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# Grain legume production and their potential for sustainable agriculture in Botswana between 2008 and 2015: a review

**Mashungwa, G. N.,[1*] Moroke, T. S.,[1] Kgosiesele, E.,[2] and Kashe, K.[3]**
[1]Department of Crop Science and Production, [2]Department of Agricultural Engineering and Land Planning, Botswana University of Agriculture and Natural Resources, Gaborone, Botswana
[3]Okavango Research Institute, University of Botswana, Maun, Botswana

*****Corresponding Author: gmashungwa@buan.ac.bw; Tel: +26736050336, Fax: +2673552908

GNM conceptualized idea, collected and analysed data, drafted manuscript, edited final manuscript. TSM data analysis, drafted manuscript, edited final manuscript. EK data analysis, drafted manuscript, edited manuscript. KK data analysis, drafted manuscript, edited manuscript.

## ABSTRACT

Pulse crops are an integral component of arable agriculture in Botswana, particularly in subsistence farming. The benefits of these crops include provision of nutrition for both human beings and livestock, as well as environmental sustainability needs. Although they have a far reaching socio-economic impact, these benefits have not been adequately characterized for inclusion in endeavors of conservation agriculture in the country. Furthermore, data on pulses are often lumped together without identifying important pulse crops grown in Botswana. The objective of this paper was to review production of pulses and their potential as components in cropping systems and conservation agriculture in Botswana. The data used in this study were obtained from reports of Ministry of Agriculture and Food Security (MOA), Statistics Botswana, FAOSTAT and other literature sources. With the ongoing changes in climate and predicted increase in incidences of drought, pulses are among crops most relevant to sustainable agriculture. They are among the most versatile because of their variability in cropping duration from early to late maturity. Their consumption ranges from fresh forms to physiologically mature grain. Pulses play an important role in climate change mitigation through their ability to fix nitrogen, thus reducing dependency on organic and synthetic fertilizers. They use less water from relatively shallow soil and allow for stratified soil water use for companion crops in intercropping or conserve soil water for subsequent crops in rotations. Thus pulses improve both water and nutrient use efficiencies when included in cropping systems. Their production also has a low footprint in both carbon and water. Currently, pulses are among the few highly priced crops in Botswana markets and together with the possibility of replacement of imported grain, investments in their production can generate income and improve livelihood of both farmers and consumers in Botswana. Crop production management technology involves judicious use of integrated nutrient, pest and disease management; appropriate integrated management packages that include pulses can be promoted to ensure sustainable crop production under the adverse impacts of climate change.

**Keywords:** Botswana, climate change, nitrogen fixation, pulses, sustainable agriculture

## INTRODUCTION

The family Leguminosae, is the most important to man after the grass family, Gramineae (NAS, 1979; McKevith, 2004). With the exception of groundnut (*Arachis hypogaea* L.) and soybean (*Glycine max* L. Merril), most research and development efforts have been expended on cereal crops such as maize (*Zea mays* L.), pearl millet (*Pennisetum glaucum* L. R. Br.), grain sorghum (*Sorghum bicolor* L. Moench) and wheat (*Triticum aestivum* L.) (McKevith, 2004; ICRISAT, 2016). Nonetheless, the Leguminosae have occupied attention in recent years because of increased awareness and concern regarding animal and human food and nutrition securities and degraded environmental health, especially for poorly-resourced farmers (Hugue et al., 1986; ICRISAT, 2016).

This plant family is divided into three subfamilies: Caesalpinioideae (mainly trees of the tropical savanna and forests); Mimosoideae (small trees and shrubs) and Papilionoideae (mainly shrubs, distributed worldwide). Leguminous plants grow worldwide but their greatest variety is found in the tropics and subtropics. All legume plants bear pods that contain seeds, a characteristic by which they can easily be recognized. The Papilionoideae subfamily contains the most important legumes cultivated by man.

The yields and production of pulses have remained stagnant and fluctuate mainly due to climatic conditions and poor management prevalent in subsistence agriculture. In contrast, developments in cereal production have excelled as a consequence of the Green Revolution (Considine et al., 2017). Additional reasons for poor productivity of pulses are that they are considered secondary to cereals in terms of consumer preferences and prices are unstable due to high variability in their yield. However, due to the complementary benefits of the two grain crops, development efforts for them should be parallel to be useful for the farming community and the nation as a whole.

Pulses are recognized as important for food and nutrition securities, soil health and as climate smart crops. The government of Botswana in its strategies for developing agriculture is promoting increased crop production that includes pulses (MOA, 2008). The FAO has made a declaration to promote the cultivation of pulses and hence declared 2016 as International Year of Pulses (FAO, 2016). There has also been a rise in prices that has led to an increase in demand for pulses, leading to an increase in numbers of farmers growing them. The increased demand for livestock feed has contributed significantly to changes in the demand structure. Furthermore, high prices and shortage of fertilizers and the need for efficient use of resources have increased interest in pulses, in particular, their inclusion in conservation agriculture (MOA, 2017).

