Volume 16 Issue 22
Originally issued as C3

Global Journal of Science Frontier Research: C
Biological Science
Volume 16 Issue 3 Version 1.0 Year 2016
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Review: Distribution and Productivity of Dekoko (*Pisum Sativum* Var. *Abyssinicum* A. Braun) in Ethiopia

By Berhane Gebreslassie & Berhanu Abraha
Bahir Dar University

Abstract- The genus pea is originated in Near Eastern and Mediterranean centers of diversity. Since Ethiopia is one of the Vavilov's centers of origin of cultivated flora, distribution of the single *Pisum sativum* subsp. *abyssinicum* A. Braun is in Ethiopia in the Ancient Mediterranean area of origin of cultivated plants. Field pea is one of the oldest crops in Ethiopia with a unique subspecies developed in Ethiopia, *Pisum sativum* subsp. *abyssinicum*. Dekoko (*Pisum sativum* var, *abyssinicum*) an important crop in mixed farming and is widely mixed with the main cereal crops growing in south Tigray such as sorghum, barely and teff and is the potential grain growing or cultivated in the region with chick pea, linseed, grass pea and fenugreek. While varieties of field peas can be found around the world. The existing field pea germplasm endemic to Northern part the Ethiopia particularly the highland areas of South Tigray and the Northern part of the former province of Wollo has a phenotypic diversity and tolerance/resistance to disease. Dekoko is capable of producing seed yield of up to 1.95 t/ha under phosphorus fertilization but not yet record data without fertilizer treatment. Dekoko can be used as landrace in Ethiopia because, land races are the genetic wealth that a crop acquires over many years of its existence and have considerable breeding values as they contain valuable adaptive genes to different circumstances.

GJSFR-C Classification : FOR Code: 279999p

Strictly as per the compliance and regulations of :

© 2016. Berhane Gebreslassie & Berhanu Abraha. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Review: Distribution and Productivity of Dekoko (*Pisum Sativum* Var. *Abyssinicum* A. Braun) in Ethiopia

Berhane Gebreslassie [α] & Berhanu Abraha [σ]

Abstract- The genus pea is originated in Near Eastern and Mediterranean centers of diversity. Since Ethiopia is one of the Vavilov's centers of origin of cultivated flora, distribution of the single *Pisum sativum* subsp. *abyssinicum* A. Braun is in Ethiopia in the Ancient Mediterranean area of origin of cultivated plants. Field pea is one of the oldest crops in Ethiopia with a unique subspecies developed in Ethiopia, *Pisum sativum* subsp. *abyssinicum*. Dekoko (*Pisum sativum* var, *abyssinicum*) an important crop in mixed farming and is widely mixed with the main cereal crops growing in south Tigray such as sorghum, barely and teff and is the potential grain growing or cultivated in the region with chick pea, linseed, grass pea and fenugreek. While varieties of field peas can be found around the world. The existing field pea germplasm endemic to Northern part the Ethiopia particularly the highland areas of South Tigray and the Northern part of the former province of Wollo has a phenotypic diversity and tolerance/resistance to disease. Dekoko is capable of producing seed yield of up to 1.95 t/ha under phosphorus fertilization but not yet record data without fertilizer treatment. Dekoko can be used as landrace in Ethiopia because, land races are the genetic wealth that a crop acquires over many years of its existence and have considerable breeding values as they contain valuable adaptive genes to different circumstances.

I. Introduction

Legumes (*Fabaceae* Lindl., syn. *Leguminosae* Juss. and *Papilionaceae* Giseke) are one of the plant families comprising the largest number of economically important crops. Among them are some of the first domesticated species in the world, such as common chickpea (*Cicer arietinum* L.), common lentil (*Lens culinaris* Medik.), pea (*Pisum sativum* L.) and bitter vetch (*Vicia ervilia* (L.) Willd.) (Zohary & Hopf, 2000). This has been attested by many archaeobotanical (Tanno & Willcox, 2006) and historical linguistic (Mikić, 2012) analysis. The total world pea grain production fluctuates 10–12 million tons, with Canada as the leading producer, followed by USA, India, Russia, France and China (Smýkal *et al*. 2012). Legumes are facing the bottlenecks caused by environmental factors that emphasize adaptation to deal with productivity and yield quality aspects, raising the questions how to solve the issue of this challenging the productivity basis of cultivated legume species.

Peas and other legumes are desirable in crop rotations because they break up disease and pest's cycles, provide nitrogen, improve soil microbe diversity and activity, improve soil aggregation, conserve soil water, and provide economic diversity (Chen *et al*., 2006). Peas are grown as green manures and cover crops because they grow quickly and contribute nitrogen to the soil (Clark, 2007). Grain legumes, play a crucial function in organic cropping systems (Aslam *et al*., 2010). They possibly will supply nitrogen (N) to the organic cropping system via N_2 fixation and produce grain rich in protein at the same time as improving soil N for the succeeding crop (Corre-Hellou & Crozat, 2005). Like the other legumes crop roots, pea roots have nodules, formed by the bacteria *Rhizobium leguminosarum*, which convert atmospheric nitrogen (N_2) to ammonia (NH_3).

Scarcity of water is a severe environmental constraint to legume productivity (Farooq *et al*., 2009). Early maturing varieties escape terminal drought (Agbicodo *et al*., 2009), but if exposed to intermittent moisture stress during the vegetative growth stage, they perform very poorly. Peas have survival mechanisms when grown in dry regions by reducing loss of water that help them in early and efficient increases in diffusion resistance and reduction of transpiring surface (Agbicodo *et al*., 2009), by having high water conducting capacity through more xylem and dense leaf venation, or peas also can avoid desiccation by storage of water via production of an abundance of root systems that absorb quickly and provide nitrogen (Clark, 2007). Dekoko (*Pisum sativum* var. *abyssinicum* A. Bruan) pea which is this type is the most common type of pea used as a green manure or cover crop in South Tigray and North Wollo because it adapted to cold temperatures and fit in many rotations. Besides to this, grain legumes are good "rupture" crops to pests (Chemining-wa and Vessey, 2006). *Pisum sativum* var. *arvense* A.Bruan, a synonym of Dekoko, produces antifungal proteins help the plant to combat phytopathogenic fungi and thus protect the plant from devastating damage caused by fungal infections and prevent massive economic losses (Wang and Ng, 2007).

Author α σ: Department of Plant Biology, Bahir Dar University, Ethiopia. e-mail: berh.gebre@yahoo.com

© 2016 Global Journals Inc. (US)

Dekoko (*Pisum sativum* var, *abyssinicum*) an important crop in mixed farming and is widely mixed with the main cereal crops growing in south Tigray such as sorghum, barely and teff and is the potential grain growing or cultivated in the region with chick pea, linseed, grass pea and fenugreek as reported by Girmay *et al*. (2014). While varieties of field peas can be found around the world, this endemic variety is unique to Ethiopia, and particularly the highland areas of South Tigray and the Northern part of the former province of Wollo. Its distribution is limited to Northern Ethiopia.

