

TREND ANALYSIS OF DRY BEAN PRODUCTION, YIELD, CONSUMPTION, IMPORT AND EXPORT IN SOUTH AFRICA FROM 1970 TO 2019

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Abstract. In South Africa, the dry bean is planted mostly for human consumption. The study assessed the growth rate and instability of area, production, yield, consumption, import and export of dry beans in South Africa from 1970 to 2019. The exponential model was used to estimate the growth of area, production, yield, consumption, import and export of dry beans in South Africa. The Cuddy-Della Valle index was used to estimate variability. The study indicated that a 50-year average on area, production and export of dry beans in South Africa had a 1.497%, 0.472% and 0.282% reduction in growth rate, respectively, while yield, consumption and import resulted in a 1.040%, 1.880% and 7.443% increase, respectively. There is a need to increase the area under dry bean production through mobilisation of small-scale farmers to venture into dry bean production and research, in order to come up with high-yielding and drought-tolerant dry bean varieties in South Africa. The study also recommends that the government should formulate appropriate policies for mechanisation, production and export which will support the development of the dry bean industry.

Keywords: common bean, legume, import, consumption and productivity

INTRODUCTION

Agriculture remains the foundation of many African economies (Van Niekerk and Conradie, 2023). The dry bean (common bean) (*Phaseolus vulgaris* L.) is the most important legume crop, in terms of growth, in all continents of the world except Antarctica (Pathania et al., 2014), comprising 29.5 million hectares (37.5%) of the world's pulse area, producing 23.1 million tons (32%) (Joshi and Rao, 2017). It is a vital grain legume crop and supplies the daily protein requirement of the people of South America, the Caribbean, Africa and Asia (Fageria et al., 2010). It is an important component of production systems and a major source of protein for the poor

in Eastern and Southern Africa (Katungi et al., 2009). The dry bean is recognized as a significant protein-rich grain crop cultivated primarily for human consumption (Mathobo et al., 2017) and the third most important legume in South Africa. Stable growth is very important for agricultural development. There is plenty of information on crop yield and production increase and instability from theoretical and empirical perspectives (Jain, 2018). In addition to growth, an understanding of crop output instability is crucial to comprehending the nature of food security and income stability. Since the 1950's, several studies have been conducted to determine whether South African agriculture can still meet the country's demand for food. Over decades, this issue has grown to

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be a major concern among policymakers, researchers and other stakeholders (Oehmke et al., 1997; Greyling, 2012). The annual compound growth rate and variability studies have been conducted in groundnuts (Uttam and Pramanic, 2015), coffee (Ayele et al., 2021), sugarcane (Singh et al., 2022), pulses (Devi et al., 2017), and sorghum and millet (Orr et al., 2016).

Breitenbach and Fényes (2000) investigated the Maize and Wheat production trends in South Africa in a deregulated environment within the country. They concluded that there was a significant decline in the area cultivated and in the production of maize and wheat, which could have resulted from crop farmers lacking funds, due to possible challenging climatic conditions in the summer rainfall areas and non-profitable crop production.

Liebenberg and Pardey (2010) studied the South African agricultural production and productivity patterns between 1910 and 2007. The results indicated that since 1981 the rate of expansion in agricultural output has slowed due to a slowing rate of increase in the field crop production. The heavy increase in the horticultural sector drives the overall expansion in total agricultural production. Drought became a regular problem in South African agriculture and had a detrimental impact on agricultural production, especially in the 1980s and 1990s.

Greyling and Pardey (2019) studied the shifting structure of maize production during the twentieth century (1909–2015) in South Africa. The results indicated that South African maize production increased from 1.68 million tons in 1935 to 12.2 million tons in 2015. The increase in production in South Africa can be attributed to the benefits gained from the green revolution, which resulted in the adoption of improved varieties, improved agronomic practices (fertilization and pest control practices) and improved mechanisation practices (use of tractors) (Thirtle and Van Zyl, 2000).