The objective of this paper was to analyse trends of planted area, total grain production and yield of pulses between 2008 and 2015. The information was further evaluated for possibility of using pulses technologies to improve overall productivity of farming systems and their usefulness in environmental and human health and economic vitality in Botswana. This paper was produced through reviewing of secondary data published in research, annual and consultant reports. The share of pulses in total cultivated area and production was examined for the period between 2008 and 2015.

***Classification and use***

Legume crops can be classified into those with low or high edible lipids with the latter being known as oil seeds while the former are harvested for dry grain (also known as pulses) (NAS, 1979; ICRISAT, 1991). Many of both classes are eaten raw or cooked as green vegetables (Muelhlbauer, 1993). A third class of legumes of agricultural importance include many species of pasture, cover and fodder as well as green manure crops. Other legumes grow in the wild and some are being domesticated, for example marama bean (*Tylosema esculentum*) (Dakora et al., 2015) and wild coffee bean *(Bauhinia petersiana* Bolle.) (UPP Botswana, 2012). Pulses or grain legumes are dry seeds of legumes eaten as a food or crops that produce these seeds (NAS, 1979; FAO, 1984). Soybean and groundnut are grain legumes that are mostly grown as oil seeds and are generally not referred to as pulses (FAO, 1984). However, sometimes the name pulse is not used strictly as oil versus food grain because dry legume seeds may be used for different purposes. For example, soybean is grown as an oil seed in Brazil (Alves et al., 2003) and as a food grain in Africa (IITA,2013), and in China (Liu et al., 2017). Leguminous crops grown for seed production are not considered as pulses.

In Botswana, different portions of legume crops may be harvested at various stages of development for food including dry grain at the end of the season. From two to three weeks after emergence, young leaves are harvested and cooked as a vegetable. Similarly, immature pods and green grain of beans and peas and immature seeds of Bambara groundnut and peanut are harvested, cooked and eaten. Finally, dry seeds of legume crops are harvested and cooked or stored for future uses. In this way, pulse crops can provide food for most of the year. Thus, it may be difficult to classify a crop solely as a pulse. Furthermore, oil extraction from groundnut is not documented in Botswana, but the crop is grown for grain only and it is thus a pulse crop.

Pulse crops are a vital component of crop production because they assist in achieving food and nutritional security for farmers and consumers in Botswana (Lightfoot, 1980; Lightfoot, 1982; Muehlbauer, 1993; Statistics Botswana, 2014). Since they are important sources of protein, essential elements, vitamin B and fiber, pulses play a significant part in the diet for subsistence communities and the peri-urban population who have limited financial resources to buy the more expensive animal protein. For instance, faba beans, peas and lupins can be used as protein source, in place of meat (BAMB, 2017). Owing to their ability to fix nitrogen, they are commonly intercropped with cereal crops (López-Bellido et al., 2005) and thus reduce the application of nitrogen fertilisers (People et al., 1995; Plaza-Bonnilla et al., 2016) and are considered as secondary crops. In Botswana, pulses are multipurpose crops that provide food throughout the cropping season as various plant components such as leaves, immature pods and mature seeds are eaten. Crop residues are then fed to livestock, which can be helpful during drought when forage for livestock is limited.

The importance of pulse crops goes beyond food and nutrition as they can fix nitrogen for companion crops in intercropping or for the next crop in rotation systems. Nitrogen fixation becomes an essential process given the scarcity of N-bearing minerals in soils (Couto-Vazquez and González-Prieto, 2016). Besides improving soil health, pulses are climate smart as they can withstand climate fluctuations and high temperatures common in tropical areas (McKevith, 2004). They use water and nutrients more efficiently. Pulse crops are ideal for on-farm diversification as various portions of the plant can be used as food for humans and livestock and they bring extra income for the farmer (Hugue et al., 1986; ICRISAT, 2016).

The desirable attributes of grain legumes have led them to be considered an essential component of conservation agriculture (CA), a cropping system considered as climate smart, to improve organic matter inputs and soil fertility through biological nitrogen fixation (Giller, 2001; Meyer, 2010). The addition of nitrogen to soil N-budget by grain legumes is particularly important to smallholder farmers with limited inputs (Rusinamhodzi et al*.,* 2012).

***Trend of area planted, production and yield***

Generally in Africa, including Botswana, grain legumes cover a small proportion of the farm area and thus cannot be said to be part of a crop rotation (Giller et al., 2009). Lack of access to a grain market and high labour requirements have been cited as hindrances to increasing farm area for grain legume production (Snapp et al., 2002).

Pulse crop production is concentrated mostly in the south, east, northeast, north and northwest areas of Botswana where a total annually cultivated land is estimated to be 350 000 ha (Oland et al., 1980; MOA, 2000). This is due to the fact that soils in these regions are more fertile than elsewhere in the country (Oland et al., 1985; MOA, 2000), and annual average rainfall ranges between 400 and 650 mm, and is higher and more reliable compared to other parts of the country (Pike, 1971; Sims, 1981; Bhalotra, 1985: LWMRP, 1992). Several pulse cultivars have been selected at the Department of Agricultural Research (DAR) (Table 1).