Ethiopia is the largest producer of cool-season food legumes (CSFLs) in Africa and unique producer of Dekoko in the world. CSFLs including Dekoko are largely produced by subsistence farmers and serve as supplementary protein sources and soil fertility restorers. Yields are very low, mainly limited by soil fertility (Yemane and Skjelvåg, 2002), as CSFLs are cultivated in poor soils, often without fertilization. However, CSFLs require an adequate supply of nutrients for optimum growth and yield (Yemane and Skjelvåg, 2002). Therefore, enhancing the productivity of CSFLs through improved agronomic practice, such as fertilization, expanding in distribution of localized crops like Dekoko to other agro-ecological area contribute to sustainable crop production in Ethiopia.

For expansion, knowledge on the distribution and productivity of native important crops but underutilized is crucial for the discovery of modern productive crops because modern crops were gradually derived from their wild ancestors through continual selection for larger size, improved fruit, and other desired traits (Esquinas-Alcazar, 2005).

Also, despite its domestication thousands of years ago by natives of the North Ethiopian, until this 21th century dekoko is a neglected and less known crop in the whole country where it is commonly cultivated, in and outside the tropical and subtropical belt of Africa. Therefore, information from this study is important in drawing the attention of researchers mainly in the whole country, and hence generally researched for its importance as anti-famine food security source by subsistence farming systems, drought and disease resistant, and export crop that will receive greater attention and interest from many international research and development organizations beyond the owner country.

II. Origin and Distribution of Dekoko in Ethiopia

The genus pea is originated in Near Eastern and Mediterranean centers of diversity. Since Ethiopia is one of the Vavilov's centers of origin of cultivated flora, distribution of the single *Pisum sativum* subsp. *abyssinicum* A. Braun is in Ethiopia in the Ancient Mediterranean area of origin of cultivated plants. Field pea is one of the oldest crops in Ethiopia with a unique subspecies developed in Ethiopia, *Pisum sativum* subsp. *abyssinicum*. The existing field pea germplasm in the country has a phenotypic diversity and tolerance/resistance to disease (IBC, 2007).

The taxon *Pisum sativum* var. *abyssinicum* as its name implies was initially found in the northern region now forming Ethiopia with two ethnolinguistic regions of the country, Tigray and Amhara regions in the northern part of Ethiopia. According to some earlier views, dekoko which was once common is now very infrequently grown in some area of South Tigray and North Wollo. It had not reached other similar agro-ecological areas of the country although the crop was said to have been common in 'the time of Haileselassie'. Yet it is important festival foods and, despite its high price, it is bought from Mekelle market in small quantities, four or five times a year (Wetterstrom, 2006). Dekoko is a unique variety independently developed and cultivated in Ethiopia. Currently, Dekoko is restricted to two provinces of the country particularly of South Tigray and North Wollo in distribution and Southern Yemen and shows a greater affinity to *Pisum sativum* var. *fulvum* (Yemane and Skjelvåg, 2002) and *Pisum sativum* var. *arvense* (Wang and Ng, 2007).

According to Keneni *et al*. (2013), dekoko accessions may show genetic similarities regardless of the differences in places of origin. This may be related to the fact that the Abyssinian field pea exists in confined adjacent regions that could be considered similar in terms of both agro-ecology and crop production system under which distinct pattern of evolution may not be expected. A study previously conducted on *P. sativum* var. *sativum* also suggested that differences in eco-geographic origin might not necessarily suggest presence of genetic divergence for other morpho-agronomic traits (Keneni *et al*., 2013).

III. Taxonomic and Biological Description of Dekoko (*Pisum Sativum* Var. *Abyssinicum*)

The local name of *Pisum sativum* var. *abyssinicum* A.Braun is dekoko, which means "minute seeded." It is also known as yagere ater ("pea of my country") or tinishu Ater ("the smallest pea") in Amharic. *Pisum sativum* var. *abyssinicum* is also locally known as Ye-Ethiopia Ater (Ethiopia pea, Abyssinian pea) in Amharic (Hadiss Yirga and Dargie Tsegay, 2013).

The genus *Pisum* consists of five species: *P. fulvum* (Sibth. *et* Smith.), *P. abyssinicum* ((A.Braun) Govorov), *P. sativum* L., *P. humile* (Boiss. *et* Noë), and *P. elatius* ((M. Bieb.) Asch. *et* Graebn) (Cupic *et al*., 2009). However, Vershinin *et al.* (2003) found close relationships among *P. sativum, P. humile* and *P. elatius* species and divided the genus into three major groups: *P. fulvum*, *P. abyssinicum* and *P. sativum- P. humile - P.*

© 2016 Global Journals Inc. (US)

elatius complex and majority of modern taxonomic classifications recognize the three pea species, namely common pea (*Pisum sativum* L.), red-yellow pea (*Pisum fulvum* Sm.) and dekoko, the Ethiopian pea (*Pisum sativum* var. *abyssinicum* A. Braun).

The exact status of Ethiopian pea has been an object of discussion for decades. *Pisum sativum* var. *abyssinicum,* previously classified as a species, was regarded as an ecotype of *Pisum sativum* var. *arvense;* afterwards, it was considered as synonym of *Pisum sativum* in respect to which *abyssinicum* differentiated into a morphologically distinct form under cultivation and selection in a different geographical area. The results of diverse tests, including ecogeographical (Maxted & Ambrose, 2001), genetic (Baranger *et al*. 2004) and biochemical (Hadačova *et al*. 1980) confirmed the view that Ethiopian pea deserved a status of a separate species within the genus *Pisum* L., together with red yellow (*P. fulvum* Sm.) and common peas. Early hypothesis suggested that Ethiopian pea was simply a geographically isolated variety of common pea, but soon it became clear that it was a separate species domesticated in Ethiopia (Wetterstrom, 2006). An analysis using flow cytometry revealed that, while having the same number of chromosomes of $2n = 14$, Ethiopian pea had between 4% and 8% more DNA than common pea (Baranyi & Greilhuber, 1995). An electrophoretic test with DSD-PAGE showed a clear distinction of Ethiopian pea from common pea (Mishra *et al*., 2012). Various genomic tools also confirmed that Ethiopian pea is characterized by a rather narrow polymorphism in comparison to other *Pisum* taxa and that it was quite independently domesticated from common pea (Vershinin *et al*. 2003). Generally, all these results fully or partially are in accordance with the traditional botanical taxonomy of the genus *Pisum* (Zong *et al*. 2009).

The subspecies appears to be intermediate between *P.* sativum ssp. *sativum* and *P.* sativum ssp. *elatus*. With the former, it shares the traits of indehiscent pod, relatively smooth seeds (Fig.1), and relatively thin testa. However, *Pisum sativum* ssp. *abyssinicum* also is dominant for *A* factor that has a great role for flower colour, and possess an extra set of recessive genes for flowering time, and has relatively small flowers and pods, all characteristics that are fixed or known to occur in *Pisum sativum* ssp. *sativum* and are often lacking in *Pisum sativum* ssp. *abyssinicum* (Weeden and Wolko, 2001).