Van Niekerk and Conradie (2023) analysed the field crops production trends in the Eastern Free State province of South Africa. The results showed that there was a reduction in cereal, legume and oil seed production between 1981 and 2007. The reduction resulted from a decline in planted area. They further indicated that the reduction might also have been caused by unfavourable weather conditions.

Analysing dry bean output trends over the previous few decades can shed light on potential future developments. These forecasts are crucial for ensuring timely action that will allow the dry bean industry to satisfy

South African society's demands. The results of the study will assist farmers and policy developers to come up with suitable plans and policies that will assist in raising the level of production and also invite investors interested in the dry bean industry. Therefore, the objective of the study is to assess the growth rate and instability of area, production, yield, consumption, import and export of dry beans in South Africa from 1970 to 2019.

LITERATURE REVIEW

The *phaseolus* species is believed to have originated from America, despite their wide distribution worldwide. It has been accepted that all the species of the genus *Phaseolus* originated in Mexico, Guatemala, and the high Andes, based on the wide genetic diversity of the cultivated and wild species that exist in the region (Siddiq and Uebersax, 2013).

Dry bean production in the World and Africa

The dry bean is grown globally on all continents with the exception of Antarctica (Fageria et al., 2010). The leading countries in this production are Latin America and sub-Saharan Africa, where three-quarters of this crop is grown (Bellucci et al., 2014). The major producers of dry beans worldwide are India, Myanmar, Brazil, United State of America, China, Tanzania, Mexico, Uganda, Kenya and Ethiopia (FAOSTAT, 2020).

The average production statistics of the past five years indicates that the biggest producer of dry bean in the world is India, with a share of 18.7%, followed by Myanmar and Brazil, with a share of 16.5 and 10.4%, respectively (FAOSTAT, 2020) (Fig. 1).

African dry bean production

In Africa, dry bean production is concentrated in the Eastern and Southern Highlands of the continent (Mwamahonje, 2018), extending from Ethiopia to South Africa, with Tanzania being the largest producer in the region, followed by Uganda and Kenya (FAOSTAT, 2020).

In Africa, substantial dry bean production takes place in the Eastern region, contributing about 52% of the total African production, followed by West Africa and Central Africa contributing about 18 and 15%, respectively. The biggest producer for the past five years has been Tanzania, followed by Uganda, Kenya, Ethiopia and Rwanda contributing about 17.52, 15.28,

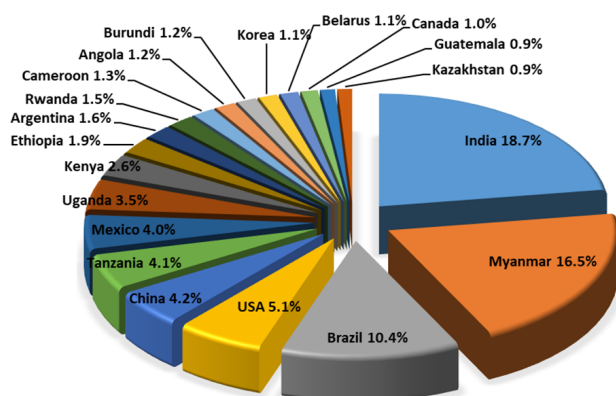


Fig. 1. Share of global top 20 dry bean-producing countries
Source: FAOSTAT, 2020.

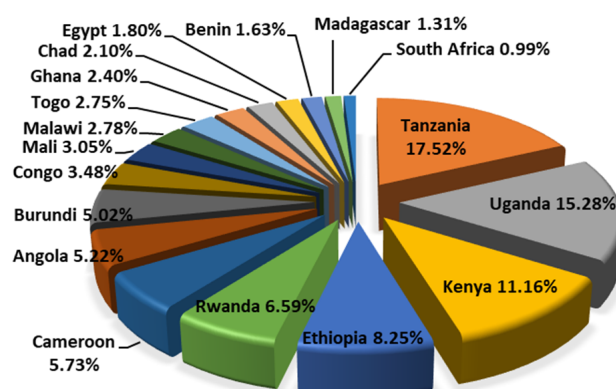


Fig. 2. Share of top 18 dry bean-producing countries in Africa
Source: FAOSTAT, 2020.

