

# FABA BEAN (*Vicia faba*) IN ETHIOPIA



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**Yohannes Degago**

*This publication was prepared in June 1997 by the late Dr Yohannes Degago who was a highland pulses researcher at Holetta Research Center of the Ethiopian Agricultural Research Organization (EARO). The Institute of Biodiversity Conservation and Research (IBCR) is pleased to publish the work of Dr. Yohannes Degago.*

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## INTRODUCTION

The faba bean, known as botanically as *Vicia faba* L., is a cool season food legume crop. In Ethiopia, the crop grows mainly because the chilling requirement is fulfilled by cold temperatures in the high elevation of the mountains from altitudes of 1900 to 3000 m and sometimes even higher. Hence, it is known as one of the "highland pulses" together with field or dry peas (*Pisum sativum*), chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), grass or rough pea (*Lathyrus sativum*), fenugreek (*Trigonella foenum graecum*), and Lupin (*Lupinus albus*) all that inhabit the highlands of Ethiopia in great diversity.

Ethiopia is the second largest grower of faba bean in the world after the Peoples' Republic of China. It is the most important of the highland pulses in terms of acreage, production and food supply among the highland pulses. It plays a key role in the cropping system where it is grown in rotation with cereals and oil crops for the purpose of improving soil fertility and as a break crop against soil borne diseases. It used to be an important export commodity until 1977 but there has been a decline ever since because of low supply and low quality seeds.

Faba bean also holds an important place in the national recipe where it is consumed in various forms, i.e., by children who herd livestock to people who live in seclusion in the monasteries and holy places. In other parts of the world the green immature beans are boiled and eaten as vegetable. The mature seeds may be used for feeding livestock, swine, equine, and poultry animals. The stocks or haulms may be used as animal feeding stuff also. The stocks are used as fire wood for cooking. The crop may be grown for green manuring and for silage. Production in Ethiopia is totally rain-fed on Nitosols and Cambisols soils.

Yield per hectare is rather low (about 1 ton/ha) because of various production constraints among which the inherently low yielding ability of most of the local cultivars, primitive production practices, poor soil fertility, and diseases are the major ones. A substantial amount of research attention has been given to faba bean for the last 18 to 20 years when a number of improved production packages that include varieties, agronomic practices and pest management have been generated, verified, demonstrated and disseminated to farmers in the central (Shewa), south east (Arsi and Bale) and northwest (Gojam and south Gonder). Adoption rate of these improved production technologies must have been very poor among farmers or demonstrations and popularizations have been done in very few areas since production per hectare is still low.

## DESCRIPTION

### Plant

Erect, stiff, robust, glabrous annual with a well-developed taproot

### Stems

Stout, square, hollow with one or more basal branches

### Leaves

Alternate, pinnate, without tendrils

### Leaflets

Sub-opposite or alternate, sub-sessile, ovate, 2-6, 40-80(-100) x 10-20 (-40) mm, grey-green

### Inflorescence

An axillary, sub-sessile, short raceme.

### Raceme

Sub-sessile, short, 1-6 flowered

### Calyx

Campanulate, glabrous or nearly so, tube about 7 mm long, lobes, sub-equal, narrowly triangular 5-8 mm long

### Corolla

Standard - approaching the keel, broadly ovate, about 2.5 x 1.5 cm; wings - oblong-ovate about 2.5 x 0.5 cm, white marked by a dark brown blotch

### Androecium

Stamens - diadelphous (9+1), about 15 mm long; anthers - ellipsoid to ovoid about 1 mm long basifixed, dark brown

### Gynoecium

Ovary - sessile or nearly so, very slender, compressed about 14 mm long; style - abruptly upturned about 3 mm long, glabrous with an abaxial tuft of hair near the stigma. Stigma - terminal, glandular-papillate

### Pods

Narrowly oblong, cylindrical to flattened; bulging over the seeds, 3-5-6(-8) x 1-1.5 cm, sparsely pubescent when mature, beaked, generally 2-5 seeded.

**Seeds**

Variable in shape and size, ovoid to oblong, compound, 1-2 cm in diameter, dark brown, brown, reddish, or green.

**Hilum**

Narrowly oblong.

**Seedling**

With hypogaea germination

**Sources**

Thulin (1983), Westphal (1974).

**SPECIES NAME****English**

Most English names refer to a particular subgroup rather than the whole species (Bond 1979).