The pulses grown in Botswana include Bambara groundnut, cowpea, groundnut, common bean, mung bean, pigeon peas and chick peas. There are effort to domesticate morama bean (Tylosema esculentum L.) (Dakora et al., 2015). Between 1979 and 2015, the total area planted to pulses ranged between 17 714 and 82 807 ha (Figure 1). From this information, the average area cultivated under pulses is 38 522 ha, representing eleven percent of the total average area cultivated annually in the country. The trend shows that average area under pulses increased from below 20 000 ha to over 80 000 ha (Figure 1). This was possibly because of development of interest by commercial farmers in Pandamatenga in including legumes in their rotation cycles, due to benefits associated with legumes; increase in the number of farmers growing legumes as a result of an increase in market prices of pulses introduced by the Government of Botswana (GOB) through the Botswana Agricultural Marketing Board (BAMB). There was also a general interest in crop production by the general public due to the introduction of the Integrated Support Programme for Arable Agriculture Development (ISPAAD) which provides subsidies of up to 100% to farmers in land preparation, seed and fertilizer use.

Most arable land is cultivated under dryland subsistence agriculture and production of pulses in Botswana is no exception (Oland et al., 1985; MOA, 2000). Potential grain yield of most pulses selected by the DAR ranges between 1500 and 3000 kg ha$^{-1}$ (Maphanyane and Manthe-Tsuaneng (undated); Summerfield and Roberts, 1985).

**Table 1.** Length of maturity and potential yield of pulse crops planted in Botswana

| Common Name | Scientific Name | Days to Maturity | Potential Grain Yield (t ha$^{-1}$) | Potential N-Fixation (kg N ha$^{-1}$) |
|---|---|---|---|---|
| [β]Bambara groundnut | *Vigna subterranea* | 130-150 | >4.0 | 28 |
| [β]Common Bean | *Phaseolus vulgaris* L | 60-85 | 1.0-3.0 | 64-121 |
| [β]Cowpea | *Vigna unguiculata* L. Walp | 60-120 | >3.8 | 24-240 |
| [β]Mung bean | *Vigna radiata* L. | 90-120 | >3.0 | 50-100 |
| [β]Groundnut/peanut | *Arachis hypogaea* L. | 90-150 | >3.0 | 87-220 |
| [†]Chickpea | Cicer arietinum L. | 160-180 | 4.0-5.0 | 1-114 |
| [†]Lentil | *Lens culinaris* Medik. | 110 | 2.5 | 149 |
| [†]Tepary bean | *Phaseolus acutifolius* | 75-120 | 1.5 | **260** |
| [1]Pigeon pea | *Cajanus cajan* L. Millsp | 80-250 | 1.0 | 235 |
| [1]Soybean | *Glycine max* L. | 140 | 2.0-2.5 | 146-200 |
| [1]Haricot bean | *Phaseolus vulgaris* L. | 70-120 | 1.2 | 30 |

[β] Evaluated and selected by Department of Agricultural Research, MOA. [†]Seed imported and crop produced by individual farmer. [1]Adapted from Manthe-Tsuaneng and Maphanyane (undated), Summerfield and Roberts, (1985), FAO (2017), Gelfand and Robertson (2015) and Shisanya (2003).

However, on farmers' fields, as in many situations around the world, the yield of pulse crops is below one tonne ha$^{-1}$. This indicates that there is a lot of room for improving the yield of pulses. When considering the amount of grain imported annually, the possibility of export, food insecurity and nutritional deficit, increased productivity can go a long way in uplifting the livelihoods of people with low incomes.

Research to evaluate the potential of different pulse crops has been ongoing in Botswana (Pule-Meulenberg and