11.16, 8.25 and 6.59%, respectively (FAOSTAT, 2020) (Fig. 2). South Africa contributes an average of 0.99% to the five-year level of dry bean production, ranking number 18 in Africa.

South African dry bean production

In South Africa, dry bean production is dominated by the Free State province, followed by Limpopo. In South Africa, dry beans are produced annually by commercial and small-scale farmers (Fourie, 2011). The areas under commercial production are: Free State (Bethlehem, Fouriesburg, Ficksburg, Clocolan, Harrismith, Kroonstad, Henneman), KwaZulu-Natal (Kokstad, Vryheid, Bergville/Winterton, Greytown, Weenen, Mooi River), Limpopo (Thabazimbi, Koedoeskop, Marble Hall, Tuniplaas, Vaalwater, Ohrigstad, Lydenburg, Burgersfort), Mpumalanga/Gauteng (Middelburg, Nigel Delmas, Ermelo, North West (Brits, Lichtenburg, Koster, Rysmierbult) and Northern Cape Kimberley, Douglas and Modder River (DPO, 2015). Dry beans always command a good price in the market and can be used to increase income and improve household food security for rural provinces of South Africa.

Dry beans have gained a lot of attention as a very important food due to their health benefits and role in human disease prevention (De Ron et al., 2015). Dry beans have the potential to improve diet quality and long-term health if consumed regularly (Garden-Robinson and McNeal, 2013). They are low in lipids and sodium, are nutrient-dense, and are a good source of proteins and complex carbohydrates, as well as fibre, minerals, and vitamins

(Ocampo et al., 2018; Sathe et al., 2011; Wiesinger et al., 2016; Siddiq et al., 2011). The consumption of dry beans has been increasing for some time, while production is decreasing. The production is heavily affected by biotic (pests and diseases) and abiotic (drought, floods, heat and cold stresses and soil fertility) factors (Singh and Schwartz, 2010; Pathania et al., 2014; Padder et al., 2017).

METHODOLOGY

Data sources

The study is based on secondary data. A major source of secondary data are several reports of the Directorate of Statistics and Economic Analysis of the Department of Agriculture Land Reform and Rural Development of South Africa. The time series data for the period 1970/71 to 2019/2020 (50 years) for area, production, consumption, import and export was analysed. The period was divided into 5 periods and each spanning 10 years: period 1 (1970–1979), period 2 (1980–1989), period 3 (1990–1999), period 4 (2000–2009), period 5 (2010–2019) and period 6 (1970–2019). The production was further analysed to determine the contribution by provinces from 2000/01 to 2019/2020 in South Africa.

Analytical framework

Growth rate estimation

The compound growth rate was used to study the trends in area, production, consumption, import and export of dry beans in South Africa. Compound growth rate is an

important parameter to assess agricultural growth and can be used for predicting future performance. The compound growth rates were computed using the exponential model as suggested by Dandekar (1980). The model was also used in previous studies (Rajarathinam and Vetriselvi, 2017; Kumar et al., 2022). The model is as follows:

$$Y_t = a + b \cdot t$$

where: Y_t – area / production / consumption / import / export for the year t , a – intercept, b – regression coefficient and t – time variable

The growth rate (GR) was calculated according to Rehman et al. (2011) and the formula has been used in literature by several researchers (Ikueomonisan et al., 2020; Devi et al., 2017). The formula is as follows:

$$GR = (Antilog b - 1) \cdot 100$$

The t test was applied to test the significance of b .