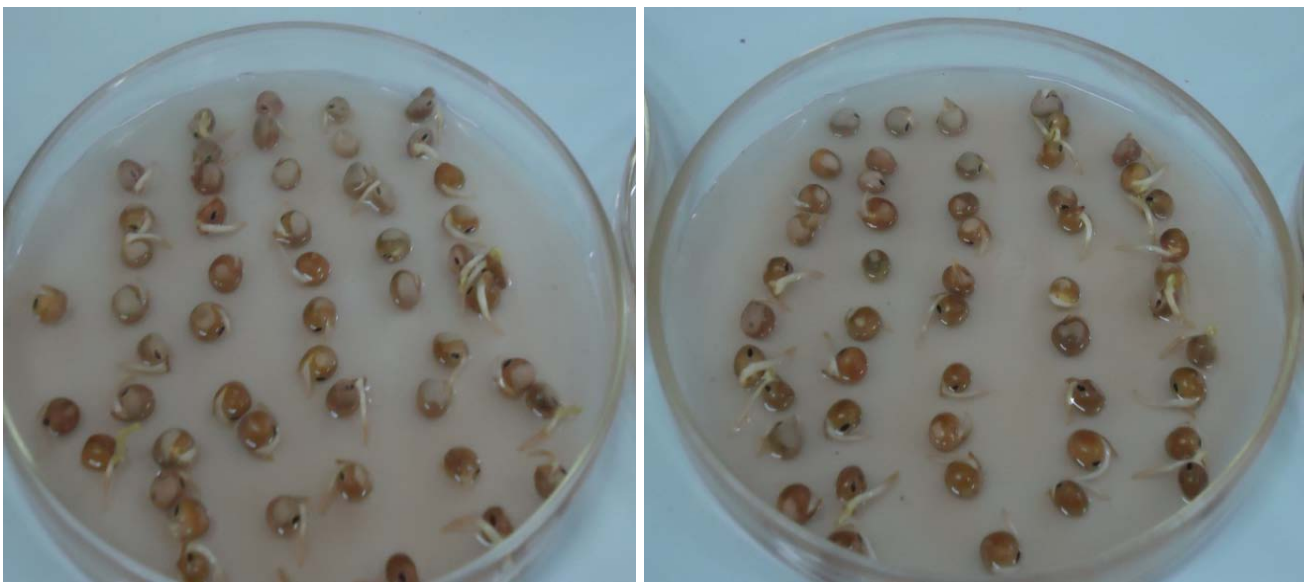

Figure 1 : Seeds of Dekoko (photo: Berhane G. in 2013)

The pea *Pisum sativum* var. *abyssinicum* is a cool-season annual vine that is smooth and has a bluish-green waxy appearance (Fig.2). Pea vines can be up to 9 ft long, however modern cultivars have shorter vines, about 2 ft long. The stem is hollow, and the taller cultivars cannot climb without support (Elzebroek and Wind, 2008), Dekoko (*Pisum sativum* var. *abyssinicum* A.Braun) shares the morphological characteristic of modern cultivars. Leaves are alternate, pinnately compound, and consist of two large leaflike stipules, one to several pairs of oval leaflets, and terminal tendrils in pea (McGee, 2012; Mikić *et al*., 2013c).

© 2016 Global Journals Inc. (US)

Figure 2 : Yellow flower of Ethiopian pea in glasshouse tests at Rimski Šančevi in 2013 (Photo: Sanja Mikić)

The abyssinicum pea, *Pisum sativum* var. *abyssinicum* can be easily recognized from other similar peas strongly by its serrate leaflet margins (Fig. 3) with 5 to 12 nodes which constitute the most obvious morphological character also it has traits such relatively large seeds, lack of dehiscent pods and lack of dormancy mechanism (hard seededness), strongly suggest that *Pisum sativum* ssp. *abyssinicum* has undergone partial domestication (Weeden *et al*., 2001). The serrate character was shown to be controlled by a dominant gene in crosses using the line 808 (= WBH 808). From the three types of leaflet serration present in the *Pisum* germplasm, the *serratus,* or saw-form that controlled by *Ser* distinct loci is common in Dekoko. The *Ser* is typical of *P. sativum* ssp. *abyssinicum* and a line from Afghanistan (WL 1414) or *Ser*: JI 2781 (= WL 1414) (Weeden and Ambrose, 2004).

Figure 3a : Serrate leaflet margins of Dekoko. Photo: Berhane G. in 2013

© 2016 Global Journals Inc. (US)

Figure 3b : Serrate leaflet margins of Dekoko Source: Missouri Botanical Garden

Ethiopian pea is considered examples of wild relative that may be gene pools of desirable traits for introducing into the crops while retaining a high agronomic performance. Ethiopian pea is also regarded as the source of novel genes, such as *er3* (Fondevilla *et al*., 2008), controlling resistance to powdery mildew (*Erysiphe pisi* DC), as well as to *Mycosphaerella pinodes*. On the other hand, there are certain chromosomal differences and partial fertility between Ethiopian peas and common pea. Such complex restrictive behaviour frequently limits a degree of the success of introgressing desirable traits related to enhancing biotic stress resistance from wild into cultivated germplasm. This is also a long process, since numerous back-crosses between Ethiopian and common pea F1 hybrid and common pea cultivar are needed to introgress a trait improving biotic stress tolerance and merge it with high, quality and stable grain yield (Fondevilla *et al*., 2008).

Pisum sativum var. *abyssinicum* is a compact, well delineated taxon with a narrow genetic base and little allozyme variation. It can be clearly defined on the basis of the genotype rather than phenotypically (Weeden and Wolko, 2001). The low genetic diversity in *Pisum sativum* ssp. *abyssinicum* may in part be due to a relatively small number of accessions available with small geographical distribution. In addition, there may be germplasm growing in Ethiopia that is not collected. Based on the data available from different studies, *Pisum sativum* ssp. *abyssinicum* is considered as an isolated and genetically unique taxon that may be important source of genetic diversity for breeding application once the semi sterility problem is overcome. In any event, one and probably only one accession of *Pisum sativum* ssp. *abyssinicum* needed be included in any core collection of *Pisum sativum* germplasm (Weeden and Wolko, 2001).

IV. Productivity of Dekoko (*Pisum Sativum* Var. *Abyssinicum)* in Ethiopia

Agricultural biodiversity, comprising all the elements from gene to agricultural ecosystems, is one of the principal components of natural resources (Atta-Krah, 2004), even though it is often treated separately from other natural resources in many parts of the world (Atta-Krah, 2004), including Ethiopia. A reservoir of irreplaceable genes and gene complexes of a number of crops is currently being lost at a rapid rate through genetic erosion as a result of displacement of landraces by modern varieties, dynamics of agriculture and land uses, destruction of natural habitats, and drought that finally lead to less productivity (Esquinas-Alcazar, 2005). Genetic erosion, the gradual depletion of natural resources in general and crop germplasm in particular with both natural and artificial interferences is, therefore, a current topic all over the world to overcome crop production problems.

Some crops which were common in the past have recently become rare. Faba bean (*Vicia faba* L., *abie*), the common field pea (*Pisum sativum* subspecies *arvense* L., ater), and the Ethiopian variety of the field pea (*Pisum sativum* L. var. *abyssinicum* A.Bruan., dekoko), which were once common, are now very infrequently grown in some parts of Ethiopia as near Adi Ainawalid in south Tigray (Hassan, 2002). They are important festival foods and, despite their high price, they are bought from Mekelle market in small quantities, four or five times a year. All these crops were said to have been common in 'the time of Haile Selassie' (prior to 1973). The main cause for their decline was given as the lack of rainfall, coupled with the small land holdings. Implicated also is the political disruption of traditional farming during the 1970s and 1980s, which caused much loss of germplasm. At a national level, attempts are now being made to conserve and reintroduce the

© 2016 Global Journals Inc. (US)

landraces, which may include varieties better adapted to the current climatic conditions (Hassan, 2002).