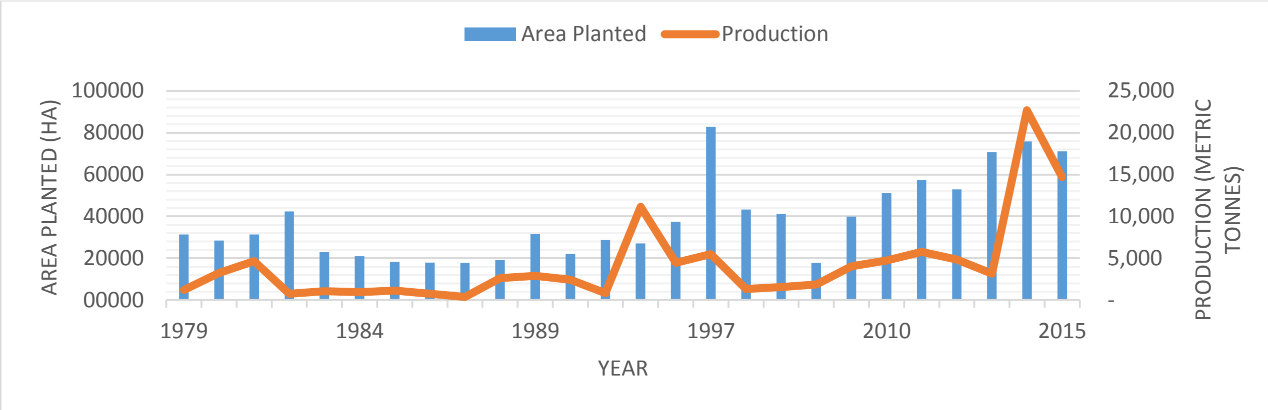


**Figure 1.** Area planted and total production of pulse crop in Botswana between 1979 and 2015

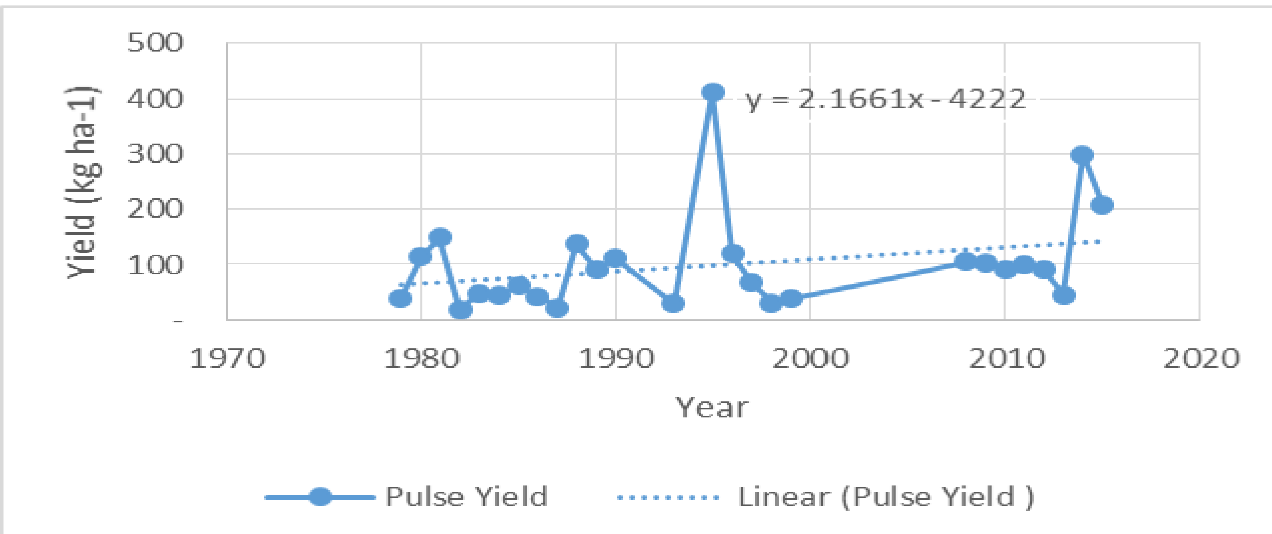


**Figure 2.** Yield and yield trend of pulse crops in Botswana between 1979

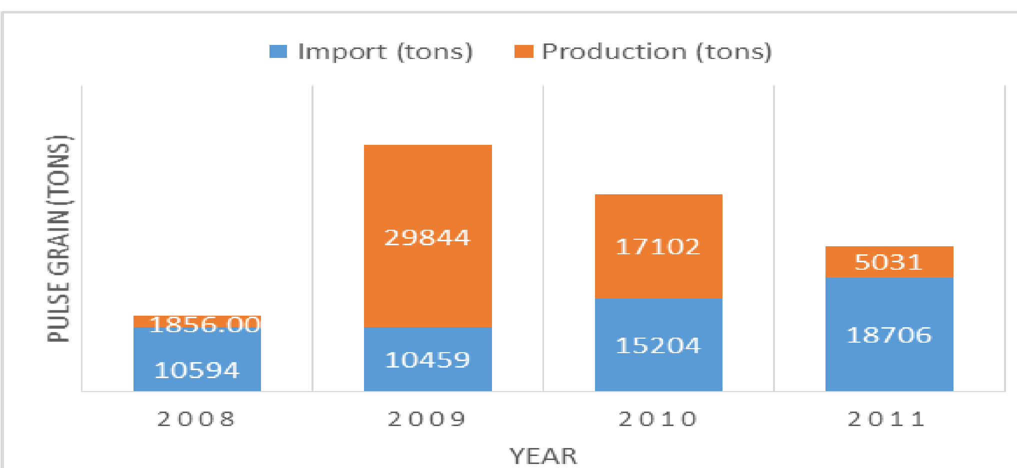


**Figure 3.** Total annual local production and imported pulse grains between 2008

Dakora, 2009; Sesay et al., 2010; Molosiwa et al., 2014) but limited. Therefore more studies on the subject is needed to improve productivity of pulses.

Between 2008 and 2015, actual yield of pulses ranged between 60 and 412 kg $ha^{-1}$ (Figure 2). Average yield was 101 kg $ha^{-1}$ and there was a slight improvement to 150 kg $ha^{-1}$ by the end of the cropping season in 2015. Total pulse production averaged 4184 tonnes and ranged from 385 to 22 683 tonnes (Figure 1). Assuming that pulse requirements are 55 g per capita per day (Lightfoot, 1980; EFSAIP, 1984), current total annual demand for pulses is more than 40 000 tonnes. This indicates that production for the best year needs to double to come close to the pulse requirements in Botswana.

