



The Importance of Legumes in the Ethiopian Farming System and Overall Economy: An Overview

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Authors' contributions

This review work was carried out in collaboration between all authors. Author MA prepared the paper design and setup and all drafts of the manuscript, and managed the statistical analyses of the review. Author KT and KD framed and edited the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Crops, livestock and trees are major components of farming systems in Ethiopia. Crop production is dominant in Ethiopian agriculture as well as in the farming system. Legumes are among the various crops produced in all regions of the country in different volumes after cereals. More than twelve legume species are grown in the country. Pulses production by volume has been increased by 71.92% for the duration of nearly 20 years and with a growth rate of 3.78% per annum. Area coverage by pulse crops for the same period grown by 53% with a growth rate of 3% per year. Total pulses grain yield, which is volume of production per unit area, showed good increment from 8.79 quintals per hectare in the cropping year 1994/1995 to 14.76 quintals per hectare in

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2012/2013 cropping season. However, it is much lower compared to the potential demonstrated in research managed fields. Legumes have multiple uses. Grain legumes provide food and feed and facilitate soil nutrient management. Herbaceous and tree legumes can restore soil fertility and prevent land degradation while improving crop and livestock productivity sustainably. The pulse industry in the country has developed significantly with little intervention, and great potential exists to increase the production and impact of pulses through proactive and targeted support. The role that Ethiopia now plays in the international pulse market can be attributed to significant growth rates in pulse production over the last nearly 20 years. However, bunch of constraints and considerable gaps lean the legumes along the value-chain from production to marketing and utilization. The country needs to target the constraints and gaps to optimize the importance of legumes in the farming system and economy of the country.

Keywords: Ethiopia; farming system; legumes/pulses; sustainability.

1. INTRODUCTION

Ethiopia has diverse agro-ecology that permits different farming systems. Crops, livestock and trees are major components of the farming systems in the country [1]. Existence of diverse farming systems, socio-economic, cultures and agro-ecologies, endowed Ethiopia with a diverse biological wealth of plants, animals, and microbial species, especially crop diversity. Crop plants such as coffee (*Coffea arabica*), safflower (*Carthamus tinctorius*), tef (*Eragrostis tef*), noug (*Guizotia abyssinica*), anchote (*Coccinia abyssinica*) and enset (*Ensete ventricosum*) originated in Ethiopia. High genetic diversity is found in major food crops (wheat, barley, sorghum and peas); industrial crops (linseed, castor and cotton); cash crop (coffee); food crops of regional and local importance (tef, noug, Ethiopian mustard, enset, finger millet, cowpea, lentil) and in a number of forage species of world importance such as clovers, medics, and oats [2].

Though the diverse agro-ecological setting permits diverse farming and livelihood systems, crop production is by far the largest component of agriculture in particular and the country's economy in general [3]. Out of the total arable land of 50.5 million hectares, close to 16.4 million hectares are suitable for producing annual and perennial crops. Of this estimated land area, about 8 million hectares (nearly 50%) are used annually for rain-fed small holder crops [4 -11].

Food crops can be categorized as cereals, pulses, oilseeds among others for simplicity of description and comparison purposes [11]. According to CSA (2012/2013), Out of the total grain crop area, 78.17% (9.6 million hectares) is covered under cereals. Tef, maize, wheat,

sorghum and barley took up the lion share of cereals area coverage and volume of grain production. Pulses are among the various crops produced in all the regions in different volumes across the country after cereals. Twelve and more legume species are grown in the country. Of these, faba bean (*Vicia faba* L.), field pea (*Pisum sativum* L.), chickpea (*Cicer arietinum* L.), lentil (*Lens culinaris* Medik.), grass pea (*Lathyrus sativus* L.), fenugreek (*Trigonella foenum-graecum* L.) and lupin (*Lupinus albus* L.) are categorized as high to mid land pulses. On the other hand, haricot bean (*Phaseolus vulgaris* L.), soya bean (*Glycine max* L.), cowpea (*Vigna unguiculata* L.), pigeon pea (*Cajanus cajan* L.) and mung bean are predominantly grown in the warmer and low land parts of the country [11].

