Residue in Soil Fertility Management

According to Frederic *et al. (*2016), in conservation agriculture, a practice is said to be sufficiently adopted if and only if at least 30% of the soils surface/plot covered by organic material/crop residues immediately after the planting operation. Actually, this requirement isn't well satisfied to different farming system in Ethiopia. Nutrient depletion is an overriding constraint in agricultural field due to leaching effect, fixation and crop removal. The rate of replacement is mostly restricted due to certain limitations like poor adoption of soil fertility management options by farmers and limited supply of organic sources of plant nutrient. These phenomena are known to affects all aspects of crop production and food security at large due to shrinkage in agricultural land.Poor soil fertility status is currently the main constraint to improve crop yields in Ethiopia (Getachew*et al.,*2012; Tewodros and Belay, 2015; Alemayehu, 2006).Organic matter plays a key role in maintaining the fertility of soils by strongly influencing several properties. The application of organic residues to the soil as a means of improving its physical, chemical and biological and thus sustaining its fertility and productivity is currently receiving due attention.A soil with good organic matter enriched through crop residues is known to sink for carbon dioxide, increases soil's water retention capacity and reduces soil erosion (Getachew *et al.,* 2012; Turmel *et al.,* 2015).

Surface cover with residues is more protected, thus reduce directraindrop impact on the soil hence reducingsoil erosion (Anderson, 2009), and well-conditioned (Stephanie and Kristine, 2017; Torbert *et al*., 1999). The physical, chemical and biological properties of soil could be adjusted to the level of best suited for crop growth and development.Residue retention on farm will result in higher soil quality and more stable and higher yields (Getachew *et al*., 2012; Nele *et al*., 2009). Crop residues are applied to the soil as a source of nutrients for the plant, a practice that fits in well with the current world-wide trends towards resource conservation in agriculture, and, particularly, with the growing interest of local farmers in alternative agricultural practices, such as organic farming and zero- or reduced-tillage (Borie *et al.,* 2002). Today, the burgeoning population pressure has forced many countries to use chemicals and fertilizers to increase the farm productivity for meeting their ever-increasing food requirements. In Ethiopia, inorganic fertilizers remain the main yield-augmenting technology being aggressively promoted by

the government and institutions. However, from sustainability point of view, without organic recycling it is impossible to achieve long-term positive and significant impacts on soil and agricultural productivity and greater economic benefits (Getachew *et al*., 2012). It was well evidenced in a number of studies thatcombined application of inorganic fertilizer and crop residues improved crop yield compared to application of only inorganic fertilizer (Bationo *et al*., 1993; Mubarak *et al.,* 2003). From this perspective, the integrated use of chemical fertilizer and locally available soil amendments is the best approach for achieving higher fertilizer-use efficiency and economic feasibility. Crop response to chemical fertilizer and other inputs dramatically improved through intensive use of crop residues. In this case, chemical fertilizers address short-term crop nutrient demands, organic inputs are fundamental for soil fertility management through their longer-term contribution to soil organic matter formation (Lal 2009). Therefore, a key policy intervention for sustainable agriculture is to encourage adoption of agricultural technologies that rely to a greater extent on renewable local or farm resources, like crop residues.However, researchers have been reporting that there is a huge competition to retaining adequate crop residues on the farm particularly in Ethiopia.

The competitive uses of crop residues at the expense of soil fertility management in Ethiopia

Livestock feed

The majority of farming system in Ethiopia is mixed type of practices in which both animal husbandry and crop production practiced in complimentary way. This to mean that, crop production depends on animals particularly for cultivation, threshing and manure source and in turn the crops, mostly its straw being produced are used as feed sources for animals. In Ethiopia, the common livestock feed resources are crop residue and natural pasture. The later one is characterized by poor management and overstocking, and are highly overgrazed as well as excessive conversion in to cultivated land and resulted in severe land degradation, loss of valuable species and dominance by unpalatable species (Alemayehu,1985). Feed scarcity in both quantitative and qualitative dimensions is the major impediments for the promotion of the livestock sub-sector in Ethiopia (Jimma*et al*., 2016). With decline in grazing resources/shortage of grazing lands and the absence of alternative feed resources accentuate the increased dependence on crop residues in different parts the country (Tsegaye *et al.*, 2008; Julia *et al.,* 2016).

Large number of research report conducted in different parts of the country confirmed that, crop residues of different sources played a significant role as source of animal feed and hence crop residues have long been important as a maintenance feed for ruminants. Alemayehu, (1985) reported that, Straws from teff, barley and wheat form the largest component of livestock diet in the mid and highland areas, while maize, sorghum and millet Stover's constitute larger proportion of livestock feed in lower to medium altitudes. Accordingto Funte*et al. (*2012), crop residues were found to be major feed resources for the livestock in southern Ethiopia, particularly during the dry season in which the biomass of the natural grazing lands is very minimal. According to these authors, Enset by-products, sugarcane top, maize stover, haricot bean are among the type of residues used. In the Ethiopian Rift Valley, the bulk of the cereal residues produced is fed to livestock such that over 80% of all the teff, wheat and barley straw, and about two thirds of the maize and sorghum stover (Frederic *et al.,* undated). Tesfaye, *et al.* (2006) reported that, the bulk of haricot bean haulms were used as livestock feed as it was known to be of high feeding value because of being a legume. The report of Frederic, *et al*. (2016) showed that, about 95% of farmers from sub-humid areas of East and West Shewa zones in Ethiopia used crop residues for animal feed. The commonly prevailed types of crop residues are wheat, maize, barley an teff.

