Dual-Purpose Crops

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Competition over land between food and fodder production, along with recurrent droughts and increasing population, has put mixed crop–livestock farming systems in the drylands of sub-Saharan Africa under pressure. Dual-purpose crops hold huge potential to ease this pressure and simultaneously improve food and fodder availability in these systems.

mixed farming system | maize | sorghum | groundnut | dual-purpose crops | trait preference | Zimbabwe

1. Introduction

Mixed crop–livestock farming systems dominate smallholder agriculture in many sub-Saharan African countries [1][2]. Crops provide food and income to households, while crop residues are an essential fodder source for livestock [3][4][5]. In return, livestock provides power and animal traction, livestock manure to increase soil fertility, and livestock improves the quality of human nutrition. In addition, livestock serves as a buffer against adverse climatic changes and other disasters. Finally, farmers use livestock sales to smooth consumption and invest in crop production [6][7][8]. Therefore, it is hard to imagine farming without the tight integration of crops and livestock in smallholder agriculture in sub-Sahara Africa.

Across Africa, smallholder agriculture is confronted with the degradation of natural resources, such as soils, land, water, and forests [9]. Relatedly, mixed crop–livestock farming systems are under increasing pressure as a result of intensified competition for land between crop and livestock production, along with recurrent droughts and an increasing human population [10][11]. For example, where land allocated by farmers to pasture has declined over time, feed production is at stake [12]. Because farmers in these systems live on meager resources and struggle with achieving household food security, much of the crop production is targeted for food, although crop residues are important livestock feed resources [12][13]. Therefore, feeding livestock adequately throughout the year remains a challenge for many smallholders in sub-Saharan Africa [14][15].

In response to livestock feeding challenges, farmers increasingly look for new options to improve their crop–livestock enterprises' productivity and efficiency [16]. One such option is dual-purpose crops that have a high potential to mitigate the land competition between food and feed through simultaneously enhancing grain yields and the availability and quality of livestock feed [15][17][18][19]. Compared with grain-only crops, dual-purpose crops

help to improve the profitability, environmental sustainability, and resilience of the whole farm system substantially [6][20]. Dual-purpose crops can also offer great opportunity for intensifying farming systems.

As elsewhere in Africa, farmers in Zimbabwe rely heavily on mixed crop–livestock activities for their livelihood. Amongst the most important dual-purpose crops for farmers are maize (*Zea mays*), sorghum (*Sorghum Bicolor* L. Moench), and groundnut (*Arachis hypogaea*). These crops are the most important food crops for most of the country's predominantly rural population, while their residues are essential animal feed resources in the mixed crop–livestock systems [21]. In support of these farmers, most efforts by researchers for improving the quality of crop residues for feed have considerably focused on post-harvest interventions [18]. Traditionally, crop improvement programs of the national and international agricultural research community bred for higher grain yield and resistance to biotic and abiotic stress of varieties, ignoring biomass and other fodder attributes. However, recently, these crop improvement programs have shifted the focus to developing dual-purpose cultivars of maize, sorghum, and groundnuts [22][23].