As shown in Figure 3, pulses are imported annually to supplement local production in order to meet national needs. However, since annual requirements for pulses are affected by rainfall and other factors, importation and production vary from one season to another. In addition to the characteristic semiarid conditions, recent extreme changes in temperature and rainfall patterns are likely to drastically impact yield of pulses in Botswana.

The data presented in this paper point to a steady increase in total area planted, production and yield of pulses in Botswana (Figures 1 and 2). Despite the overall pattern of increasing the area planted and production, the productivity of pulses is below 0.5 t $ha^{-1}$. Thus, increasing the average yield of pulses remains a great challenge for sustainable production. Other constraints to crop production in Botswana include low input use, poor soil and water management techniques, inherently low soil fertility and fragile soils (Sims, 1981; DLFRS, 1985; Radcliffe et al., 1992), low and erratic rainfall, poor marketing systems, poor information dissemination and consideration of pulses as secondary crops by both farmers and policy makers.

Recent initiatives by ISPAAD that include provision of free fertilizers, soil testing, draft power and certified seed to subsistence farmers are the right steps for increasing pulse productivity in Botswana. However despite similar previous agricultural programmes and since ISPAAD was implemented eight years ago, the productivity of pulses has been very low compared with their potential grain yield of 3.0 t $ha^{-1}$ (Manthe–Tsuaneng and Maphanyane, undated).

## Opinion on Government of Botswana interventions to improve pulse production

One of the objectives in dryland agriculture is to increase efficient use of nutrients and water. Since pulses biologically fix their own nitrogen, ISPAAD should not automatically give nitrogen fertilizers to farmers growing pulses. Instead, they should be educated to optimize production of pulses which will lead to maximization of nitrogen fixation. Information dissemination for use of early maturing pulse crops should be intensified. Some of the pulses selected and released by DAR are early maturing (cowpea, mung bean and tepary bean) and high yielding (groundnut, Bambara groundnut). These pulses can be matched with cropping window such as soil water availability to avoid water stress. In this way, nutrients and water could be used more efficiently to improve yield stability in both bad and in good years, thus improving food security. There is pressure on pulse production systems to increase yield towards potentially attainable value and maintain it under the changing climate.

Promoting commercialization is one of the objectives of ISPAAD (MOA, 2017). Further, to promoting agriculture as a business, subsistence farmers with interest in engaging in commercial farming could be identified. These farmers can then be exposed to opportunities of marketing, mechanization and any other activities associated with commercial agriculture such as increased labour and land productivity. There is a need for the MOA to facilitate collaboration between subsistence and commercial farmers where possible, to enable successful experiences from each category of farmers to be replicated to enhance technology adoption.

The lack of technology improvement is not necessarily the reason for lack of increase in crop yield in Botswana, rather the combination of suitable technology, enabling environment and timely and suitable community support have not been achieved. Furthermore, any technology needs to be developed for subsistence or small scale farmers should meet the priorities and constraints of those farmers. Mostly, efforts towards increasing crop yield are conducted in collaboration between the MOA and farmers. Some of the biggest obstacles include poor infrastructure such as roads, electricity, transport and markets in the rural areas.

Pulses in rural, peri-urban and urban areas are sold as snacks and part of meals by mostly women in the markets. In mixed cropping and rotation systems, pulses can be used to reduce fertilizer application. Crop residues can be used in soil surface management and water conservation practices to improve water use efficiency and crop productivity. Pulses or their residues can be used as animal feed to provide forage and enhance feed quality, especially during dry periods. The various forms in which pulses are utilized have important positive implications of meeting food security, nutritional and income benefits.

### *Benefits in cropping systems*

Most pulses are grown in a mixed cropping system with cereals and other crops under dryland subsistence agriculture in Botswana (MOA, 2000). This production system uses low input resources and results in low crop yields (Figure 2; Oland et al*.,* 1980). This was accepted in the past, but has been overtaken by events due to high population growth that requires an increased food supply and changes in socio-economics both locally and internationally (MOA, 2008). A persistent grain deficit that compels grain importation requires intensification of agriculture and conservation of natural resources (MOA, 2000).

Inclusion of pulses in improved intercropping or mixed cropping increases total food production per unit of land under subsistence agriculture (Rowland, 1993). This also increases farm diversification and reduces risks of food shortage in the farming system. Traditional mixed cropping in Botswana commonly involves staggered planting dates, (LWMRP, 1992; Persaud et al., 1992), resulting in variation of crop maturation. In this way, later planted pulses may escape drought or diseases and allows the farmer to have food supply in a situation where there could have been crop failure and shortage of food. Pulse crops biologically fix nitrogen to meet much of their own requirements and those of companion crops in mixed or intercropping systems (Zahran, 1999; Jensen and Hauggaard, 2003; Pule-Meulenberg and Dakora, 2009; Dakora et al., 2015). In a rotation, they can fix and leave significant amounts of nitrogen in the soil for the next crop. Pulses can fix from 28 kg N $ha^{-1}$ (e.g. Bambara groundnut) to some 200 kg N $ha^{-1}$ (e.g. cowpea, groundnut, pigeon pea and soybean) (Table 1). Thus pulses reduce fertilizer costs, which is helpful, especially to poorly resourced subsistence farmers. The reduction in the use of nitrogen fertilizers while maintaining levels of crop yields can improve the overall nitrogen use efficiency of a farming system compared to the use of synthetic nitrogen fertilizer only.