**Field bean:** refers to the medium and small seed sizes;

**Broad beans/Windsor bean:** refer to large seeded types;

**Horse beans:** refer to winter and spring sown medium types;

**Tick beans:** refer to small seeded type.

**Arabic**

Ful

**Ethiopian**

Tigre - **Baldenga, Ater-bahri, Bar-ateri**

Amhara, Oromo, Guragie, Kambata and most others - **Bakela**.



## DOMESTICATION

Faba bean domestication is believed to be around 5000 BC (Zohary 1977). There is insufficient evidence to be precise about the exact origin of the crop. But it is widely believed that the center of primary diversity and cultural origin somewhere in the near and middle East (Lawes et al. 1983) from which the culture of the species, according to Cubero (1974), radiated out in five directions towards:

- Southern Europe via North Africa;
- Western and Northern Europe via Turkey, Greece and Northern Italy;
- Eastern Europe and the USSR;
- India and China via Iraq and Iran;
- Ethiopia via Egypt.

Thus, Ethiopia is a secondary center of diversity for faba bean. Faba bean is listed in the "Near eastern Region" by Zeven and Zhukovsky (1975) in the one of their twelve mega-centers of crop plant diversity. The derivation of *Vicia faba* is not clear and its immediate ancestor is not known. Muratova (1931) classified *Vicia faba* as Species: *Vicia faba*, Subspecies: *Paucijuga* (2-2.5 pair leaflets), and *Eu-faba* (3-4 pairs leaflets). Botanical varieties derived from Eu-faba are divided into *Minor* (small seeded), *Equina* (medium seeded), and *Major* (large seeded). Even though there is no discontinuity in seed size between them.

The subspecies *Paucijuga* is known to be found in North India and Afghanistan characterized by few flowers, many short stems and indehiscent pods. The eu-faba on the other hand is dominant in North Africa including Ethiopia and Western Europe and most of the Soviet Union.

In Ethiopia, expatriate investigators earlier claimed that faba bean types grown are mainly the var. *minor* (Westphal 1974 and Muratova 1931) and that the Ethiopian beans were very uniform except in very few cases where recently introduced seed of the major (large-seeded) types were encountered. Recently, however, Ethiopian scientists write about the existence of both the var. *equina* (medium seeded) and the var. *minor* (small seeded) types in the country. But they take opposite views as to which botanical group is predominantly found in what part of the country. Asfaw et al. (1994) claimed that the northern part of the country including north Shewa mainly grows the *Equina* type whereas farmers in the southern half of the country mainly grow the var. *minor*. Amare (1994) claims the opposite to be true. He bases his belief in the fact that recommended landraces such as the CS 20 DK, medium seed size, came from Arsi region.

## WILD RELATIVES

In most literature investigated, the following are listed as wild relatives of *Vicia faba*:

By Westphal (1974), *V. pliniana* - known to grow wild in Algeria;

By Witcombe (1982), *V. angustifolia* L. (2n=12) and *V. narbonensis* L. (2n=14) - Narbonne vetch

By Lawes et al. (1983) *V. galilaea*, and *V. byaeniscyamus*

By Muehlbauer et al. (1994) *V. johannis*, and *V. bithynica*

By Dawit T. et al. (1994) as known to grow in Ethiopia, *V. sativa*, *V. villosa*, and *V. panicifolia*

The relationship between these wild relatives and *Vicia faba* must be distant since no artificial hybridization attempt between them anywhere in the world has been successful so far.

## Uses of Wild Relatives

Wild relatives of a crop have been valued very highly in plant breeding because of the possibility of transferring desirable genes from them to the domesticated relative in which that specific gene is lacking. Such genes could be those responsible for resistance to diseases, insects, drought and water logging, early maturity or desirable plant type (height, structure etc.)

In faba bean such compensatory possibilities exist widely. *Vicia narbonensis* is known to have high levels of resistance to *botrytis fabae*, *ascochyta fabae* and to *aphis fabae*. And the subspecies *paucijuga* is said to have many short stems/plant and indehiscent pods (Muratova 1931) and in situations where high tillering is desirable and where pod shattering is a problem in *Vicia faba* such genes are highly useful. Unfortunately, no attempts at crossing faba bean with its wild relatives, sometimes even at the tetrapod level as is the case with *V. narbonensis* (Bourgeois 1980), have succeeded. The improvements of faba bean, so far has, therefore, come entirely through crossing and selection within *Vicia faba* itself. In such situations, if natural variability is limited, induced mutation could be one of the alternatives to create variability. In modern plant breeding, techniques such as genetic engineering (tissue culture, DNA manipulation etc.) open-up a whole new array of other possibilities for future use in our case.