Yields of grain legumes are smaller and generally more variable than those of many other crop species. In developed countries, grain yields of legumes have not increased as rapidly as those of cereal crops (Jeuffroy and Ney, 1997). There is thus a need to increase the performance of pulse crops, particularly in developing countries, where most grain legume production is for human consumption and demand is increasing due to population increase. Jeuffroy and Ney (1997) estimated that yields in developing countries were only 45% of those of developed countries for pea, and 75% for faba bean and chickpea.

By the year 2013, Africa ranked fifth in pea crop production (730.4 tons) after North America (Canada and US with 4,669.3 tons), Europe (3,024.0 tons), East Asia (mainly china with 1,567.3 tons) and South Asia (839.1 tons) from the 2013 world major pulse crops producers countries or regions of the world, but the third major chick pea production region (670.4 tonnes/ha) after South Asia (9,895.4 tons) and Oceania (813.3 tons) in the world (CSA, 2011). Overall, from the 2013 world major pulse crops production areas, Africa is second (18,707.1 tons) after Northern America (20,881.5 tons) with the leader producer of cowpea (7,782.1 tons) (CSA, 2011).

In the 2013 world trade of pulse crops, pea held the highest exported (4,978.1 tons) and imported (4,284.7 tons) crop of which Northern America (Canada and US) exported 3,275 tons of the total export and South Asia importing 1,840.9 tons of the total import. There are no clear reasons for the discrepancies between total import and export quantities. According to CSA (2011), perhaps reporting error, duplication of reports, periodicity or a combination may be the reasons.

Field pea (*Pisum sativum* L.) is known to be grown in Ethiopia since antiquity (Keneni *et al*., 2013). Currently, the crop is the fourth most important pulse crop in Ethiopia, preceded only by faba bean, haricot bean and chickpea in terms of both area coverage and total national production (CSA, 2011). There are two botanical cultivars of *Pisum sativum* known to grow in Ethiopia, namely *P. sativum* var. *sativum* and *P. sativum* var. *abyssinicum* (Keneni *et al*., 2013). The botanical cultivar *P. sativum* var. *sativum* dominates the production system in the highlands of Ethiopia (Messiaen *et al*., 2006) while *P. sativum* var. *abyssinicum* is limited to sporadic growth in some pouches, particularly in Wollo and Tigray in the north and Arsi in the southeast (Keneni *et al*., 2013). Like all other cool-season food legumes, the productivity of field pea in general and that of the abyssinian pea in particular was very low in Ethiopia compared to many other continents and countries of the world (Kelley *et al*., 2000), which, among many other factors, may be attributed to poor soil fertility (Getachew *et al*., 2006 in keneni *et al*., 2013). Field pea (*Pisum sativum* L.), the crop that widely grow in mid to high altitude the fourth most important legume crop in Ethiopia after faba bean, haricot bean and chick pea had area coverage over 203,990.64 ha with a total production of 257,031.41 tons which accounts for 13% of the total grain legume production and average yield of 1.26 t/ha until 2011 which is very low (CSA, 2011). However, by 2015 the average yield of field pea in Ethiopia was 12.37 t/ha in area coverage reaching 212,890 ha with an annual production of 2,632,663.87 tons (Cherinet Alem and Tazebachew Asres, 2015) which is 9.8t/ha times more. This may because of increasing number of high yielding and disease resistant varieties, good management practices, supplement of organic and inorganic fertilizers, and reduction in insect and disease problems. Though, both field pea and dekoko are consumed as a protein supplement in the cereal-based diets of Ethiopia there is no national yield record yet for Dekoko (Sentayehu, 2009). The reasons are because of lacking of estimated area coverage per hectare and productions status per tons records of dekoko. This signifies the current review to assess the distribution and productivity of the crucial crop.

There is one scientific field check in strange area on the productivity of dekoko from project TR-31024 of the Ministry of Education, Science and Technological Development of the Republic of Serbia. A field trial with wild populations of Ethiopian pea of diverse geographic origin dealt with the mutual relationship of various seed yield components for the breeding purposes, along with some preliminary crossings with common pea was tested. Seed yield per plant are highly correlated with number of fertile nodes per plant, number of pods per plant (Table 1), while number of fertile nodes per plant was also highly correlated with number of pods per plant (Mikić *et al*. 2013c).

Table 1 : Simple correlation coefficients (*r*) among the seed yield components and seed and straw yields in Ethiopian pea accessions

	2	3	4	5	6	7	8	9
1	-0.263	0.176	-0.406	-0.237	-0.526	0.194	-0.363	-0.023
2		0.156	0.743*	0.706*	0.446	0.367	0.615	0.505
3			0.399	0.303	0.157	-0.006	0.161	0.109
4				0.973**	0.600	0.091	0.638*	0.285
5					0.580	0.233	0.692*	0.285

© 2016 Global Journals Inc. (US)

6						-0.027	0.807**	0.211
7							0.547	0.508
8								0.442

*(1) Main stem length (cm); (2) Number of stems plant^{-1}; (3) Number of total nodes plant^{-1}; (4) Number of fertile nodes plant^{-1}; (5) Number of pods plant^{-1}; (6) Number of seeds plant^{-1}; (7) Thousand seeds weight (g); (8) Seed yield (g plant^{-1}); (9) Straw yield (g plant^{-1}); * = significant at 0.05; ** = significant at 0.01(Mikić et al. 2013c)*

Earliness is one of the prominent traits in Ethiopian pea, giving a basis for a view that earliness may have been selected before Ethiopian pea split from the main track of the domestication within the genus *Pisum* (Mikić and Mihailović, 2014).

V. Soil Requirement

Ethiopian pea is highly suitable for cultivating on the soils with rather low fertility, such as those in northern Ethiopia, where it achieves better results than common pea and other cool season legumes (Yemane & Skjelvag 2003a), as it is resistant to high concentrations of microelements, such as cadmium, in the soil (Manasi *et al*. 2014). In a glasshouse and field trial in Spain, the wild populations of Ethiopian pea with nonspecific resistance genes to pea bacterial blight, proved to be much less affected by all three races of the disease (Elvira-Recuenco *et al.* 2003). The resistance of Ethiopian pea to various pea bacterial blight races was confirmed in several other tests (Martín-Sanz *et al*. 2011, Martín-Sanz *et al*. 2012b). An incomplete resistance to pea powdery mildew was assessed in some wild populations of Ethiopian pea (Fondevilla *et al*. 2007). Ethiopian pea is also much less affected by *Fusarium* root rot in comparison to common pea (Grünwald *et al*. 2003). It was also determined in the case of nematodes, such as *Heterodera goettingiana* Liebscher, where the resistance of Ethiopian pea is controlled by recessive genes.

Dekoko is a neglected and underutilised cool season annual legumes crop in Northern Ethiopia. Concerning the significance of plant genetic resources little has been done recently for dekoko as the concern for significance of other plant genetic resources has been discussed for last several decades. It has always been accurately declared that they are not only a live capital of both one country but also of the whole mankind. However, it has also been stressed that their *ex situ* preservation and *in situ* conservation are very demanding in numerous ways, especially if considering human resources and financial support. It is quite punctually noted that plant genetic resources are in danger to become 'museum items' (Maxted *et al*. 2000 in Mikić *et al*., 2014). But, their *ex situ* preservation is without regard of the ecophysiological nature of the plants in developing countries like Ethiopia.