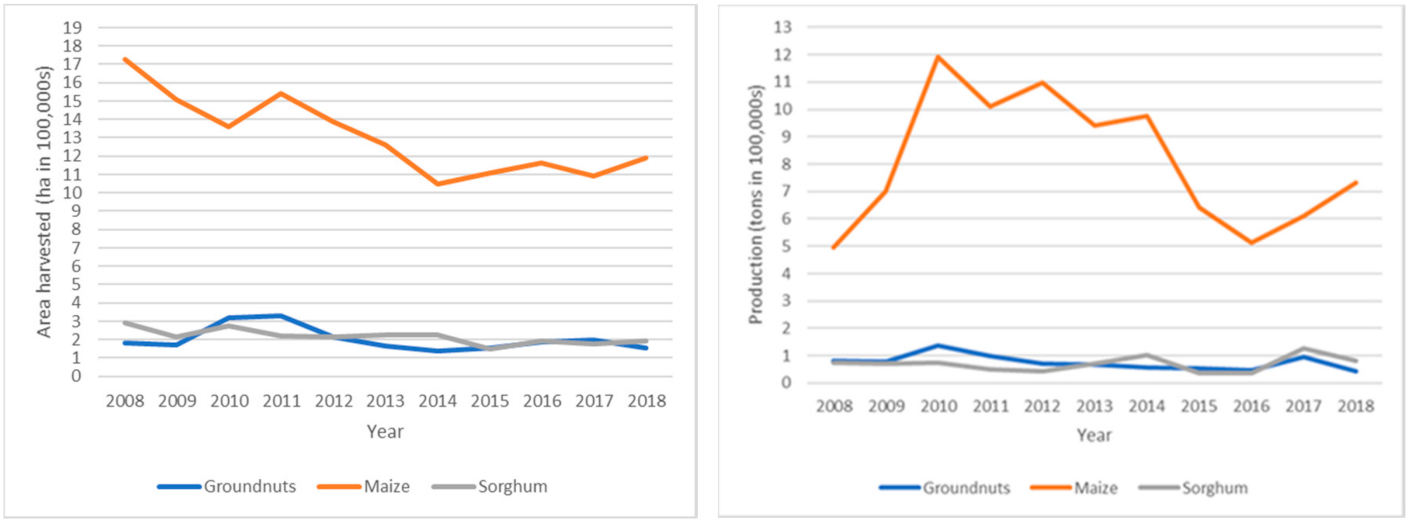
Despite the recent reorientation of crop improvement programs, farmer adoption of improved dual-purpose crops is not a given. A farmer's decision to adopt a new variety is a complex process governed by social, economic, and technical factors [24][25]. Trait preferences of farmers further influence adoption, but these are not well documented for dual-purpose crops [11], and they are hardly available for Zimbabwe. Understanding farmers' perspectives and preferences for specific traits of dual-purpose crops is critical to inform breeding and the targeting and development of improved dual-purpose varieties by researchers.

2. Dual-Purpose Crops in Zimbabwe

In Zimbabwe, maize, sorghum, and groundnuts support the integration between crop and livestock enterprises in various forms, driving the development and research agenda. Shortage of feed, particularly during the dry season, has long been recognized as one of the major factors limiting livestock productivity in Zimbabwe [10][26]. This suggests a large role for dual-purpose crops to play in addressing this challenge in the country.

Previous studies have also documented that dual-purpose cultivars could mitigate feed shortages by increasing the available feed quantity and quality in the country [27]. The integration of crop and livestock enterprises is expected to enhance general technical efficiency and improve the input-to-output ratios of water, land, labor, and other inputs in the system [28]. Additionally, exploiting potential synergies between crop and livestock production can help farmers use the most of every resource in their mixed farming systems and avoid less optimal "early specialization" of the systems [28]. Similarly, dual-purpose crops could improve environmental outcomes and provide ways to mitigate risk and minimize adverse effects of long-term climate changes [8][20][29]. Dual-purpose crops can help smallholder farmers deal with trade-offs between competing uses of scarce land for food and feed production. This may also help reduce conflicts between crop and livestock farmers over land resources, especially trespass by nomadic communities.

In Zimbabwe, maize, sorghum, and groundnut are major crops in the mixed crop–livestock systems. Figure 1 displays the land coverage and production trends for these crops over the last decade. Maize is an essential crop for food and feeds in Zimbabwean mixed crop–livestock systems [27]; it is the most widely grown cereal across the country in all agroecological zones. It accounts for about 80 to 90% of the total cereal area in Zimbabwe, with the annual area under the crop effectively exceeding one million hectares over the last ten years. Maize production is mostly rain-fed in Zimbabwe. As a result, maize production is hampered by frequent dry spells and erratic rainfall due to current climate change threats [30]. This is evident from Figure 1 as the land coverage and maize production has declined for the large part of the last decade.



(**a**) Land coverage (**b**) Crop production

Figure 1. Land coverage (**a**) and production (**b**) trends for maize, sorghum, and groundnut in Zimbabwe. Source: FAOSTAT 2018.

Sorghum and groundnut are also relevant crops in terms of importance and area coverage in Zimbabwe. Sorghum is unique in its ability to grow under a wide array of harsh environmental conditions, making it a resilient crop widely used for food, feed, and beer brewing, especially in drylands where the adversities presented by climate change are substantial [31]. Residues of sorghum are an important source of dry season fodder for livestock [32]. Sorghum can be fed for livestock as wilted green chop, silage, and grain. It is primarily a feed energy source, with an estimated 65% total digestible nutrients. Similarly, groundnuts are an important source of Zimbabwe's food and income [9]. Groundnut haulms have a higher crude protein content compared to cereal residues and are a valuable source of supplementary feed during the dry season in mixed crop–livestock farming [33]. Groundnuts also contribute to soil fertility through biological nitrogen fixation.