## GEOGRAPHIC DISTRIBUTION

### International

Faba bean ranks among the world's most important grain legumes. Most of the production comes from few countries in four continents: Asia, Africa, Europe and South America. Total world production is about 4.3 million tonnes over half of which is by China.

Faba bean production is wide spread in temperate subtropical regions of the world and high elevations within the tropics in such countries as Ethiopia. But it is more important in the Middle east, North Africa, China, and in some countries of Europe such as Italy and South America such as Brazil. It was introduced to South and Central America by Columbus during the discovery of the Americas. In the pre-Colombian era, before the introduction of *Phaseolus vulgaris* from the New World, faba bean is said to have had a prominent role in European agriculture. The crop experienced a substantial setback in this century with the declining need for feed for domestic animals. The important faba bean growing regions of the world and production in important countries in each region is given in Table 1.

Table 1 Area and production of faba bean in various countries in 1981

Continen/country	Area in 000'ha	Production in metric tonnes
Asia	2259	2791
China	2200	2700
Africa	708	716
Ethiopia	325	277
Morocco	130	65
Egypt	105	262
Europe	380	565
Italy	162	206
South America	232	115
Brazil	173	62
World	3664	4300

Source: FAO 1981

It is evident from the table that the world's largest producer of faba bean is China. The figures for North and Central America, Eastern Europe, and USSR, Oceania and Australia are very small.

There is a renewed interest in the crop world wide because of rising protein feed cost, issue of national food security and rapidly increasing population, and the need for agricultural diversification. Therefore, faba bean may have a more promising future.

## **Ethiopia**

Faba bean grows in most administrative regions in Ethiopia but major production areas are the highlands of Shewa, Arsi, Gojam, Gonder, and South and Western Welo. The highlands of Bale, the Chercher highlands of Harerge, the Arjo and Shambu highlands of Wellega, Atsibi and Hagere Selam areas of Tigray and in the south: Hagere Mariam areas of Sidamo, some areas of Kefa, North Omo and Gamo Gofa are also important production areas.

Faba bean ranks first in area, production and yield and is grown by 20-88% of the farmers where each household devotes 3-18% of its total cultivated land to the crop each year (Hailu B. et al. 1994).

### **Uses of Faba bean in Ethiopia**

#### ***As a protein source***

The high protein concentration of the food legumes, including that of faba bean, makes them valuable yet cheap substitutes for meat and high protein animal products. Their nutritional value and composition are very similar, in many ways, to that of meat and they are often called "poor man's meat".

Although Ethiopia stands first in the number of livestock population in Africa, the production of beef, milk, and other animal products is either below the demand or too expensive for the poor majority of the population. In rural livestock herding population where animal products are sources of cash, women often sell milk and butter and buy edible oil for cheaper price and saves some money to purchase other items the family needs. Religious beliefs also prohibit the consumption of animal products for a considerable number of days throughout the year. Highland pulses in general, and faba bean in particular then, are important sources of protein.

In such situations, the consumption of food legumes in supplement with cereals satisfies the protein requirements of the diet. Faba bean plays a central role in the legume diet in Ethiopia in that several traditional dishes that are famous and widespread involve faba bean. These dishes can be divided into snacks, main and side dishes and occasional dishes (Senayit and Asrat 1994).

**Snacks**

- **Eshet:** fresh green faba seeds either eaten raw or roasted.
- **Kolo:** roasted dry beans.
- **Nifro:** boiled dry or fresh green beans.
- **Gunkul:** seeds soaked and sprouted and roasted
- **Ashuk:** seeds roasted first and then soaked;
- **Endushdush:** seeds soaked first and then roasted

**Main dishes**

- **Shiro Wet:** dehulled seeds ground and made into stew.
- **Kik Wet:** dehulled and split beans boiled and made into stew.
- **Ful:** dehulled and boiled and spiced and minced with butter and eaten for breakfast.

**Side dishes**

- **Siljo:** flower fermented paste

**Occasional dishes**

- **Gulban:** dehulled, split and broken faba bean seeds boiled together with cereal seeds such as corn and white or yellow sorghum eaten spiced from Good Friday to the eve of Easter Sunday.

## **Neighboring Countries**

**Sudan**

According to Ali et al.(1981), beans are consumed minced with onion, garlic, and herbs and deep fried eaten for breakfast as ful; stewed beans are eaten at all time of day; and beans made into a paste and are often used as a sandwich filling.

**Egypt**

Young seeds may be eaten raw with bread and vegetable; mature beans soaked in water, allowed to germinate and boiled in water to make soup; beans are slow boiled for long hours in water until they are soft, and salt and lemon juice, oil and garlic are added and the resulting soft dough eaten (Gabriel 1981).