Pulses production by volume has been increased by 71.92% for the duration of nearly 20 years and with a growth rate of 3.78% per annum (Fig. 1). Area coverage by pulses crops for the same period has been increased by 53% with a growth rate of 3% per year (Fig. 2). Total pulses grain yield, which is volume of production per unit area, showed significant increment from 8.79 quintals per hectare in the cropping year 1994/1995 to 14.76 quintals per hectare in 2012/2013 cropping season (Fig. 3). However, it is much lower compared to the potential demonstrated in research managed fields (Fig. 7). Area coverage and productivity are the two most important factors of production. From these data, one can safely deduce that the increment of volume of pulses production was attributed to both of the above mentioned factors. Currently, the national average productivity of soybean, chick pea, faba bean, and grass pea is greater than the productivity of the pulses as a group.

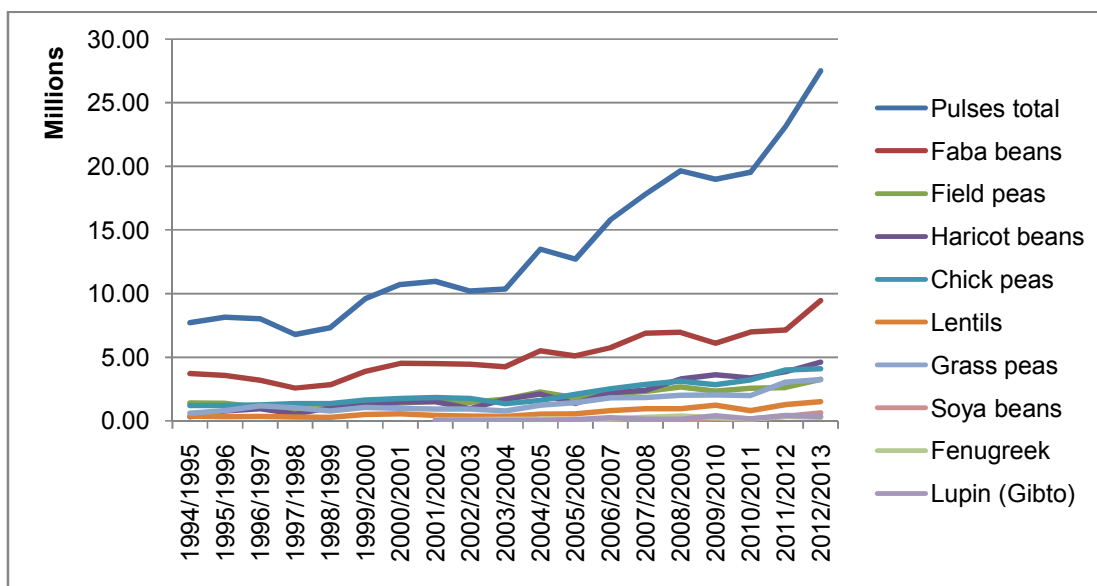


Fig. 1. Nineteen cropping years (1994/95-2012/2013) volume of production (in million quintals) trend of different pulses crops in Ethiopia (Source: [4-22])

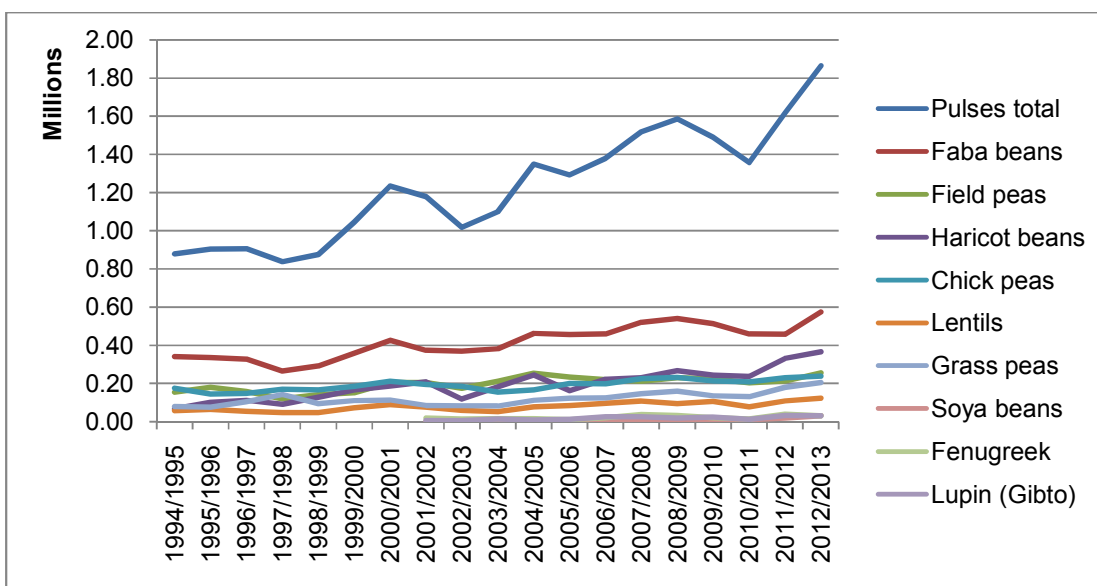


Fig. 2. Nineteen cropping years (1994/95-2012/2013) area coverage (in million hectares) trend of different pulses crops in Ethiopia (Source: [4-22])