It is obvious that crop yields can be improved by application of commercial fertilizers but such practices, apart from the environmental concerns, must be repeated each season and hence are expensive particularly for totally neglected crops like the Abyssinian field pea which are grown by the resource-poor farmers under marginal conditions. It is known that the majority of the farmers in Ethiopia did not apply fertilizer to legumes and, out of the total land area under pulse crops; the proportion of the fertilized area was insignificant as compared to cereals (Messiaen *et al*., 2006). Now days, nitrogen and phosphorus fertilizer applications and researches are becoming common in pulse crops. Field pea is known to fix more nitrogen than some of the other legumes like chickpea and lentil but less than the others like faba bean (Schmidt, 1988 as cited in Keneni *et al*., 2013). There are also starting on the effect of nitrogen and phosphorus fertilizers on Dekoko. Biological nitrogen fixation of *P. sativum* var. *abyssinicum* grown in nitisols and vertisols ranged between 38.60 % and 46.10%, the average on the two soils being 42.39 % less than the improved varieties of *P. sativum* var. *sativum,* Holetta-90 with a fixation efficiency of 45.37% and Adi with a fixation of 50.19% which apparently superior (Keneni *et al*., 2013). This may be attributed to: (1) the botanical cultivar *P. sativum* var. *sativum* may be inherently superior for biological nitrogen fixation to *P. sativum* var. *abyssinicum,* (2) the past genetic improvement efforts for other traits may inadvertently improved biological nitrogen fixations in Adi and Holetta-90 (Gemechu Keneni *et al*., 2013).

Nitisols and vertisols are among the dominant soil types in Ethiopia, making 12.5 % and 10.0% of the land area (IFPRI and CSA, 2006 in Gemechu Keneni *et al*., 2013), particularly in the highlands where field pea is among the most dominant pulses (Mussa *et al*., 2006). Dekoko pea has better level of average biological nitrogen fixation under nitisol (45.01 %) than under vertisol (39.29 %) and this could somehow be associated with the variable characteristics of the two soil types particularly the difference in drainage of excess moisture as the impeded drainage in vertisols may reduce the level of nitrogen fixation (Keneni *et al*., 2013).

VI. Effect of N and P Fertilizers on Dekoko (*Pisum Sativum* Var. *Abyssinicum*) Growth

Little green house experimentations are conducted on the physiochemical trait of dekoko seeds based on the application of NP fertilizers although no more work has been done on farm based on native soil characterization. There is an increment of leaf area (LAI) with the application of NP fertilizers. Leaf area

© 2016 Global Journals Inc. (US)

determines the amount of solar radiation intercepted and consequently the amount of dry matter produced (Kiros wolday *et al*., 2015). The increase in LAI was closely related to the number of branches, which increase the total number of leaves. Also it could be in an increase in leaf expansion (Yemane and Skjelvåg, 2003b).

Plant height can be affect by varying nitrogen and phosphorus fertilizer levels (Table 2). From the study of Kiros Wolday *et al*. (2015), there is linear trend between plant height and fertilizer rate as nitrogen is the essential component for growth of the crop. Nevertheless, application of NP beyond 60 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} has limited increment on plant height that is recommended for further proof in the average values of the higher treatments. Dekoko plant grown without fertilizer application has minimum plant height (40.50cm) compared with plants grown with NP_2O_5 fertilizer application (Kiros Wolday *et al*., 2015). This is common on other pulse crops like chickpea that, increase in plant height with increase in N fertilizer rate and lentil (Togay *et al*., 2005).

Table 2 : Growth parameters of Dekoko (*Pisum sativam* var. *abyssinicum)* as influenced by Nitrogen and Phosphorus fertilizer levels

N + P_2O_5 (Kg ha^{-1})	LAI (m^2m^2)	PHT (cm)	NBBP
0 (Control)	1.04c	40.50[b]	1.68[b]
30 + 30	1.84bc	41.44[b]	1.93b
60 +60	2.13ab	48.98[a]	2.63[a]
90 +90	2.82a	50.83[a]	2.73a
CV (%)	9.4	6.79	13.84
LSD (5)	0.68	4.93	0.48

Where: LAI= Leaf area index, PHT= plant height, NBBP= number of basal branches per plant (Kiros Wolday et al, 2015).

Number of basal branches per plant increased as the NP level increases from the control except treatment T2 (30 kg N ha^{-1} and 30 kg P_2O_5 ha^{-1}) (Table 2). Increasing of N and P fertilizer from 0 to 90 kg ha^{-1} + 90kg P ha^{-1}) enhanced the number of basal branches per plant in a linear fashion. Number of basal branches per plant revealed a similar trend as that of the plant height. EL- Desuki *et al*. (2010) also reported, in field pea where increases in NP level tend to increase basal branches per plant.

The response of cool season grain crops to fertilizer (DAP and Urea) added to vertisol soils is good on the whole because of their high moisture holding capacity, so crops are less likely to be affected by the fluctuation of soil moisture (and low rainfall) as opposed to the other soil types. Crop production is good whenever there is sufficient rainfall and application of fertilizer. Farmers of the dekoko growing area generally use DAP and Urea on vertisol and sandy soils and only DAP on alluvial soils for other crops excluding dekoko. Farmyard manure (FYM) is applied on vertisol soils to improve the workability of the soil. But there is no yet recorded data and clear information about the response of dekoko to composite and its relative impact from DAP and Urea. According Kiros Wolday *et al*. (2015), growth rate of dekoko (*Pisum sativum* var. *abyssinicum*) increases in response to nitrogen and phosphorus fertilizers application increment.

VII. Physical Characteristics of Dekoko Seed

Dekoko seeds have lower seed volume and seed weights than the common pea, Ater by about 30 and 36%, respectively (Table 3). These physical characteristics differences could be attributed to variation in cell number and mean volume of cells in their respective cotyledons, as sizes of matured seeds in peas are determined by the number and mean volume of cells in the cotyledon. The values for percent seed swelling, hydration capacity, and percent husk content are much higher for dekoko than for Ater (Table 3).

Table 3 : Some physicochemical characteristics of the seeds of dekoko and common pea (Ater[a])

Variety	Weight (g 100 $seeds^{-1}$)	Volume (ml 100 $seeds^{-1}$)	Density (g ml^{-1})	Absoption (g 20 g $seeds^{-1}$)	Swelling (%)	Husk (%)
Dekoko	12.5	10.6	1.18	19.54	96	12.2
Ater	17.1	13.8	1.24	13. 9	73	11.0
P value	< 0.001	< 0.001	< 0.022	< 0.001	< 0.001	< 0.001

[a]*Values are mean of four parallel samples. P=probability value from the analysis of variance*
Source: (Yemane and Skjelvåg, 2003b)

Water absorption, in legume seeds, depends on the seed coat thickness, hilum size, and protein content of the cotyledons (Yemane and Skjelvåg, 2003a). The difference in hydration capacity between the varieties could be ascribed to either of these features. As seed volume of legume pea's increase,

© 2016 Global Journals Inc. (US)

their husk content decreases. Dekoko seeds have relatively higher husk percentage (12.2%) than Ater seeds (11%) that could be attributed to dekoko's smaller seeds as husk content were negatively correlated to seed volume.