Over the years, many improved maize, sorghum, and groundnut varieties have been developed and released in Zimbabwe. Under the Ministry of Agriculture, Mechanization and Irrigation Development, the Seed Services Institute has registered more than 100 improved and hybrid varieties of maize, about 5 sorghum, and more than 15 groundnuts, developed for different purposes. Table 1 shows the most widely grown varieties of the three target crops and a summary of their main characteristics. Nationally, SC 513 is the most widely grown variety of maize.

This is not surprising as it possesses the highly valued and preferred grain and field attributes by farmers. SC SILA and SC SMILE are the most preferred sorghum varieties in Zimbabwe, while Macia is an early-maturing variety with a terminal drought escape mechanism and wide agronomic adaptation. Nyanda and Ilanda are widely grown groundnut varieties.

Table 1. Selected widely grown maize, sorghum and groundnut varieties and their associated characteristics in Zimbabwe.

Variety	Local Name	Release Year	Main Preferred Trait(s)	Non-Preferred Trait(s)
Maize				
SC 513	Mbizi	1999	Yield, earliness, drought tolerance	Susceptible to ear rots, maize streak virus
SC 403	Tsoko	1998	Earliness, drought tolerance	Susceptible to ear rots
PAN 53	PAN 53	2007	Appeal, nitrogen use efficiency, drought tolerance	Susceptible to maize streak virus
SC 727	SC 727	2010	Yield, wide-area adaptability, drought tolerance	Open tips, susceptible HT
PHB 30G19	PHB 30G19	2008	Drought tolerance, high bulk density	Susceptible to maize streak virus
SC 719	SC 719	2004	Yield, wide-area adaptability, biomass yield, drought tolerance	High ear placement
Sorghum				
SC SILA	SC SILA	2004	Yield, grain color	Bird damage (highly preferred by birds)
SC Smile	SC Smile	2011	Drought tolerance, earliness, plant architecture	Susceptible to leaf blight
Macia	Macia	1998	Yield, grain color, wide adaptation	Bird damage (highly preferred by birds)
NS 5511	NS 5511		Yield, market demand	Cost of seed is expensive
Groundnut				
Natal Common	Kasawaira	1988	Earliness and drought tolerance	Susceptible to cercospora, web blotch
Nyanda	Nyanda	2000	Yield, drought tolerance	Susceptible to ground rosette and cercospora

Variety	Local Name	Release Year	Main Preferred Trait(s)	Non-Preferred Trait(s)
Jesa	Jesa	1999	Yield	Less preferred grain color
Ilanda	Ilanda	2006	Grain color	Susceptible to ground rosette and cercospora
Flamingo	Flamingo	1982	Yield, confectionery use	Susceptible to drought
Makulu Red	Makulu Red		Yield, confectionery use	Susceptible to drought

Source: Seed Services Institute, Ministry of Agriculture, Mechanization, and Irrigation Development.

Still, the potential of crop breeding to improve the quantity and quality of crop residuals is huge [15][19], particularly in the Zimbabwean drylands where fodder is scarce. Assessments of the potential of dual-purpose cultivars for enhancing feed supply show that they can considerably increase feed quantity and quality to mitigate feed shortages [27]. Several studies show that grain yield, disease resistance, and drought tolerance or early maturity are the most important traits that farmers in Zimbabwe appreciate in their crops [30][34]. All these traits matter, especially given the potential that [35] estimated that a one-percentage unit increase in digestibility in sorghum and pearl millet stover would increase milk, meat, and draught power from 6 to 8%. Unlocking such benefits in Zimbabwe would make important contributions to more sustainable livelihoods for farmers.

Given the potential benefits of dual-purpose crops, breeding and testing for dual-purpose cereals and legumes have attracted growing interest. Several ongoing dual-purpose crop improvement efforts seek to optimize both grain yield and feed quantity in many developing countries [15]. Nevertheless, for new varieties to succeed in Zimbabwe, crop breeders must account for end-user and market trait preferences in developing varieties. To this end, insights into farmers' demand for specific varietal attributes are useful for setting goals for crop improvement programs, optimizing limited resources in breeding programs, and motivating farmers to adopt improved varieties.

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