2. IMPORTANCE OF LEGUMES

Legumes are known to perform multiple functions. Grain legumes provide food and feed, facilitate soil nutrient management and contributes to climate change mitigation [23]. Herbaceous and tree legumes can restore soil fertility and prevent land degradation while

improving crop and livestock productivity on a more sustainable basis. Thus cultivation of such dual-purpose legumes, which enhance agricultural productivity while conserving the natural resource base, may be instrumental for achieving income and food security, and for reversing land degradation [24].

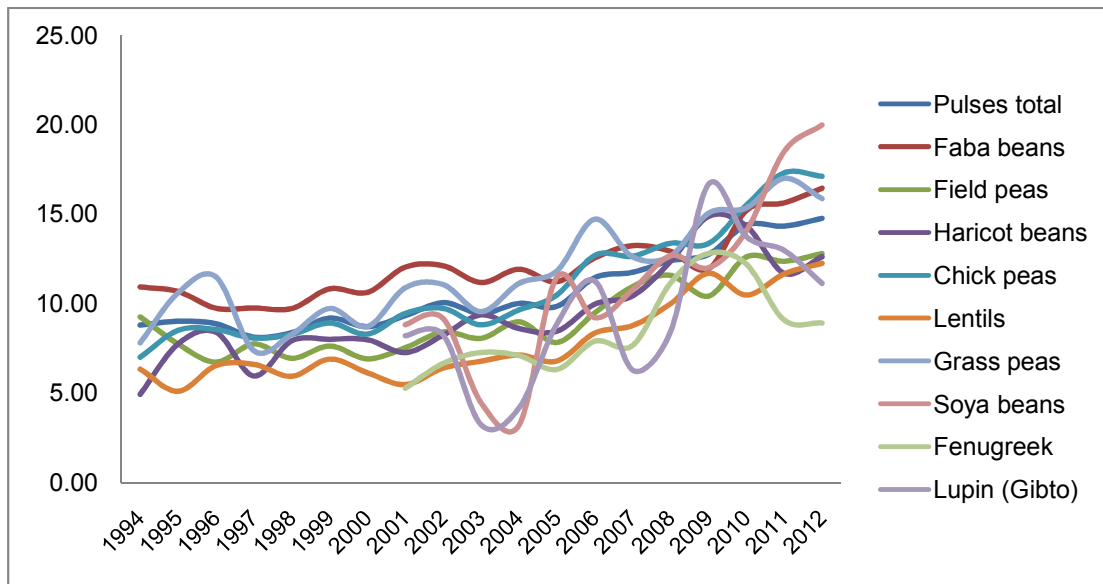


Fig. 3. Nineteen cropping years (1994/95 - 2012/2013) productivity (measured in quintals per hectare) trend of different pulses crops in Ethiopia (Source: [4-22])

Ethiopian farmers' produce different legume crops mainly for food and feed, to fetch cash, and more importantly to restore the fertility of the crop land. Participation of farmers on cultivation of pulses in the country has been increased nearly by double from 4.5 to 8.5 million farmers for the last nearly 20 years (Fig. 4). Legumes contribute to smallholder income; as a higher-value crop than cereals and to diet, as a cost effective source of protein that accounts for approximately 15 percent of protein intake. Moreover, pulses offer natural soil maintenance benefits through nitrogen-fixing, which improves yields of cereals through crop rotation, and can also help smallholder farmers reduce cost of inorganic fertilizers. It also contribute significantly to Ethiopia's balance of payments [25].