Instability analysis

The dry bean instability in production area, production, yield, consumption, import and export was measured using the coefficient of variation (CV) and Cuddy-Della Valle Index (CDI). The CV has the limitation of overestimating the instability level (Ayele et al., 2021). Several studies have used CV for determining the instability of these variables (Sahu et al., 2020; Rana et al., 2021; Halagundegowda et al., 2023).

The instability of all the above-mentioned variables was measured by computing the coefficient of variation.

To overcome the problem of overestimating the CV, Cuddy and Della-Valle (1978) revised the CV by applying a coefficient of determination R^2 . It seeks to turn around the trends by using the coefficient of determination and so indicate the exact direction of instability. CDI can be calculated as follows:

$$CDI = \frac{CV}{R^2}$$

where: CV – is the coefficient of variation in percent and R^2 – is the coefficient of determination from the time trend regression, adjusted for its degrees of freedom. The ranges of the Cuddy Della-Valle Index have been defined by Sihmar (2014) as follows: 1) If the value of CDI in the time series is less than 15, then it has low instability 2) If the value of CDI is more than 15 and is less than 30, then it has moderate instability and finally 3) If the CDI is more than 30, then it has high instability.

RESULTS AND DISCUSSION

Trends in dry bean production Area, production, yield, consumption, imports and exports in South Africa

The five-year averages for area under dry bean production, production, yield, consumption, imports and exports is presented in Table 1. The trend in dry bean production in the 50 years from 1970 to 2019 has been

Table 1. Trend in dry bean area, production, yield and consumption from 1970–2019 (5-year average)

Periods	Area (000 ha)	Production (000 t)	Yield (t ha ⁻¹)	Consumption (000 t)	Imports (t)	Exports (t)
1970–1974	74	66	0.929	53	5 796	4 900
1975–1979	103	89	0.891	61	2 705	6 502
1980–1984	75	79	1.065	61	9 111	5 552
1985–1989	82	109	1.327	73	8 330	16 654
1990–1994	73	72	0.978	102	58 679	12 999
1995–1999	57	70	1.240	102	42 474	4 450
2000–2004	56	80	1.435	123	53 259	6 049
2005–2009	48	63	1.333	131	79 398	2 834
2010–2014	49	67	1.354	139	78 513	2 909
2015–2019	48	67	1.381	86	26 443	13 530

Source: own elaboration.

divided into 10 sub-regions, starting from 1970–1974 to 2015–2019. The results in Table 1 shows a considerable change in area under dry bean production, production, yield, consumption, imports and exports in South Africa.

The five-year averages of area under dry bean production in South Africa has been declining since 1980 (75 000 ha). It picked up a bit in 1985–1989 (82 000 ha) but from 1990–1994 (73 000 ha) to 2015–2019 (48 000 ha) there has been a considerable decline (Table 1). The results suggest that there was a 53% decline from 103 000 ha during 1975–79 to 48 000 ha during 2015–2019.

The five-year average of dry bean production was the highest during 1985–1989, with 109 000 tons, and declined to 67 000 tons during 2010–2014 and 2015–2019, which is a 38% reduction. The highest dry bean yield was 1.434 tha^{-1} produced during period 7 (2000–2004) and the lowest was 0.890 tha^{-1} produced during period 2 (1975–1979). From 1970–1974 to 2015–2019, there was an improvement of 48%. The South African dry bean yield per hectare was higher than the world and Africa by 41% and 60 %, respectively.

The dry bean consumption rate has been increasing since 1970–74 (53 000 t) to 2010–2014 (139 000 t) (Table 1). The domestic demand is higher than production, leading to the deficit being addressed with imports. The maximum quantity of dry bean imported and exported was during 2005–2009 (79 398 tonnes) and 1985–1989 (16 653 tonnes), respectively (Table 1).

The 20-year average for provincial contribution to national production is presented in Fig. 3. The biggest

role players in the system are Free State, Mpumalanga and Limpopo, contributing 35%, 29% and 11%, respectively. The poorest contributors were Western Cape, Eastern Cape and Northern Cape, contributing less than 1%, 1% and 2%, respectively.