VIII. Chemical Composition of Dekoko in Relative to Common Pea Seeds

Dekoko seeds contain higher crude protein (CP) than Ater both in the cotyledon (251 vs. 242 g/kg DM) and whole seed flours (235 vs. 229 g/kg DM) (Table 4), also the cotyledon flours contain higher CP than whole seed flours in dekoko seeds. The higher crude protein in dekoko relatively from common pea is due to less incorporation of the seed coat in to the dekoko seeds. In general the CP contents for dekoko seeds are within the ranges reported by a number of workers (Zdunczyk *et al*., 1997 in Yemane and Skjelvåg, 2003b), which are in the range of 207–264 g/kg DM for different pea varieties. Such broad variation in protein content could emanate from genetic differences and variations in growth conditions (soil, fertilizer, etc.). Peas, in general, are known to have low fat contents. It is in the range of 1–2% (Yemane and Skjelvåg, 2003b).

Table 4 : Proximate chemical composition (g/kg DM) for Dekoko and Ater[a]

Seed parts	Variety	CP	Fat	Sugar	Starch	NDF
Cotyledon	Dekoko	251	18.9	31.7	375	13
	Ater	242	16.6	23.7	402	109
Whole seed	Dekoko	235	16.7	26.6	-	-
	Ater	229	15.3	22.4	-	-
Seed coat	Dekoko	71.4	2.60	-	-	-
	Ater	68.0	2.00	-	-	-
	P value	0.024	0.019			

[a]*Values are mean of four parallel samples. P=probability level from the analysis of variance. CP= crude protein, NDF = neutral detergent fiber, - = not determined (Yemane and Skjelva˚g, 2003).*

Fat content of dekoko, in the cotyledon flour (18.9 g/kg DM), is closer to the upper value indicated for peas. Dekoko contain higher fat content than the Ater which contain both in the cotyledon (16.6 g/kg DM) and whole seed (15.3 g/kg DM) flours than those of dekoko cotyledon and whole seeds. Fat is an important source of energy. Its presence also makes food more palatable (Yemane and Skjelvåg, 2003b). The appreciation of the local people for dekoko, in terms of its taste, could be attributed to its relatively higher fat content, although there could be other factors that affect the sensory taste of consumers. Dekoko had a higher NDF content in its cotyledon (131 g/kg DM) than that of Ater (109 g/kg DM) (Yemane and Skjelvåg, 2003b). NDF measures a fraction of the dietary fiber-the insoluble fraction (Yemane and Skjelva˚g, 2003b), which is mainly composed of cellulose, hemicelluloses, and lignin.

Among the 20 building block proteins (standard amino acids) glutamine is found in highest level, followed by asparagines and arginine in dekoko and its relative common pea, Ater (Table 5). These amino acids constituted about 39% of the total amino acid content in both peas. Glutamine is lower in dekoko than in Ater, but they have a difference in relativity only by 4%. Sulfur containing amino acids (methionine and cysteine) exist in smaller quantities (3.01 in dekoko and 2.23 g/16 g N in Ater), like in other legumes reported by a number of workers, which are in the range of 2.2–3.5 g/16 g N. The sulfur containing amino acids (methionine and cysteine) values for Dekoko are also higher than those reported values for a number of pea cultivars, with the maximum value for dekoko about 2.8 g/16 g N even if it is limited to a single accession with a single study report. According to Yemane and Skjelvåg (2003a), the higher total sulfur amino acids content of dekoko compared with common pea might indicate its primitive nature, as primitive and small seeded peas exhibit a higher relative amount of total sulfur amino acids (Yemane and Skjelvåg, 2003b).

Table 5 : Amino acid composition of the cotyledon flour of Dekoko and Ater (g/16 g N), and FAO/WHO (24) reference pattern for children 2-5-year-old[a]

Amino acid	Dekoko	Ater	Dekoko/Ater	Ref
Cysteine[b]	1.97a[c]	1.45b[c]		1.36
Methionine[d]	1.04	0.78		1.33
Asparagine	12.06	11.83	1.02	
Threonine[d]	4.10	3.78	1.08	3.4
Tryptophan[d]	1.14	1.10	1.04	1.1
Serine		5.50	5.36	1.03
Glutamine	16.78a[c]	17.55b[c]	0.96	
Proline[b]	4.29	4.60	0.96	
Glycine[b]	4.31	4.37	0.99	

© 2016 Global Journals Inc. (US)

Alanine	4.22	4.07	1.04	
Valine[d]	4.81	4.73	1.02	3.5
Isoleucine[d]	4.28	4.33	0.99	2.8
Leucine[d]	6.93	6.86	0.99	6.6
Tyrosine[d]	3.52	3.18	1.11	
Phenylanine[d]	4.85	4.74	1.02	
Histidine[d]	2.52	2.46	1.02	1.9
Lysine[d]	6.93	6.86	1.01	5.8
Arginine[b]	10.23	9.57	1.07	
Methionine + Cysteine	3.01a[e]	2.23b[c]	1.35	2.5
Phenylalanine ± Tyrosine	8.37	7.92	1.06	6.3

[a] Values are mean of two parallel samples, [b] conditionally essential amino acids (Reeds, 2000), c a, b significant difference across columns at α = 0.05 and [d] Essentail amino acids.

Lysine, the limiting amino acid in cereals, occurs in fairly high quantity in dekoko seeds. It constitutes about 7% of the total amino acids in dekoko together with Ater variety, the values for comparative contents of the alpha amino acids are (6.93 and 6.86 g/16g N for dekoko and Ater, respectively) and are within the range for common pea (6.19–7.4 g/16 g N) (Yemane and Skjelvåg, 2003b). Therefore, dekoko can be considered as a good protein supplement for a cereal–based diet and an indication of the potential role of dekoko as a good complementary protein source.

In terms of minerals content, the whole seed and cotyledon flours of dekoko contained less calcium (Ca) and magnesium (Mg) than that of the related variety of pea, Ater. Dekoko seeds have much higher phosphorus (P), than Ater (Yemane and Skjelvåg, 2003b). Overall, the Ca and Mg contents of dekoko (34 and 90.7 mg/100 g, respectively) are close to the values reported by Yemane and Skjelvåg (2003b) (34.9 and 87.2 mg/100 g, respectively), while the values for common pea (42.3 and 98.7 mg/100 g) are higher than those of Yemane and Skjelvåg (2003b) for split peas. Ca and Mg for both varieties and P value for dekoko are also higher than the mean values reported for split peas, which were 28, 70, and 278 mg/100g, respectively. Genotypic differences in accumulating these nutrients and/or differences in growing conditions may account for such variations.

With regard to the distribution of minerals in different seed parts of Dekoko, Ca and Mg concentrations are higher in the seed coats than in cotyledon and whole seed flours, while P is highest in the cotyledon flour. Yemane and Skjelvåg (2003a) also reported higher P in cotyledons and higher Ca concentrations in seed coats for a number of legumes. The seed coats are rich in Ca and Mg, and their removal through decortications seems to cause significant losses of minerals. Because of the husk proportion, the losses of Ca and Mg, for example, in dekoko are greater than 55 and 25% of the total, respectively.