2.1 Farming System Importance of Legumes

One very important offer of legumes is that it improves soil and environmental health. Biological nitrogen fixation (BNF) is the distinguishing feature of a legume in a cropping system. Most legume species are able to form a symbiosis with alpha- or beta proteo-bacteria, collectively called rhizobia, that use solar energy captured by the plant to break the bond in inert atmospheric di-nitrogen and form reactive N species, initially ammonium (NH₄⁺). As a result of this symbiosis, the legume crop requires little or no input of N fertilizer and makes little demand

on soil N reserves [23,26,27]. For example, lupin can potentially fix and accumulate a total of 150 to 400 kg/ha per year nitrogen [28,29,30] and faba bean up to 200 kg/hectare per year. The benefits of using legumes such as soybean and peanut as break crops in sugar cane monoculture on the wet tropical coast of Queensland are well documented with yield increases of the following cane crop in the order of 20–30% [31,32]. In addition to reducing the levels of cane pests and diseases [33], soybean rotations also provide economic benefits from the harvested grain and economic and environmental benefits from the N-rich residues reducing subsequent fertilizer N inputs [32]. Similarly, other legumes play a vital role in controlling major cereal root diseases, particularly cereal eelworm or cereal cyst nematodes, *Heterodera avenae* in the Mediterranean region. The combination of high soil N and reduced nematodes population is cumulative and can result in a big increase in subsequent cereal yield [34].

Since the manufacture of synthetic fertilizer consumes fossil fuel, thereby releasing CO₂, and the transport and spreading of organic and synthetic N fertilizers consumes further fuel, the use of legumes in cropping systems has immediate environmental benefits arising from reduced fossil fuel use. Nitrates from fertilizers and soil N reserves may also leach through the soil column into groundwater, and the

denitrification of nitrates from synthetic or organic sources is the primary source of nitrous oxide (N₂O), a powerful greenhouse gas, from agricultural soils [35]. Hence maintaining the reactive N within the plant, as happens in a symbiotic legume in the growing season, avoids some potential for environmental damage.

2.2 Importance of Legumes to Livestock Feed

Legumes have been shown to improve both the quantity and quality of fodder, and thus sustain feed production during the dry season and increase livestock productivity. Experiments in Ethiopian highlands showed that forage legumes did not reduce the barley grain and straw yield, but significantly increased the total fodder yield – barley straw plus forage [36]; similar results were found for maize [37]. Average fodder yields of 14.2 and 3.4 tons per hectare of maize-vetch and barley-clover, respectively, were reported compared to 9.3 and 2.3 tons per hectare of sole maize and barley, respectively [38]. The average crude protein content of crop residues is about 3.8% of dry matter, whereas legumes crude protein content on average varies between 14-24% of dry matter [39]. In Ethiopia, Crossbred cows given an oats-vetch diet produced on average 1.40 kg/day more milk than those given hay diet (5.54 vs. 4.14 kg milk/day) [40]. Legumes mixed with crop residues also increase

other livestock production parameters like weaning rate, manure and lactation yield [24].

2.3 Importance of Legumes for Human Nutrition and Health

Legumes are plant-based alternatives to animal products with low health impact. They are characterized by a high content of protein, fiber and micronutrients and low fat. The protein content of legumes is generally between 20-30% which corresponds to levels found in fish and meat. Low lipid intake is important for good health. The total oil content in legume seeds was the lowest, compared with that in seeds and grains of other crops. Except chick peas (5 g/100 g), the total oil contents of other legumes are less than 1.6 g/100 g.

The levels of saturated fatty acids are also very low in all types of legumes. Moreover, there are high levels of unsaturated fatty acids (>70% of total oil). The content of unsaturated fatty acids in chickpeas is up to 4.3 g/100 g. Low saturated fatty acids are identified as an important standard for evaluation of the quality of food [41]. Legume seeds contain low levels of total oil and saturated fatty acids, as well as high content of unsaturated fatty acids, therefore increase intake of legumes can be beneficial to human health [42,43]. For instance, lupin grain is uniquely high in protein