## **Protein Quantity and Quality**

Average ranges given for world faba bean protein content from various sources is close to each other: 22-37% (Monti and Grillo 1983), 26-41% (Picard 1977), 23-38% (Griffin and Lawes 1978) and 23-39% (Hulse 1994).

In Ethiopia, figures for protein contents are much lower than those given

elsewhere. It is generally between 22 and 29%. Here, protein content seems to vary with altitude, being higher at mid-altitude than at high altitude (Table 2) areas.

Table 2 Average protein content (%) over several years of elite faba bean lines (different entries each year) at mid and high altitude areas of Ethiopia

Year	High altitude* (2300-2700 m)	Mid-altitude** (1900-2300 m)
1989/90	26.6	28.4
1990/91	24.6	25.5
1991/92	24.2	26.6
1992/93	24.5	27.3
1993/94	22.4	25.5
1994/95	25.3	28.1
1995/96	24.0	26.5
Mean	24.5	26.8

High altitude = Holetta, Bekoji and Sheno.

\*\* Mid-altitude = Denbi, Kulumsa-Gongie, Asasa, and Adet.

The composition of Ethiopian faba bean as compared to other highland pulses and cereals looks as follow, Tables 3, 4, and 5.

Table 3 Composition per 100 g edible portion of faba bean (Agren & Gibson 1968)

Crop	Calorie	Protein (g)	Fat(g)	CHO (g)	Fibre (g)	Fat (g)
Faba bean	344.0	21.5	1.4	63.2	9.6	2.9
Chickpea	363.0	17.4	5.2	63.9	9.4	3.2
Lentil	344.0	22.6	1.0	63.2	4.8	3.0
Fieldpea	345	20.1	1.4	64.8	4.3	3.0
Grasspea	347	22.6	1.4	63.6	8.2	4.3
Cereals*	342.0	8.8	2.8	74.5	3.0	1.9

Average for barley, maize, wheat, sorghum, and mixed tef

Table 4 Mineral and vitamin composition of Ethiopian faba bean (per 100g edible portion (Agren &amp; Gibson 1968))

Crop	Minerals (mg)			Vitamins (mg)		
	Ca	P	Fe	Thiamine	Riboflavin	Niacin
Faba bean	99.0	420.0	8.4	0.44	0.30	2.1
Chickpea	251.0	231.0	14.3	0.43	0.12	1.5
Lentil	68.0	359.0	28.3	0.37	0.15	1.6
Field pea	79.0	309.0	13.6	0.30	0.16	2.4
Grasspea	336.0	273.0	108.2		0.17	
Cereals*	53.0	307.0	18.0	0.35	0.11	3.6

\* average for barley, maize, wheat, sorghum and mixed tet

Table 5 Essential amino acid composition of faba bean seeds (mg/100 g of food) (Agren et al. 1975)

Crop	Lys	Thr	Val	Leu	I Leu	Met	Try	Phe	Arg	His
Faba bean	426	225	306	452	273	45	45	261	653	166
Chickpea	420	228	320	476	293	89	72	361	603	156
Lentil	530	270	350	495	310	57	47	342	650	174
Field pea	479	224	291	478	276	46	47	294	609	145
Grasspea	390	216	231	414	167	36	59	272	425	205
Cereals*	179	227	335	590	256	136	70	299	284	157

\* average for barley, maize, wheat, sorghum and mixed tet

Lys=lysine, thr=threonine, val=valine, leu=leucine, I Leu=isoleucine, met=methionine, try=tryptophan, phe=phenylalanine, arg=arginine, and his=histidine

Food legumes in general, and faba bean in particular, and cereals are nutritionally complementary in that the essential amino acids that are deficient in one may be provided by the other. Faba bean contains relatively large amount of lysine and cereals have great amount of sulphur containing amino acids - methionine and cysteine. Therefore, a balanced blend of amino acids from food legumes and cereal mixture has a greater nutritional value than either ingredient alone.

In comparison of the contribution of energy and protein at low cost of some of food legumes and cereals, faba bean with 3995 kcal/birr was second to grass pea (*Lathyrus sativus* L.), and protein/Birr (257 g) and index of nutrient density (10267) which are much higher than cereals (Hailemariam et al. 1989).

## AS ANIMAL FEED

Ethiopia is known to own the largest livestock population in Africa but due to increase in human population more and more mouth has been filled each year and therefore more land is ploughed and the size of land devoted to pasture is getting less and less each year. Although faba bean is primarily used for food, it provides an excellent protein-rich feeding stuff for domestic livestock. In the developed world, the whole plants, by-products from industry, crop residues are used in place of more conventional protein supplements for all classes of livestock industry: poultry, swine, sheep and cattle.