Generally, water shortage in dryland areas and effective soil and water conservation practices are required for the successful crop production. In this situation, knowledge of water footprint of crops is critical in cropping systems. Compared with cereals and other crops, many pulses are early maturing and extract water from shallower soil depths and leave greater total residual soil water stored deeper in the soil profile. DLFRS (1985) and Persaud et al., (1992) found that early and winter ploughing improved soil water conservation and increased crop yield; winter or early spring rainfall could rapidly fill the soil profile allowing for early planting. Efficient use of soil water could be achieved by intercropping or rotating pulses with deep-rooted crops that allow stratified soil water use or mining of water stored deep in the soil profile. Under many situations, water use efficiency of pulses is similar to cereals but most pulses are well-adapted to severe climate conditions, are early maturing and can produce food or feed when other crops fail. As a result of these water use characteristics, pulses effectively increase water use efficiency of the entire cropping system and achieve one of the main aims of dry land agriculture. Compared to other crops, pulses are considered environmentally friendly since they have a low food wastage footprint, as well as carbon and blue water footprints. In addition, growing pulses in intercropping systems allows for a higher water utilization efficiency due to their root structures. Pulses help in weed, disease and pest control (Wollenberg et al., 2012).

Arable soils in Botswana are characterized by low fertility, and water retention capacities, low organic matter and high acidity (MOA, 1990). Furthermore, nitrogen and phosphorus deficiency are widespread with localized deficiency in the micronutrients zinc and iron (MOA, 1990). These problems are compounded by soil compaction, high rates of runoff and erosion. Consequently, the potential for crop production of soils in Botswana is very low. Pulses and their residues are sources of organic matter and may contain 100-600 kg N $ha^{-1}$. When pulses are included in a cropping system and their residues incorporated into the soil, soil health, including microbial diversity and tilth are improved. Residues would generally improve soil structure, thereby increasing water infiltration and reducing runoff and erosion. Including pulses in crop rotations reduces the risk of soil erosion and nutrient depletion, and results in a high accumulated soil carbon sequestration potential (Rowland, 1993; Rochester et al., 2001).

Used with discretion, many pulse crops can be used as initial planting on fragile soils and once established and the soil improved, other crops may be planted. When pulses with dense foliage are planted together with cereals in mixed cropping systems, they can reduce the destructive effect of raindrops on soil structure, runoff and erosion, thus conserving soil and water. Conservation agriculture techniques such as reduced tillage and residue management can be combined to enhance the productivity and sustainability of the cropping system.

Pulse crops can provide animals with much-needed protein. In subsistence agriculture in Botswana, the crops of choice for animal feed are maize, pearl millet, sorghum and pulses (Maphane and Mutshewa, 1999). During or at the end of the cropping season, farmers collect crop residues and store them until needed for feeding animals. During the dry season or when fattening animals before sale, the stored animal feed is used. Therefore, including pulse crops in a farming system can be cost-effective and would enable farming in a sustainable manner, especially for subsistence farmers aspiring to be involved in commercial activities. When included in livestock feed, the high protein content of pulses contributes to an increased food conversion ratio, while decreasing methane emissions from ruminants, thus reducing greenhouse gas emissions (Wollenberg et al., 2012).

### *Improvement of food security, nutrition and health of people*

In Botswana, crop production output is low and does not meet the food requirements of the rapidly growing human population (GoB, 2017). Therefore, agricultural production needs to be intensified to supply food needed by the growing population and feed for modernized livestock production systems. Pulses can play an important role in sustainable food production aimed towards food, feed and nutrition securities. Most pulse crops are drought-tolerant and suitable for cultivation in marginal and fragile areas in Botswana. Some pulses such as Bambara groundnut, cowpea, peanut, field bean, pigeon pea and lentil are often successfully cultivated in dryland areas with annual rainfall of 300 to 400 mm. These crops thus use less water and are early-maturing (Hugue et al., 1986; Summerfield and Roberts, 1986). Since they use less water and have relatively shallow rooting systems, they can leave greater residual soil water, enabling faster filling up of soil profile by early rains and allowing early planting. Besides leaving greater soil water for subsequent crops in a rotation system, pulse crops allow for stratified soil water extraction with deep-rooted companion crops in intercropping. Therefore, in dryland regions where food security is a huge challenge and is likely to worsen under the changing climate, intensification of sustainable cropping systems can be achieved using locally adapted pulse crops.