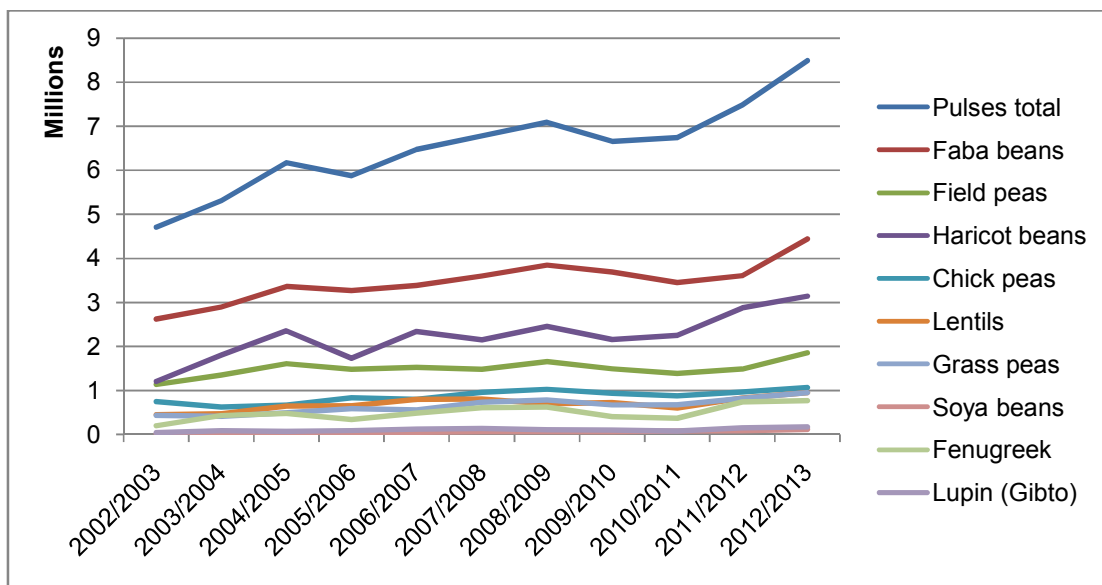


Fig. 4. Number of participant farmers who cultivated different pulses crops during the last 11 years (2002/2003 - 2012/2013) in Ethiopia (Source: [4-11 & 19-22])

(30 to 40 per cent) and dietary fiber (30 per cent) and low in fat (6 per cent). It contains minimal starch and, therefore, has a very low glycemic index which has significant implications for modern societies with an increasing incidence of obesity and associated risk of diabetes and cardiovascular disease [44]. In nutritional terms, lupin seed is an attractive alternative to soybean for human consumption. Food laboratory studies have shown that the protein and fiber components have excellent functional properties [42]. Lupin ingredients have been included in a range of highly palatable breads and other baked goods, meat products and beverages [45]. Studies have also indicated the substantial health attributes of lupin such as diets supplemented with lupin grain may play an important role in treating type 2 diabetes, particularly in overweight and obese people, beneficially influence satiety (appetite suppression) and energy balance, improve blood lipids, lower hypertension and improve bowel health [45,46,47,48].

2.4 Contribution of Legumes to Small Holder Livelihood

Pulses contribute to smallholder livelihoods in multiple ways. Firstly, it can play a significant role in improving smallholders' food and nutrition security, as an affordable source of protein (pulses make up approximately 15 percent of the average Ethiopian diet) and other essential nutrients like potassium, iron and zinc. As a protein source, pulses are more affordable than meat, fish, and dairy products for smallholders, and for more than 43 percent of Ethiopians who practice Orthodox Christianity, pulses become the single largest source of protein during the fasting period. Secondly, pulses can have an income benefit for smallholders, both in terms of diversification and because they yield a higher gross margin than cereals. The income benefits of diversifying from cereals to pulses for one smallholder farmer are exemplified in a case study considering the net profit of wheat, barley and teff, compared to faba beans and chickpeas in Ethiopia. The results demonstrate that pulses are generally more profitable than cereals, giving smallholders an economic incentive to increase pulse production. Faba beans provide the highest net return among the crops considered, while chickpeas provide higher returns than barley and teff, but comparable returns to wheat [25].

2.5 Wider Economic Perspectives

Legume comprise different important commodities such as haricot bean, chick pea, faba bean etc both in domestic and export markets, in the Ethiopian trade of balance. The export value of legumes in the Ethiopian economy has been increased by 89.92% over the last 18 years with 5% annual growth rate (Fig. 5). The actual export value by legumes in 1995 was 20.34 million USD and 201.86 million USD in the year 2012. This export value increment have a positive impact on the trade balance, and contribute to the country's foreign exchange reserves. The national export value as whole has been increased during the same period from 568 million USD in 1995 to 2.99 billion USD in 2012. The export share of legumes to the national export value during the period mentioned has been increased though fluctuated from 3.59% in 1995 as minimum to 8.2% in 2002 as maximum and a little bit lower (6.73%) in 2012 (Fig. 6).

3. POTENTIALS AND OPPORTUNITIES

The pulse industry has developed significantly with little intervention, and great potential exists to increase the production and impact of pulses through proactive and targeted support. Rough calculations suggest that Ethiopia could expand its foreign market presence by at least doubling its current exports through increased production levels [25]. Smallholder income could also be increased by at least 40-70 percent per hectare of pulses planted through greater pulse productivity (with better inputs and sound agronomic practices) [25]. There is an opportunity to stabilize and increase supply by improving production up to the full potential which would meet domestic demands, helping to ensure food security.