Growth rate in area, production, yield, consumption, imports and exports

The growth rate for area under dry bean production and consumption is presented in Table 2. The statistical difference amongst the means for area under production, production, yield, consumption, import and export was determined using t-test. The highest and most significant growth rate in area under dry bean was found during period 1 ,with a growth rate of 6.76% ($P \leq 0.05$), while the lowest growth was found in period 4 and was also significant, with a growth rate of -3.69% ($P \leq 0.05$). Periods 2 and 5 resulted in a non-significant growth rate in area under dry bean at 1.53 and 2.41%, respectively, while period 3 resulted in a non-significant reduction, with a growth rate of -3.90%. The results for period 6 shows that there was a significant reduction in area under dry bean production in South Africa, with a growth rate of -1.49% ($P \leq 0.01$). The fluctuations in area might also be a result from fluctuations in weather conditions. The country experienced drought during 2015 (Malherbe et al., 2020; Baudoin et al., 2017) and it continued to 2016 and 2017 in the Cape (Otto et al., 2018).

The decade average indicated that there was a positive and significant growth rate in dry bean production for periods 1 and 2, with a growth rate of 5.51 and 5.83%, at $P \leq 0.01$ and $P \leq 0.05$ respectively (Table 2). During periods 3 and 5 there was a non-significant increase in production with a growth rate of 0.58 and 3.52%, respectively. The results further indicated that there was a non-significant decrease in production, with a growth rate of -3.82% during period 4. There was a non-significant (-0.472%) reduction in dry bean production for the period 1970/71 to 2019/20. This reduction might have resulted from a reduction in the area under production.

The decade analysis for dry bean yield per hectare (Table 2) indicated that periods 2, 3 and 5 resulted in a non-significant increase, with a compound growth rate of 4.23, 4.67 and 1.01%, respectively. Periods 1 and 4 indicated a non-significant reduction, with a compound growth rate of -1.16 and -0.13%, respectively. On the other hand, the results further showed that there was a significant increase in yield per hectare of dry bean,

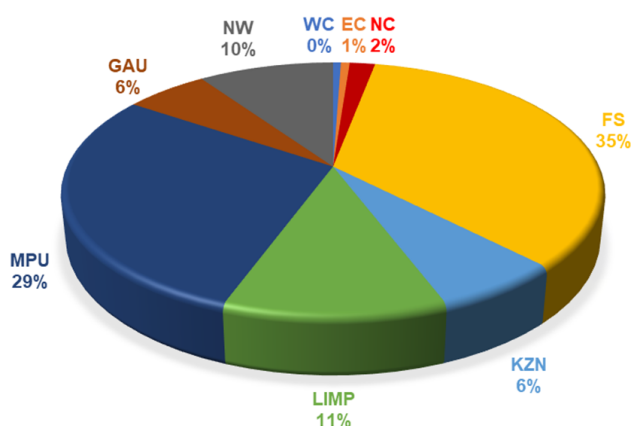


Fig. 3. Provincial contribution to dry bean production of South Africa (20-year average)
Source: own elaboration.

Table 2. Compound growth rates in the dry bean area, production, yield and consumption from 1970–2019

Period	Area	Production	Yield	Consumption	Import	Export
1970–79	6.758*	5.517**	-1.162	2.6598*	-19.287*	12.414
1980–89	1.533	5.835*	4.237	2.760*	4.836	20.021*
1990–99	-3.903	0.582	4.668	1.147	22.428	-15.334*
2000–09	-3.696*	-3.696	-0.137	1.943	10.725*	-9.749
2010–19	2.411	3.520	1.010	-8.199**	-22.727**	27.22**
1970–2019	-1.497**	-0.472	1.040**	1.880**	7.443**	-0.282

Significant at: *5% level, ** 1% level.

Source: own elaboration.

with a growth rate of 1.04% at ($P \leq 0.01$) for the period 1970–1974 to 2019–2020. The increase might have resulted from using proper agronomic practices and through the introduction of improved dry bean varieties to the farmers.