References Références Referencias

1. Agbicodo E. M., Fatokun C. A., Muranaka S., Visser R. G. F., and Linden van der C. G. (2009). Breeding drought tolerant cowpea: constraints, accomplishments, and future prospects. *Euphytica*, **167**:353-370.
2. Aslam, M., Hussain, N., Zubair, M., Hussain ,S.B., and Baloch, M. S., (2010). Integration of organic & inorganic sources of phosphorus for increased productivity of mungbean (Vigna radiata). *Pakistan Journal of Agricultural Science*, **47**: 111-115.
3. Atta-Krah, K. (2004). Natural resources management and genetic diversity: Two sides of coin for sustainable livelihoods and development. A Paper Presented to the African Highland Initiative Conference – Integrated Natural Resource Management in Practice: Enabling Communities to Improve Mountain Landscapes and Livelihoods. 12-15 October 2004, Nairobi, Kenya (in press).
4. Baranger, A., Aubert, G., Arnau, G., Laine, A.L., Deniot, G., Potier, J., . . . Burstin, J. (2004). Genetic diversity within Pisum sativum using protein- and PCR-based markers. *Theoretical and Applied Genetics,* **108** (7), 1309-21.
5. Baranyi, M., & Greilhuber, J. (1995). Flow cytometric analysis of genome size variation in cultivated and wild *Pisum sativum* (Fabaceae). *Plant Systematics and Evolution,* **194**(3-4), 231-239.
6. Chemining-wa, G.N., Vassely, J.K., (2006). Abundance and efficacy of *Rhizobium leguminosarum* bv. *viciae* in cultivated soils of eastern Canadian prairie. *Soil Biology and Biochemistry*, **38**: 294-302.
7. Chen, C., Miller P., Muehlbauer F., Neill K., Wichman D. and McPhee K. (2006). Winter pea and lentil response to seeding date and micro- and macro-environments. *Agronomic J*ournal, **98**:1655-1663.
8. Cherinet Alem and Tazebachew Asres (2015). Adaptability of Field pea (*Pisum sativum* L.) Varieties Under Irrigation, Western Amhara Region,

© 2016 Global Journals Inc. (US)

Ethiopia. *International Journal of Plant Breeding and Genetics,* **9** (1): 28-31.

9. Clark, A. (2007). Managing cover crops profitably. 3rd ed. Sustainable agriculture research and education program handbook series 9. *Sustainable Agriculture Research and Education, College Park, MD.*
10. Corre-HellouG., and CrozatY. (2005). N_2 fixation and N supply in organic pea (*Pisum sativum* L.) cropping systems.
11. CSA (2011). Agricultural sample survey: Report on area and production for major crops (private peasant holdings, meher season). Central Statistical Authority, Addis Ababa, Ethiopia.
12. Cupic T., Tucak M., Popovic S., Bolaric S., Grljusic S. and Kozumplik V. (2009). Genetic diversity of pea (*Pisum sativum* L.) genotypes assessed by pedigree, morphological and molecular data. *Journal of Food, Agriculture & Environment,* **7** (3&4): 343 - 348.
13. EL-Desuki M., Magda M., Hafez A.R., Mahmoud F.S., and Abd El-Al. (2010). Effect of organic and biofertilizers on the plant growth, green pod yield, quality of pea. *International Journal of Academic Research,* **2**: 87-92.
14. Elvira-Recuenco, M., Bevan, J.R., & Taylor, J.D. (2003). Differential responses to pea bacterial blight in stems, leaves and pods under glasshouse and field conditions. *European Journal of Plant Pathology,* **109**(6), 555-564.
15. Elzebroek T., and Wind K. (2008). Guide to cultivated plants. CAB International, Oxfordshire, UK.
16. Esquinas-Alacazar J. (2005): Protecting crop genetic diversity for food security: political, ethical and technical challenges. *Nature Reviews Genetics*, **6**: 946–953.
17. Farooq M., Wahid A., Kobayashi N., Fujita D., Basra S.M.A. (2009). Plant drought stress: effects, mechanisms and management. *Agronomy for Sustainable Development*, Springer Verlag/EDP Sciences/INRA, **29** (1), 185-212.
18. Fondevilla, S., Carver, T.L.W., Moreno, M.T., & Rubiales, D. (2007). Identification and characterization of sources of resistance to Erysiphe pisi Syd. in *Pisum* spp. *Plant Breeding,* **126**(2), 113-119.
19. Fondevilla S., Rubiales D., Moreno MT., Torres AM. (2008). Identification and validation of RAPD and SCAR markers linked to the gene *Er3* conferring resistance to *Erysiphe pisi* DC in pea. *Mol Breeding* **22**:193–200.
20. Gemechu Keneni, Fassil Assefa, Imtiaz M., and Endashaw Bekele (2013). Genetic diversity for attributes of biological nitrogen fixation in Abyssinian field pea (*Pisum sativum* var. *Abyssinicum*) germplasm accessions. *Ethiopian Journal of Applied Science and Technology*, **4**(2): 1-20.
21. Girmay Tesfay, Girmay Gebresamuel, Alem Gebretsadik, Abrhaley Gebrelibanos,Yemane Gebremeskel and Tesfay Hagos (2014). Participatory Rural Appraisal Report: Raya-Azebo *Woreda*, Tigray Region.
22. Grünwald, N.J., Coffman, V.A., & Kraft, J.M. (2003). Sources of partial resistance to Fusarium root rot in the Pisum core collection. *Plant Disease,* **87**, 1197-1200.
23. Hadačova, V., Turkova, V., Hadač, E., & Klozova, E. (1980). Comparison of seed proteins of some representatives of the genus *Pisum* from the point of view of their relationship comparison by disc electrophoresis. *Biologia Plantarum,* **22**(1), 7-16.
24. Haddis Yirga and Dargie Tsegay (2013). Characterization of Dekoko *(Pisum sativum* var. *abyssinicum* A.Bruan) accessions by qualitative traits in the highlands of Southern Tigray, Ethiopia. *African Journal of Plant Science*, Vol. **7**(10), 482-487.
25. Hassan F. A. (2002). *Droughts, Food and Culture:* Ecological Change and Food Security in Africa's Later Prehistory. Kluwer Academic Publishers, New York, Boston, Dordrecht, London, Moscow. pp. 178.
26. IBC (2007). Ethiopia: Country Report on the State of PGRTA to FAO. Institute of Biodiversity Conservation, Addis Abeba, April 2007.
27. International Food Policy Research Institute (IFPRI) and Central Statistics Agency (CSA) (2006). Atlas of the Ethiopian rural economy. Addis Ababa, Ethiopia.
28. Jeuffroy M.H., and Ney B. (1997). Crop physiology and productivity. *Field Crops Research*. **53**: 3-16.
29. Kelley TG., Rao PP., and Grisko-Kelley H. (2000). The Pulse Economy in the Mid-1990s: A Review of Global and Regional Development. In Knight R. (ed.). Linking Research and marketing opportunities for pulses in the 21st Century. Proceeding of the third international Food Legumes Research Conference. Kluwer academic Publishers, Dondrecht. pp. 1-29.
30. Keneni Gemechu, Assefa Fassil, Imtiaz M., and Bekele Endashaw (2013). Genetic diversity for attributes of biological nitrogen fixation in Abyssinian field pea (*Pisum sativum* var. *abyssinicum*) germplasm accessions. *Ethiopian Journal of Applied Science and Technology;* **4**(2): 1-20.
31. Kiros Wolday, Araya Alemie, and Yemane Tsehaye (2015). Growth Response of Dekoko (*Pisum sativum* var. *abyssinicum*) to Nitrogen and Phosphorus Fertilizers at Enderta Woreda, Northern Ethiopia. *Journal of Biology, Agriculture and Healthcare*, **5**(21), 94-99.
32. Manasi, Rajesh, V., Kumar ASK., and Rajesh, N. (2014). Biosorption of cadmium using a novel bacterium isolated from an electronic industry