Ethiopia is now one of the top twelve producers of total legumes in the world, the second-largest producer of faba beans after China, and the fifth or sixth largest producer of chickpea. The role that Ethiopia now plays in the international pulse market can be attributed to significant growth rates in pulse production over the last nearly 20 years. For instance, in 1994/5 the country produced only 742 thousand tons of pulses, compared to 1.95 million tons in 2010/11 and 2.75 million tons in 2012/2013 cropping year [11].

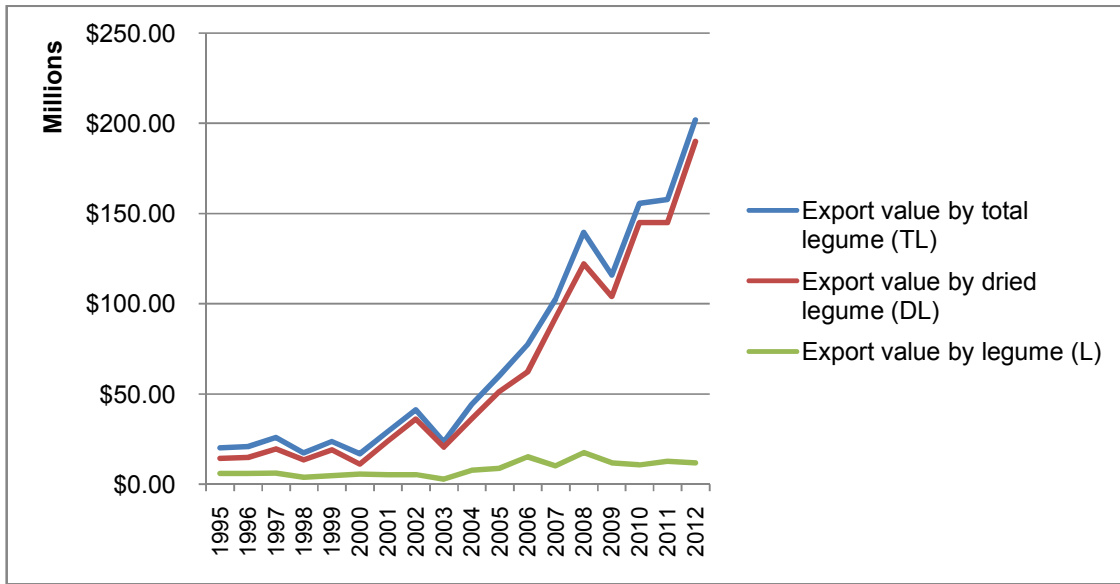


Fig. 5. Export value trend of legumes in the Ethiopian export market over the last 18 years (Source: [49])

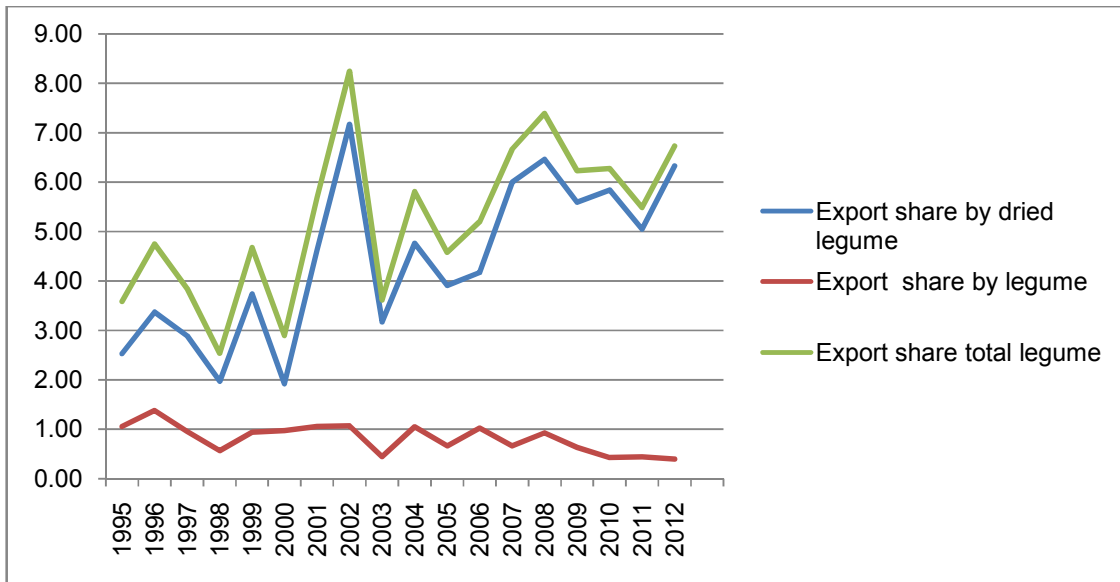


Fig. 6. Percent export share trend of legumes in the Ethiopian export market over the last 18 years (Source: [49])