The fact that pulses are an important source of plant-based proteins and amino acids for humans and animals cannot be over-emphasised. The nutritional role of these crops is especially important for subsistence farmers who consume a large portion of their agricultural produce. On a per 100 g basis, pulses contain 351 kcal, 25 g of protein, 1 g of fat, 55 g of available carbohydrates, 11 g of dietary fiber and are rich in minerals (Fe, Mg, K, P, and Zn) and B-vitamins (thiamin, riboflavin, niacin, B6 and folate) (MacKevith, 2004; De Ron, 2015). Furthermore, pulses are thought to have positive effects on the prevention of non-communicable diseases like obesity, diabetes, cancer and coronary conditions (Mudryj et al., 2014; FAO, 2016). Comparatively, cereals have low protein and high sulfur-containing amino acids but pulses are rich in protein but deficient in sulfur-containing amino acids (Mudryj et al*.,* 2014). Therefore, supplementing cereals with pulses can improve the quality of diets and address protein-calorie malnutrition challenges in poorly-resourced populations such as subsistence households and the unemployed peri-urban population. Pulses are low in fat and cholesterol and are often advocated as a suitable diet for vegetarians (Key et al., 2006). Also, where animal protein is not recommended for consumption due to health, religious or other reasons, pulses provide an alternative source of protein (Mudryj et al., 2014; FAO, 2016).

**Business opportunities for subsistence farmers, peri-urban population**

The current performance of agriculture in Botswana offers opportunities for successful agricultural development. The majority of pulses are produced by subsistence farmers and their average grain yield and labour productivity are among the lowest in the world. Consequently, there is a large deficit in pulse grain requirement, and the continued population and income growth as well as urbanization (Statistics Botswana, 2014) places further pressures on current food supplies. Therefore, the low productivity of pulses under subsistence agriculture can be interpreted as both a challenge and opportunity to close the gap between their potential productivity based on the local commercial environment and similar conditions in other countries. Although there are threats of climate change, rapid growth in demand for pulses and slow response from the sector, there is a good potential for business in pulse production in Botswana.

As a multi-use crop, growing pulses helps improve livelihoods of farmers by maintaining food security and economic stability particularly for female farmers who are a major part of the labour force in farming. Furthermore, different processed portions, grain or portions of pulses may be sold to generate income for the rural and peri-urban population (BAMB, 2017).

Local production of pulses has been low and not met national requirements and this has been supplemented by importation. From 2008 to 2011, between 1900 and 30 000 tonnes of pulses were imported (Figure 3). Assuming that the sum of local production and imported grain satisfy pulse requirements, then pulses required in Botswana ranged between 12 450 and 40 303 tonnes between 2008 and 2011. These figures indicate that the demand for pulses fluctuates with time. The probable causes of this include feeding of livestock when rangelands are depleted of pastures because of drought, and feeding pulses to school children and disadvantaged groups. The amount of revenue used to import pulses ranged between 80 and 90 million Pula. This indicates a great potential for business as farmers can improve their production and yield to substitute for these imports.

The government of Botswana recognized the need to assist farmers to increase crop yields and improve food security and income (MOA, 2008) by introducing ISPAAD. Under ISPAAD, the government offers assistance to subsistence farmers by issuing free seed, fertilizer, draft power and fencing of arable fields. Furthermore, the Ministry offers technical services and information through the print media, national radio and television. Although the government offers these inputs, they are limited to 5 ha for full support and half of the inputs for areas from 6 to 16 ha.

Increased cropped area will generate business opportunities in seed production and other associated inputs that may be needed by commercial farmers and the industry as a whole. Capitalizing on the assistance from the government, appropriate and reduced use of resources could result in a more efficient agricultural system. Using appropriate technologies such as high yielding cultivars of pulses and conservation agriculture, subsistence farmers can increase crop yield, reduce the gaps between them and commercial farmers and farm in a sustainable manner. These incentives can increase the scope of subsistence