Livestock feed exerts a competitive pressure on residue use as soil mulch Moti *et al. (*2012).As reported by Frederic *et al. (*2016), farmers of sub-humid areas of east and west showa zones of Ethiopia missed to allocate their crop residues as soil retention rather they inclusively, 95%, used the residues as animal feed.According to the report of Dagnachew*et al. (*2012), the current trend for increased feeding of crop residues to livestock has long term implications for soil fertility and hence local livelihoods.The result of baseline survey conducted by Ashraf *et al*. (undated) in Ethiopian highlands showed that, legume straw use as feed has been increasing and use for mulching decreasing in the past 5 years. Similar results was reported from Zimbabwe that, smallholder farmers find permanent soil cover difficult or almost impossible to maintain due to the competition for crop residue for different household uses(Mutsamba*et al.,*2012). CABI, (1997) suggested that, while livestock are the most obvious users of crop residues, we should not forget that crop residue may also play important alternative or complementary roles in sustaining future crop production by conserving soil moisture, preventing erosion and increasing soil organic matter content. It should be to make effective use of residues and by-products as feeds but also for soil amendments, fuels and/or other non-feed purposes.

The crop residue given for livestock in different parts of the country was usually at dearth periods and the type of residues, its quantity and quality as well as feeding system was quite different across the region. In some parts of the country, for instance southwest region, during dry season particularly after main harvest (October-December) animals are left free and allowed to consume residues directly on farm. Similar result was reported from central parts of the country that, communal grazing of cropland outside the cropping season is a common practice (Frederic *et al.,* 2016). However, the practice limits the ability of farmers to control the residue on their farm as the crop land is open for all. The practice of feeding livestock with crop residues in the mornings and evenings around homesteads has been reported to increase in the recent years in the Bale highlands of Ethiopia due to the reduction of the herbage obtained from natural pasture because communal grazing areas are overgrazed (Bogale *et al.*, 2008). There is no or very limited effort observed to make crop residue palatable and supplement with concentrate or other nutritionally rich feeds (Dagnachew *et al.,* 2012).

Bio Fuel Energy Source

In Ethiopia, almost all fuel consumption of the rural poor is obtained from the traditional biomass which results in disruption of the ecosystem. According to Jargstofer (2004), Ethiopia is the third largest user in the world of traditional fuels for energy use, with 96% of the population dependent on traditional biomass to meet their energy needs. Heavy dependence on wood and agricultural residues for household energy has impacts on the social, economic and environmental

well-being of society (EUEI, 2013). It has been forecasted that the mean annual firewood deficit of Ethiopia will be 5.6 million tons by the year 2030. The driving force for such upcoming shocking event includes acute shortage of firewood Chipman, (1999), poverty and technological backwardness Dawit, (2008) and limited access to alternative modern energy sources (Dugassa *et al.,* 2017). All these factors would leads to crop residues use for fuels at the expense of application to farmland to improve soil fertility. These fuels are usually collected freely from farm.

The competitive use of crop residues for fuel purpose has been declining soil fertility in Ethiopia as similar as that of using for livestock feed. Here too, literatures confirmed again the use of crop residues for fuel reduced soil fertility status. According to the report of (UEI, 2013), In Ethiopia, annually produced crop residues are estimated to be 22.4 million tons, from which about 10.3 million tons are used as fuel. As a result, soil amendment with organic wastes in the Highlands of Ethiopia (where crop residues produced in large amount) has been greatly reduced by widespread use of crop residues as fuels. Catchment based survey conducted by Kassahun *et al. (*2013) revealed that, the portion of the harvested above ground biomass of crops that remains on the field are used for fuel source. In this case, the watershed loss a significant amount of nutrients every year and consequently food insecurity and poverty of communities in the region isthreatening. Similar results were reported by Dugassa *et al. (*2017) that, complete removal of crop residues from farm resulted in the very high loss of nutrients (N, P and K) from croplands thus farmlands have become increasingly infertile and crop production without chemical fertilizer has become difficult.

It was obvious that animal dung and crop residues are important organic amendment in sustaining soil fertility status and thus increases sustainable crop production. Despite the advantages that the residues and animal dung provide, both are largely used for competing uses, especially as household energy sources, instead ofbeing recycled to maintain soil fertility (Bojo and Cassels, 1995; Getachew *et al*., 2012).In areas like highland cereal zones of the North and central Ethiopian highlands, animal dung were mixed with teff, barley and wheat straw to make cake (fig.1). Then the dried cake used for cooking (household energy source) and seldom sold to generate additional income for household.

Fig 1.Fresh animal dung mixed with teff, barley and wheat straw to form cake, Oromia region East Shewa zone, Edjere woreda.

Fig 2. Teff straw for construction purpose which is ready for sale: Mettu Town, IluAbabora Zone of Southwest Oromia

Conclusion and Recommendation

Now days, the issue of sustainable agriculture and natural resource conservation is very alarming and more often calling for intelligent efforts. The economic development of our country Ethiopia has been depending on the performance of agriculture and the contribution of this natural resource based sector is entirely depend on how the natural resources are managed. It was commonly asserted that maintaining the sustainability of natural resource is basis for boosting agricultural production. Having mentioned the multiple uses of crop residues, its value has important implications for current and future socio-economic and environmental outcomes. Although the purpose and often the type of residues used are different from region to region, the potential use of crop residues for livestock feed and biofuel source is currently seems competitive. As reported by Lal, (2006), using crop residue as feed for domestic animals and fuel isa driving force behind the depletion of the soil organic matter pool in the tropics and subtropics, leading to soil degradation, a decline in soil structure and texture, severe erosion, emission of greenhouse gases, and water pollution. Based on the existing trend in crop residue use in Ethiopia, farmers should allocate and retain proper share of crop residues for soil fertility management too. To do so, extension services for smallholders on crop residue use and management should be strengthened. More importantly, the use of crop residues should be viewed from conservation agriculture practices.

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