© 2016 Global Journals Inc. (US)

effluent. Chemical Engineering Journal, 235:176–185
33. Martín-Sanz, A., Palomo, J.L., de la Vega, M.P., & Caminero, C. (2011). Identification of pathovars and races of Pseudomonas syringae, the main causal agent of bacterial disease in pea in North- Central Spain, and the search for disease resistance. *European Journal of Plant Pathology,* **129**, 57-69.
34. Martín-Sanz, A., Perez de la Vega, M., & Caminero, C. (2012b). Resistance to Pseudomonas syringae in a collection of pea germplasm under field and controlled conditions. *Plant Pathology,* **61**, 375-387.
35. Maxted, N., & Ambrose, M. (2001). Peas (Pisum L.). In N. Maxted & S.J. Bennett (Eds.), *Plant Genetic Resources of Legumes in the Mediterranean*. (pp. 181-190). Dordrecht, the Netherlands: Kluwer.
36. McGee R. (2012). USDA-ARS. Personal communication. USDA-National Agricultural Statistics Service. 2011. Press release. USDA-NASS, Washington, DC. http://www.nass.usda.gov/Statistics_by_State/Washington/Publications/Current_News_Release/pealent11. pdf (accessed 16 may 2016).
37. Messiaen CM., Seif AA., Jarso M., Keneni G. (2006). *Pisum sativum* L. Record from Prota-base. Brink, M. & Belay, G. (Editors). PROTA (Plant Resources of Tropical Africa), Netherlands.
38. Mikić, A., Ćupina, B., Mihailović, V., Krstić, D., Dorđević, V., Perić, V., . . . Kobiljski, B. (2012). Forage legume intercropping in temperate regions: Models and ideotypes. In E. Lichtfouse (Ed.), *Sustainable Agriculture Reviews*. (pp. 161-182).
39. Mikić, A., Mihailović, V., Dimitrijević, V., Petrović, S., Ćupina, B., Đorđević, V., . . . Milovac, Ž. (2013c). Evaluation of seed yield and seed yield components in red-yellow (*Pisum fulvum*) and Ethiopian (*Pisum abyssinicum*) peas. *Genetic Resources and Crop Evolution,* **60**, 629-638.
40. Mikić, A., and Mihailović, V. (2014). Significance of Genetic Resources of Cool Season Annual Legumes. II. Neglected and Underutilised Crops. *Ratar.Povrt,* **51**(2):127-144.
41. Mishra RK., Gangadhar BH., Nookaraju A., Kumar S., Park SW. (2012). Development of EST-derived SSR markers in pea (*Pisum sativum*) and their potential utility for genetic mapping and transferability. *Plant Breed*.**131**:118–24.
42. Mussa J., Tezera W., and Gemechu K. (2006). Review of Field Pea (*Pisum sativum* L.) Genetics and Breeding Research in Ethiopia. In: Food and Forage Legumes of Ethiopia: Progress and Prospects, Kemal, A. (Ed.). ICARDA, Alepo, Syria, pp: 67-79.
43. Sentayehu, A., (2009). Assessment of Nutrient Contents of Different Field Pea Genotypes (*Pisium Sativum* L.) in South west Ethiopia. Department of Plant Sciences, Jima University, Jimma, Ethiopia.
44. Singh U. (1985). Nutritional quality of chickpea: Current status and future research needs. *Plant foods Hum Nutr* **35**: 339–351.
45. Smýkal P., Aubert G., Burstin J., Coyne C. J., Ellis N.T.H., Flavell A.J., Rebecca Ford R., Hýbl M., Macas J., Neumann P., McPhee K.E., Redden R.J., Rubiales D., Weller J.L., Warkentin T.D. (2012): Pea (*Pisum sativum* L.) in the Genomic Era. *Agronomy*, **2**: 74–115.
46. Tanno, K., & Willcox, G. (2006). The origins of cultivation of Cicer arietinum L. and Vicia faba L. Early finds from Tell el-Kerkh, north-west Syria, late 10th millennium B.P.. *Vegetation History and Archaeobotany,* **15**, 197-204.
47. Toğay, Y., Toğay N., Doğan,Y., and Ciftci,V. (2005). Effects of nitrogen level and forms on the yield and yield components. *Asian Journal of Plant Sciences*, **4** (1): 64-66.
48. Vershinin, A.V., Allnutt, T.R., Knox, M.R., Ambrose, M.J., & Ellis, N.T.H. (2003). Transposable elements reveal the impact of introgression, rather than transposition, in *Pisum* diversity, evolution, and domestication. *Molecular Biology and Evolution,* **20**(12), 2067-75.
49. Wang H.X., and Ng T.B (2007). An Antifungal Peptide from Red Lentil Seeds. *Peptides*, **28** (3): 547-52.
50. Weeden NF., and Ambrose MJ. (2004). Ser appears to be the serrate leaflet locus mapped on linkage group III. *Pisum Genetics.* **36**: 25–26.
51. Weeden, N.F., Murphy, R.L., and Lorenzi, V. (2001). The gene responsible for serrate leaflets in *P.sativum* ssp. *abyssinicum* is on linkage group III tightly linked to an STS marker. *Pisum Genetics*. **33**: 27-31.
52. Weeden, N. F., and B. Wolko. (2001). Allozyme analysis of Pisum sativum ssp. abyssinicum and the development of a genotype definition for this subspecies. *Pisum Genet*. **33**:21–25.
53. Wetterstrom, W. (2006). Food, fuels, and fields: progress in African archaeobotany. *Journal of Ethnobiology,* **26**, 174-176.
54. Yemane, A., and Skjelvåg A. O. (2002). The physicochemical features of Dekoko (*Pisum sativum* var. *abyssinicum*) seeds. *Plant Foods Human Nutrition*, in press.
55. Yemane, A., and Skjelvåg, A.O., (2003a). Effects of Fertilizer Phosphorus on Yield Traits of Dekoko (*Pisum sativum* var. *abyssinicum*) Under Field Conditions. *Journal of Agronomy and Crop Science,* **189**:14-20.
56. Yemane, A., & Skjelvåg, A.O. (2003b). Physicochemical traits of Dekoko (*Pisum sativum* var. *abyssinicum*) seeds. *Plant Foods for Human Nutrition,* **58** (4), 275-83.
57. Zdunczyk, Z., Godycka I., and Amarowicz R. (1997). Chemical composition and antinutritional factors in

© 2016 Global Journals Inc. (US)

Polish cultivars of pea. *Plant Foods Human Nutrition,* **50**: 37–45.

58. Zohary, D., Hopf, M., and Weiss, E. (2012). Domestication of plants in the old world, 4th edition.
59. Zong, X.X., Ford, R., Redden, R.R., Guan, J.P., & Wang, S.M. (2009). Identification and analysis of genetic diversity structure within Pisum genus based on microsatellite markers. *Agricultural Sciences in China,* **8**, 257-267.

© 2016 Global Journals Inc. (US)