The decade analysis for dry bean consumption (Table 2) showed that the highest and most significant growth rate in dry bean consumption was found during period 2, followed by period 1 with a growth rate of 2.76 and 2.66% ($P \leq 0.05$), respectively. During periods 3 and 4, there was a non-significant growth rate in consumption, while period 5 resulted in a significant reduction in consumption, with a growth rate of 1.14, 1.94 and -8.19%, respectively. The results also indicate that during period 6 there was a significant increase in consumption, with a growth rate of 1.89 % ($P \leq 0.01$). The increase in consumption might have resulted from the changing habits of urban people incorporating dry beans in their breakfast meal and canned beans receiving more attention for its ease of use. The increase in the demand for dry beans might be resulting from the fact that dry beans are used in soups, chilli dishes, baked beans, casserole recipes, refried bean paste and fresh salads. They can also be purchased in dried or previously canned and cooked products (DAFF, 2010). The dry bean is incorporated in the National School Nutrition Programme (NSNP) in South Africa (Department of Basic Education, 2020). Dry beans are incorporated in the food-based dietary guidelines for South Africa as one of the foods which need to be eaten regularly (Vorster et al., 2013).

The decade analysis shows that there was a significant reduction in the growth rate of dry bean imports during period 1 and 5, with a growth rate of -19.29

and -22.72% ($P \leq 0.05$), respectively (Table 2). There was a non-significant increase in the growth rate of dry bean imports during periods 2 and 3, with a growth rate of 4.83 and 22.42%, respectively, while period 4 resulted in a significant increase in imports. The results for dry bean import analysis for period 6 indicated that there was significant increase in import, with a growth rate of 7.44%. The results further indicate that consumption is responsible for 60% of variations in dry bean imports at $P \leq 0.01$. South Africa is unable to meet the dry bean demand and the deficit is met by imports. The imported dry bean is predominantly from China, at 41%, followed by Ethiopia and Canada supplying about 18 and 9%, respectively (TradeMap, 2020).

The decade analysis for dry bean export indicated that the highest and most significant increase was found in period 2 and 5, with a growth rate of 20.02 and 27.22% ($P \leq 0.05$), respectively (Table 2). The results further indicated that there was a significant reduction in dry bean export during period 3, with a growth rate of 15.33%, while period 1 resulted in a non-significant increase (12.41%) and period 4 resulted in a non-significant reduction (-9.75%). The 50 year analysis for dry bean export indicated that there was a non-significant reduction in dry bean export during period 6, with a growth rate of -0.282%. The decline in export might have resulted from the country being unable to meet the domestic demand due to a reduction in area under dry bean harvest. Most of the dry bean produced in South Africa is exported to India, Eswatini and the United Arab Emirates (DALRRD, 2020). Similar studies have been conducted on tea (Saha et al., 2021), major crops of Bangladesh (Akhter et al., 2016), sugarcane (Bee and

Table 3. Instability index for the dry bean area, production, yield, consumption, import and export from 1970–2019

Period	Area	Production	Yield	Consumption	Import	Export
1970-79	3.03	2.24	25.25	0.53	4.94	5.65
1980-89	1.68	3.72	18.85	0.55	15.72	5.17
1990-99	5.34	9.08	23.43	0.99	14.28	5.98
2000-09	2.90	5.35	18.24	1.11	2.20	7.79
2010-2019	4.90	6.43	14.92	0.32	0.62	3.91
1970-2019	3.56	6.35	16.68	1.18	9.06	9.34

Source: own elaboration.

Rahman, 2020), chickpeas (Merga and Haji, 2019), major crops of Khyber Pakhtunkhwa (Abid et al., 2014), major vegetables of Nepal (Ghimire et al., 2018), and groundnut (Gayathri, 2018; Bansal and Singh, 2020).