Through productivity and market improvements, the critical role of legumes in smallholder livelihood and food security can be expanded. The current productivity of pulses falls significantly below the demonstrated potential (Table 1). For example, current average haricot bean yields are 12 quintals per hectare, but research demonstrated potential in Ethiopia is 34 quintals per hectare if accompanied by the

appropriate inputs. This gain in productivity would not only increase smallholder income by 40 to 70 percent per hectare, but would also ensure greater food security through meeting domestic pulse demand. In addition, Ethiopia could expand its foreign market presence through increased production levels, which will lead to at least doubling of its current annual exports.

4. GAPS AND CHALLENGES

A number of constraints and considerable gaps prevail the legumes along the value-chain from production to utilization. Generally, legumes have got less attention in terms of crop management, and input utilization by different development actors' especially small scale farmers compared to cereals. This gap is mainly attributed to the perception of the farmers. The low grain productivity per unit area of legumes compared to cereals is a real challenge that legume scientists should always look into. Assessments in Ethiopia show, productivity is below potential due to: low input usage; limited availability of seed and limited familiarity with the variety of existing legumes, and limited usage of modern agronomic practices and poor extension services (Table 1).

The national agricultural research system managed the development and release of 169 improved varieties of different food legumes in the country during the periods 1973 to 2012 (Fig. 8). On average, the system delivered four varieties per annum. However, there are neglected potential pulses that the research system should look in to and develop improved and standard technologies. Lupin, grass pea, mung bean and fenugreek are good examples.

Moreover, the research system should continually deliver improved standard technologies for every potential legumes significantly produced in the country.

Numerous constrains have been identified in assessments made in the country regarding marketing and export of legumes. Weak linkage between the producers and the export markets have been identified as a major constrain. The weakness is due to the large number of ineffective intermediaries operating in the value chain who have failed to acquire scale and operate in limited geographic areas. The fragmentation of intermediaries between the producer and consumer markets creates a lack of transparency in markets. While there has been substantial growth in recent years, the current export market is underdeveloped. The less developed and fragmented exporters operating at smaller scale in the market results in inconsistent export flows and thus, inconsistent demand for exports [25]. Major causes of limited export development identified were: (i) inadequate market intelligence (ii) inability to leverage scale efficiencies due to smaller size and (iii) non-conducive business environment due to missing credit and insurance; and (iv) inconsistent policy interventions [25].

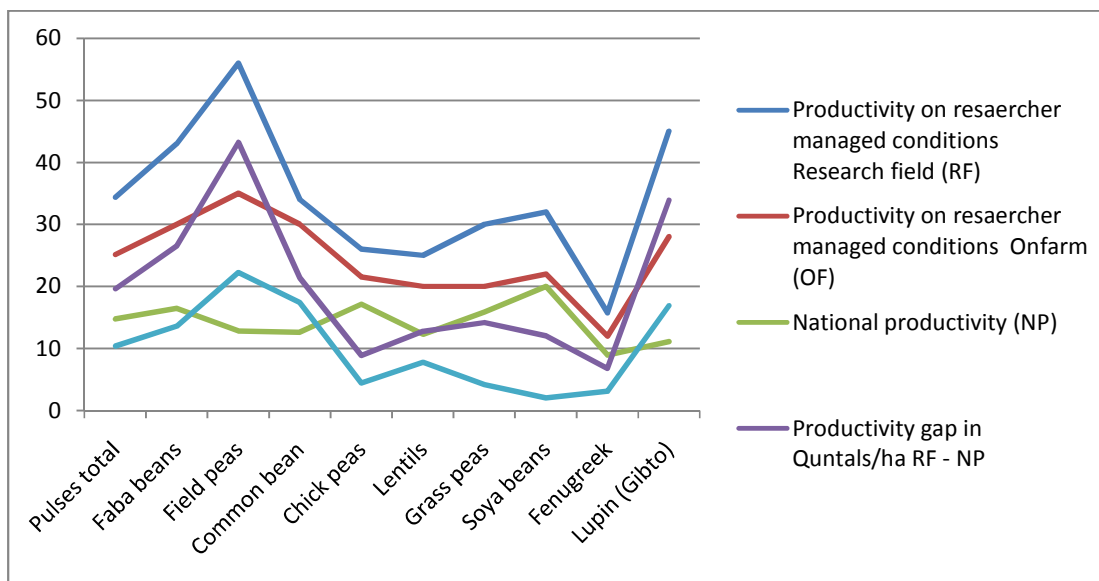


Fig. 7. Productivity gap between research demonstrated potential and national average of food legumes