In China, all the above ground parts, other than the grain, may contain 6-17.6 % protein depending on the stage of growth and milk increase is said to be considerable when faba bean is fed to lactating cows (Li-Juan et al. 1993)

The digestibility of protein for all pulses including that of faba bean is relatively high. Marquardt and Bell (1988) reported composition of milled fraction of faba bean (Table 6).

Table 6 Average protein composition and nutritive value of milled faba bean

Component	Whole bean	Hulls (Testa)	Cotyledons
<i>Chemical composition</i>			
Protein, N x 6.25 (%)	31.8	5.9	36.3
Oil (ether extract) (%)	0.9	0.3	1.1
Crude fibre (%)	8.5	53.5	1.4
Lignin (%)	0.1	0.7	0.0
Condensed tannins (%)	0.6	4.4	0.1
Vicine + convicine (%)	0.94	0.0	1.07
Trypsin inhibitors	2.20	-	-
Haemagglutinin (units/g x 10 <sup>-3</sup> )	4.1	0.0	4.6
Ash (%)	3.6	2.5	3.5
Calcium (%)	0.1	0.38	0.05
Phosphorus	0.6	0.08	0.64
<i>Nutritive value</i>			
<i>In vitro</i> digestibility (%)	76.2	10.1	87.6
ME poultry (kcal/kg <sup>1</sup> ) *	2121	532	2946

ME=metabolizable energy



The hulls account for 12% of seed weight and contain nearly all of the fiber, lignin and condensed tannins. In contrast, nearly all of the protein, phosphorus, oil, vicine and convicine, and haemagglutinins are present in the cotyledons. Separation of the beans into hulls and cotyledons would provide a practical means by which the crop could be upgraded and this procedure would also have the advantage of removing all of the condensed tannins.

For laying hens, and for ruminants (lactating cows and growing calves), beans can comprise up to 20% of compound feed. With pigs, higher levels may be possible with dehulled or low tannin varieties.

## ANTI-NUTRITIONAL FACTORS

### Favism

Favism is used to describe a haemolytic anaemia in susceptible individuals after eating seeds of *Vicia faba*. The disease is said to occur in subjects who are deficient in Glucose-6-phosphate dehydrogenase enzyme (Simpson 1983) which leads to the accumulation of B-glycosides termed vicine and convicine. It manifests itself by weakness, pallor (abnormal paleness), jaundice (a pathological condition in which the normal processing of bile is interrupted resulting in yellowish staining of the eye, skin and body fluids), and haemoglobinuria (the presence of free haemoglobin in the urine). Death may result from renal failure.

Fortunately, this incidence is not common in the world and more so in Ethiopia. Favism occurs principally in the Mediterranean countries (Egypt, Greece, Sardinia, Italy and Bulgaria) and Middle Eastern countries such as Iraq and Iran and in China in the Far-East. It generally is a paediatric disease where the majority of the case occurs in 2-5 year age group (Marquardt 1982).

### Flatulence

The presence of the oligosaccharides (raffinose and stachiose) in faba bean that cause the most uncomfortable and antisocial of disorders known as flatulence (Simpson 1983). When the oligo- saccharides are not broken down in the human small intestine and travel onto the large intestine where they are hydrolysed by bacteria enzyme action with release of quantities of methane and other gases. These gases can give rise to severe intestinal cramps and/or diarrhoea. To alleviate this problem, varieties high in oligosaccharides can be screened against during selection and oligosaccharides can be drastically reduced by boiling and cooking and by discarding the first cooking liquor.

### Other Anti-nutritional Factors

The major anti-nutritional factors that are present in faba bean and in pulses include:

- **Condensed tannins:** the principal anti-nutritional factors in faba bean (Cansfield et al. 1980); concentrated in the testa (hulls) at concentrations ranging from 0 to 7.2%. Faba bean contains the most tannins (polyphenolic compounds), most of them in the cotyledons than pea, lentil and chickpea (Singh and Jambunathan 1982).
- **Vicine and convicine:** present in the cotyledons at concentrations ranging from 0.7 to 1.3% (Gardner et al. 1982).
- **Protease inhibitors:** found at a concentration of 5-13% in pea and 2-20% in faba bean (Rachis et al. 1986)
- **Saponins:** values for saponin content in g of kg dry seed are 4.3 g/kg of dry faba bean seeds (Fenwick and Oakenfull 1983).

Most of these are inactivated and destroyed by heat during cooking and process and faba bean therefore, as any other food legume, requires proper processing before consumption to improve palatability and remove or reduce certain antinutritional factors that may be present.