Instability in area, production, yield, consumption, imports and exports

The highest instability in the overall analysis (1970/1971 to 2019/2020) was found in yield during the 1970/1971 period (925.25) and the lowest in consumption during 2010/2019 period (0.32). The yield was moderately unstable, with the instability index ranging from 14.92 to 25.25, while the consumption variable was the most stable, with the instability index ranging from 0.32 and 1.18.

Provincial trend and variability dry bean production

The provincial trend for the years 2000/2001 to 2019/2020 is presented in Table 4. The statistical difference amongst the means for provincial production was determined using t-test. The results indicated that the highest and most significant growth rate in dry bean production was produced by Limpopo province (18.59% at $P \leq 0.01$) followed by KwaZulu Natal (4.706% at $P \leq 0.05$) and Free State (2.68% at $P \leq 0.05$), while Mpumalanga had the lowest growth rate (–9.25%) followed by Gauteng (–6.749% at $P \leq 0.01$).

Eastern Cape (2.57%), Northwest (1.94%) and Northern cape (2.34%) showed a non-significant growth rate, while the Western Cape had a negative growth rate (–1.66%). The lowest instability was found in Mpumalanga (1.35), followed by Free State (2.88) and Gauteng

Table 4. Compound growth rates and instability index in provincial contribution of dry bean production from 2000/2001–2019/2020

Province	CAGR	CDI
Western Cape	–1.65	8.96
Northern Cape	2.34	9.82
KwaZulu Natal	4.70*	5.68
Mpumalanga	–9.25**	1.35
Northwest	1.94	5.05
Eastern Cape	2.571	11.30
Free State	2.68*	2.88
Limpopo	18.59**	4.81
Gauteng	–6.74**	3.23

Significant at: *5% level, **1% level.

Source: own elaboration.

(3.23), whereas the highest instability was found in the Eastern Cape with an instability index of 11.30.

Opportunities and challenges

The high nutritive value of dry bean makes it a very important crop which can help to reduce hunger and poverty in rural provinces of South Africa. The opportunities and constraints in dry bean production and marketing are presented in Figure 4. The demand for dry beans both locally and internationally is growing every year. Presently, the average consumption is around 112 000 tons per annum, while domestic production is around



Fig. 4. Opportunities and constraints in dry bean production and marketing
Source: own compilation.

67 000 tons, which allows for expanding the hectareage under production. The use of improved dry bean varieties which are adaptable to the climatic conditions of the region can improve the production. For some time, small-scale farmers did not been apply fertilisers and irrigation on the crops, which led to low yield and quality. Correct fertiliser and irrigation application will increase the yield and quality of the produce, increasing its price in the market and aiding economic growth.

The lower prices from imported Chinese beans posed a threat to local production. Bacterial brown spot has been reported to account for 55% yield losses in South Africa (Muedi et al., 2015). Climate change is affecting production due to too high temperatures, drought and floods. The high prices of inputs and unavailability of irrigation water remain a challenge too.

CONCLUSIONS

The study revealed that while consumption was higher in some periods than production, farmers still exported their produce while the country was experiencing shortages. Some of the farmers do not sell all their produce and store some in silos to wait for favourable prices in order to maximise profit. The trend, growth rates and instability of area, production, yield, consumption, import and export were analysed. The reduction in area under

dry bean production led to insufficient supply to meet the growing demand for dry bean. To increase the area under dry bean production there is a need to mobilise small scale farmers in communal lands and introduce an irrigation scheme to venture into dry bean production. The productivity can be improved through the training of farmers and extension officers on improved agromomic practices such as proper plant population, better irrigation methods and fertiliser application for dry bean production, as well as introducing the use of improved varieties. Plant breeding that will lead to the development of improved dry bean varieties which require less irrigation water will also help. The formulation of appropriate policies by the government for mechanisation, production and export in the country will further support the development of the dry bean industry. The country will be able to improve production and export, while at the same time achieving economic growth and reducing poverty. These results will be helpful to policymakers, farmers and researchers.

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