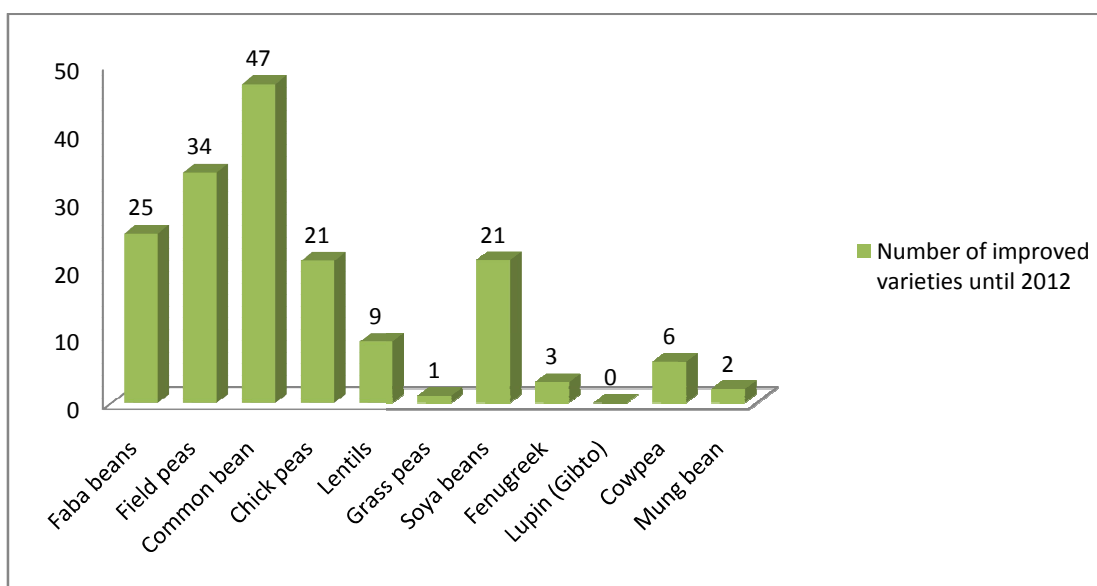


Fig. 8. Number of improved varieties of food legumes released by national agricultural research system of Ethiopia during the periods 1973 - 2012 (Source: [50,51])

Table 1. Productivity gap between research demonstrated potential and national average in the year 2012 for the different food legumes

Legume species	Productivity on research managed conditions		National productivity (NP), 2012	Productivity gap in Quintals/ha	
	Research field (RF)	On-farm (OF)		RF - NP	OF - NP
Pulses total	34.37	21.15	14.76	19.61	10.39
Faba beans	43	30	16.44	26.56	13.56
Field peas	56	35	12.79	32.21	22.21
Haricot beans	34	30	12.62	20.38	12.38
Chick peas	26	21.5	17.11	10.89	5.89
Lentils	25	20	12.25	12.75	7.75
Grass peas	35	30	15.85	14.15	4.15
Soya beans	32	22	19.98	12.02	2.02
Fenugreek	15.7	12	8.91	6.79	3.09
Lupin (Gibto)	45	28	11.12	33.88	16.88

Source [50,51]

5. CONCLUSION

Legumes could offer multiple uses. It could be used as human food, animal feed, improves soil and environmental health, and as a human nutrition and medicine. Moreover, it is good and cheap source of dietary protein and fetch reasonable cash for the Ethiopian poor farmers. The country has huge potential to produce different legumes and to benefit from their multiple uses. Nevertheless, the country needs to give sufficient attention to the sub-sector in terms of changing the perception of the farmers to produce up to the demonstrated potential by

using all the production packages. In line with this, the research system should proactively deliver productive technologies for the different legume crops that potentially be produced in the country. To make the country competitive in potential world market, the technologies should be up to the standard, and market oriented.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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