## IN CROP ROTATION

Due to years of water erosion caused by torrential rains in the Ethiopian highlands and primitive farming system, almost all the top soil has been removed and soil condition is very poor. Farmers either leave the land fallow or plant food legumes to upgrade the fertility of their soils when ever they fail to harvest reasonable yields of cereals. Recently however, due to population increase it has become very difficult for farmers to leave any piece of their lands fallow and cereal legume rotation has become the norm.

Legumes play key roles in crop rotation because they improve soil fertility fixing nitrate nitrogen from atmospheric nitrogen by the rhizobium bacteria in the nodules in the root hairs. This nitrogen, in many instances, has been found to benefit crops that grow after legumes

Wheat and barley crops when followed an oat crop required 44-50 kg/ha more fertilizer-N to achieve the same yield as after beans (Prew and Dyke 1979).

At Rothamsted Agricultural Research Center in England, a classical experiment with beans, wheat after beans and barley after beans yielded more than continuously grown wheat and barley, respectively. Without applied N the increase was about 50% (Dyke and Prew 1983).

In a multi-year wheat based crop rotation system studied by the Kulumsa Research Center of the Institute of Agricultural Research at Kulumsa and Asasa (Tanner 1997), faba bean increased wheat grain yield by 29.8% at Asasa and by 31.0% at Kulumsa relative to a rape seed precursor. Wheat grain yield was increased by 53.6 % in dicot vs. cereal rotation at Asasa and by 33.0% at Kulumsa. Wheat after faba bean exhibited a 28.9% response to P whereas only 12.6% P response was realized after rapeseed at Asasa. In the same study, when soil physical and chemical changes where measured, wheat-dicot rotation exhibited 35% higher soil nitrate levels than cereal based rotation or continuous wheat production. Wheat-faba bean rotation resulted in a 43% higher soil NO<sub>3</sub> levels than wheat-rapeseed rotation.

Food legumes, including faba bean, play important roles in sustaining the production of farming systems in the country. Their ability to fix atmospheric nitrogen and to improve soil physical and chemical structure in the cereal dominated cropping system are key to the systems

sustainability. Legumes improve soil biological properties. They also encourage the development of deeper and more extensive root system, enabling crops that come after them to take more water and nutrients. They are valuable in reducing diseases and pest infestation of cereals that follow by serving as a break crop.

Biological nitrogen fixation is an important and low-cost source of N added to the system where the use of N fertilizer is low because of high cost. The amount of N symbiotically fixed by food legumes may exceed 100 kg/ha/year (Beck et al. 1991). In Egypt, faba bean is known to fix biologically large quantities of di-nitrogen to meet 85-90% of their needs (Abdel Dairem 1988). There is no such detailed account of the amount of nitrogen fixation in Ethiopia.

## **CROPPING SYSTEM**

In most growing regions faba bean belongs to barley and wheat (among cereals) and noug and brassica (among oil crops) cropping systems. In the system, faba bean holds a special place due to its soil enriching ability that benefits crops that come after it.

At planting, a little amount of commercial fertilizer (100 kg/ha DAP) is usually applied on research plots as starter until the plant become self-sufficient in N requirement on poor soils. The Ethiopian farmer, however, generally uses no fertilizer on food legumes. Fertilizer priorities and better seed bed preparation and other cultural practices such as weeding are usually given to cereals. Minimum tillage and minimum weeding are used for pulses. Weeding in faba bean fields is frequently done in the form of cutting grasses and other weeds by sickles for the purpose of feeding domestic animals.

In most places, faba bean is grown in mixtures with field pea for the purpose of symbiotic relationship between the two crops whereby faba bean serves as support for field pea plants which can then grow in erect or semi erect position reducing suffocation when plants lie on the ground and also helping for light penetration to the lower leaves resulting in more photosynthesis and more yield and field pea in turn helps in suppressing weeds for faba bean which can then grow more luxuriously. Faba beans, otherwise, are very sensitive to weed infestation. Such mixtures are also said to decrease disease incidence that are serious production bottlenecks in sole crops of either kind (Dereje Gorfu, personal communication).

### **Soil and Seed Bed Preparation**

Faba bean requires a well drained deep fertile soil of rocky or silty or clay loam nature with Ph between 6.0 and 7.0. It is mainly grown on Nitosols, Cambisols and Vertisols. Most of these soils are acidic with ph less than 6.0 and are deficient in N and P. Application of N and P, therefore, increases faba bean yields (Angaw 1994). There has been no significance response to K application. Preliminary results of an on-going liming study on an acidic soil at Holetta Research Center indicates that liming results in healthy growth and increased yields in faba bean.