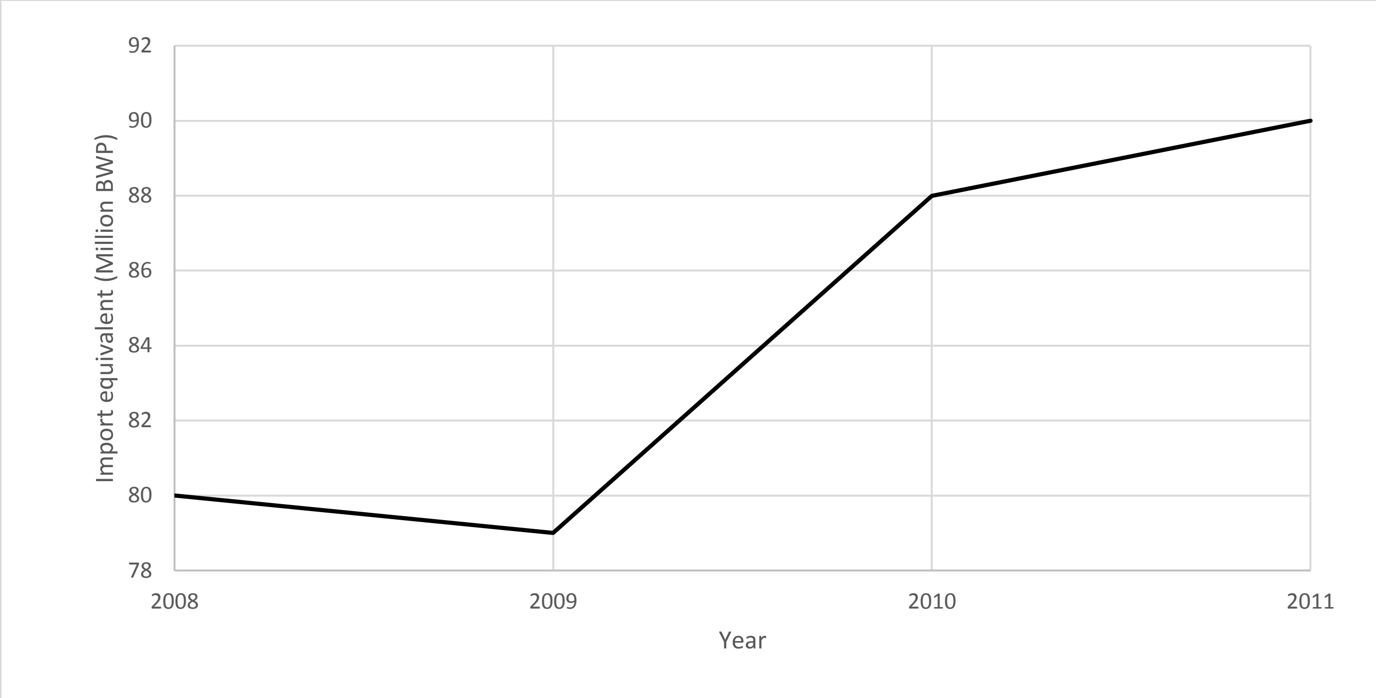


**Figure 4.** Equivalent amount of imported pulse grain in million BWP between 2008 and 2011 (Exchange rate: 1.0 USD = 11.90 BWP, 24/12/16, Bank of Botswana, 2016).

**Table 2.** Producer prices per 50 kg bag for major crops grown in Botswana

| Crop | Price in BWP | | Price in US$ | |
|---|---|---|---|---|
| | Grade 1 | Grade 2 | Grade 1 | Grade 2 |
| Maize | 150 | 105 | 14.35 | 10.05 |
| Sorghum | 125 | 87.50 | 11.96 | 8.37 |
| Millet | 150 | 105 | 14.35 | 10.05 |
| Tswana cowpeas | 700 | 490 | 66.99 | 46.89 |
| Jugo beans | 600 | 420 | 57.42 | 40.19 |
| Groundnuts | 600 | 420 | 57.42 | 40.19 |

Source: BAMB (2016)

farmers to recognize their role as commercial suppliers. While lack of access to markets and low prices limit production of grain in most African countries (Snapp et al., 2002), the Botswana government has established Botswana Agricultural Marketing Board BAMB to provide a market for local grain crops. Depending on the grade, the price for a 50 kg bag of legume can be five times that of cereals (Table 2). Ideally, these prices should motivate farmers to increase their farm area for grain legume production.

Small entrepreneurs sell pulses as snacks in local market places. Local value-added processing of pulses has the potential to stimulate domestic demand for pulse crops. This provides off-farm employment and income for the rural and peri-urban population, and increases nutritionally readily available food for the consumers. In Botswana, vegetative Portions of pulse crops such as leaves may be pounded or ground, and cooked before eating. However, seed is commonly boiled and eaten whole.

Some of the local value-added pulse products are not diversified to meet present consumer demand for ready to eat snack foods. The local pulse products need to satisfy the rural and peri-urban groups who constitute the majority of the population including children and youth, students and the working class. Modern food processing techniques should be applied to pulses to market food types that may be interesting to these groups. Processing such as milling and preparation of different dishes can increase business opportunities in the pulse industry. Development of the knowledge and innovations that expand opportunities for local processing and marketing for pulse-derived products can be a driver of productivity. This will increase food, nutrition and income security in the country.

## CONCLUSIONS AND RECOMMENDATIONS

Pulses play an important role in food security and nutrition for the majority of the rural and peri-urban population in Botswana. However, local production does not meet the demand for pulses. The national demand for pulses has increased from 12450 to 40303 tonnes between 2008 and 2011. The total area planted and pulse production between 1979 and 2015 increased from 30 000 to 80 000 ha and 5000 to 22500 tonnes, respectively. Although these are large increases, the yield has remained very low, ranging between 60 and 150 kg $ha^{-1}$ over the same period. Because of this deficit, there is a need for interventions to increase productivity to meet this demand. These interventions have the potential to reduce fertilizer requirements through nitrogen fixation and promote environmental health under a changing climate. The importance of producing pulses locally goes beyond food and nutritional securities, but can include income generation and import substitution. Pulse production can create opportunities for local value-added processing, stimulate subsistence farmers to venture into commercial farming, provide off-farm employment and generate income for rural poor and peri-urban populations in Botswana.

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## CONFLICT OF INTEREST

None.

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