In rhizobiology studies done in various parts of the country, where rhizobia species were collected, characterized and tested, strains #18 and #64 along with 22 others have been selected as superior in terms of nitrogen fixation (Tekalign and Asgellil 1994) in faba bean.

In terms of nutrient availability, pea, lentil, chickpea and faba bean grow best in soils with PH values between 5.7 and 7.2 (Mehler et al. 1988).

Seed yield of traditionally cultivated faba bean in Ethiopia is extremely low because of poor seed bed preparation. Minimum tillage, as practiced by Ethiopian farmers with the local maresha, leaves most of the seed uncovered and results in poor stand. It is also sown, in most cases, on fertility depleted soils whenever the land does no more give reasonable yields of cereals. However, agronomic researches over the last several years have disproved the traditional practices with substantial proof for the need for adequate seed bed preparation. Fine seed bed is not required but good soil contact for seed is essential for moisture absorption, germination and root establishment and development.

The recommended land preparation is that starts early to encourage weed seeds to germinate and be destroyed in the subsequent cultivation of 2-3 plowings with the local plow. Mechanized farmers can use one disc plow followed by two disc harrowing. The Nazret moldboard plow is preferable to the local maresha for farmers who can afford it.

## **Temperature**

Temperature is one of the most important environmental factors that determine the distribution, growth, and development of faba bean. Faba bean is essentially a temperate and sub-tropical crop but can be grown in the tropics in countries such as Ethiopia in the highlands where cool temperature prevails.

Faba bean is cultivated in Ethiopia Between altitudes of 1800 and 3000 m asl being most common in the temperate or Weinadega zones, 2000-2500 masl, (Amare and Beniwal 1988). Mean temperature during crop growth, May-November, are 8 and 21°C at high altitude areas and 11 and 24°C at mid altitude zones. At higher altitudes (Dega zone) frost is the limiting factor of production especially in late sown faba bean crops. At lower altitudes (warmer temperatures) plant growth is adversely affected, disease incidence especially chocolate spot becomes serious, excessive flower drops are

caused resulting in poor pod set all boiling down to decreased production in faba bean.

## **Moisture**

The rainfall pattern in Ethiopia is bimodal. Most of the rains (70-80% of the total) falls from June to August and the remainder from March to May. Faba bean is produced under rainfed conditions in Ethiopia. Therefore, the onset of rains is a prerequisite for sowing date and crop production is dependent on the timely onset of rains and their amount and distribution through the season. In good years, 700-1000 mm of rain in high altitudes and 600-800 mm of rain in the mid-altitude areas is received.

Excessively high temperature and shortage of moisture leads to, disease problems, aphid infestation, flower drops and low pods/plant and if severe, can lead to complete crop loss. Amare (1990) has reported that moisture shortage shortens plant height and maturity period and reduces total above ground biological yields.

Excess moisture is also devastating to faba bean crop. It is very sensitive to waterlogging which leads to stunting growth and yellowing of the plants and causes black root rot disease. This usually is the common occurrence in Vertisols (heavy black clay soil) and even in other soils if excess water is not properly drained and can result in yield reductions and if severe, to complete loss of crop.

## **Sowing Method**

Broadcast sowing is the traditional practice for faba bean. The local maresha places seed at the depth of about 10-15 cm. Several research that compared broadcast and unweeded treatments with properly weeded row planting resulted in substantial yield advantage of row planting (5 cm deep) and proper weeding. However, due to heavy workload on the farmer during planting the farmer in most areas are reluctant to accept row planting in the recommended packages. Then, broadcast planting accompanied by proper seed bed preparation and weed removal should be just fine until the advent of mechanized planting.



## **Sowing Date**

Date of sowing is determined by the onset of rains. Research conducted to determine optimum dates of sowing gave no conclusive results for various areas in the country. Indications varied from last week of May to early July. However, in the main season sowing mid to third week of June in mid altitude areas and last week of June to first week of July in the high latitude areas are recommended. In the small rainy season (belg) planting is usually done in February.

Timely sowing is essential for optimum yields since late sown crops can run into periods of low moisture and heavy aphid infestation in mid-altitude areas and frost in high altitude areas.

## **Seed Rate**

According to Asfaw (1988) Ethiopian farmers generally use lower seed rates than recommended by research and crop stands are therefore generally low in farmers fields. Research findings are inconsistent. However, seed rate recommended for faba bean is 175 kg/ha for small seeded cultivars and 200 kg/ha for larger seeded cultivars. In fertile soils faba bean is known to grow taller and to produce tillers and lateral branches. Growth may then result in excess biomass and lodging rather than pod and seed development. Lower seed rate could be used in such situation.

## **Weeding**

Faba bean is very sensitive to weed competition. Weeds that occur in faba bean field are annual and perennial grasses and broad leaves. Traditionally weeding is done by hand pulling in some cases faba bean field are never weeded. Where weeding is practised in form of cutting grasses and broad leaves to feed them to domestic animals, it is often done late after crop yielding potential is already reduced.

Rezene (1994) lists 46 weed species of faba bean of which 15 are the most troublesome. Full season weed competition in faba bean leads to up to 25% yield reduction.

Weeding recommended by research for hand weeding is one to two hand

weeding depending on severity within 3 to 6 weeks after planting.

## **Growth Period and Harvesting**

Faba bean matures in about 90-200 days depending on the cultivar and climatic conditions, being earlier in mid altitude areas and later in higher altitudes. The crop has the tendency to lodge in highly fertile soils. The crop matures in November. Harvesting is done using sickles at the lowest pod bearing node and crop is transported to the threshing ground, usually near the owner's house, where it safely stacked in upright position for few days to dry in the sun. For threshing, the stack is spread in the threshing ground and threshing is done by light beating with sticks, usually by women and children.

## **Production Constraints**

Production bottlenecks for faba bean in Ethiopia are numerous and can be categorized as cultural, biotic and abiotic factors.

### **Cultural Constraints**

Most Ethiopian farmers are of the opinion that pulses do not require best land, fertile soil, better seed bed preparation and better weeding practices. Attention given to pulses in these regards are minimal. They devote their best land, better agronomic practices and extra time to cereals. Land usually assigned to pulses are marginal, tillage is minimal, weeding is not usually done and a substantial amount of seed is eaten green leading to even lower seed yields compared to yields per hectare in other countries.

### **Biotic Constraints**

#### **Diseases**

Chocolate spot (*Botrytis fabae*) is the major production bottle-neck for faba bean and the problem is nation wide and is more serious in the lower altitudes of faba bean agroecologies. Faba bean plants are usually clean and attractive and hopes for a good harvest are high until they are at flowering and pod setting stage. Then the diseases sets in and changes everything resulting in light to heavy crop losses (up to 60%) depending on severity (Dereje and Tesfaye 1994). In higher altitudes, where the temperature is cooler, the crop and the pathogen seem to coexist in equilibrium whereby the disease is there without causing serious damage to the crop.

Black root rot (*Fusarium solani*) disease is most important on Vertisols of Central and North Shewa and Gojam. Severity depends on drainage where the most poorly drained fields are the most affected resulting in heavy yield losses from 5 to 100%. Planting faba bean on ridges and on broad bed and furrows (BBF) significantly reduces the disease incidence.

Rust (*Uromyces fabae*) where it frequently occurs more severely, especially in Vertisol areas of Ginchi and Ambo and serious crop losses of 30-40% can occur. Recently, lines that have been identified as black root rot resistant/tolerant are the most affected by rust.

### **Insect Pests**

The African bollworm (*Helicoverpa armigera*) and aphids (*Acyrtosiphon pisum*) are the most important insect attacking faba bean in the field (Kemal 1994). And bean bruchids are major storage pests. Aphids are usually more problematic in mid-altitude areas in late sown crops where moisture deficiency occurs. High damage by bean bruchids also occur at warmer temperatures of mid-altitude areas where they can cause average crop loss of upto 40%.

### **Abiotic Factors**

**Waterlogging:** Faba bean, by nature is adapted to be grown on hill sides and is very sensitive to waterlogging. Weather on black clay soil or red soil it is a major yield limiting factors. Waterlogged plants are stunted in growth and turn yellow and the problem is associated with black root rot disease. Well drained fields are therefore, essential and must when selecting land for faba bean production.

**Frost:** faba bean also sensitive to frost damage, especially if it occurs during flowering and pod setting stage and is an important factor at very high altitudes above 3000 m asl. There is no genetic resistance identified for frost tolerance but work so is under-way at frost prone areas of Bale and Ankober area of North Shewa.

**Hail damage:** hail can also be devastating if it occurs at and after flowering stages. At Holetta Research Center of IAR, hail storm that fell on 13 August 1995 wiped-out most of the research plots and seed increase fields causing 80-100% crop loss in faba bean and field pea. Decapitating of the main stem by the hail balls, then, induced several tillers which grew so fast that they flowered in matters of weeks but failed to produce seeds because the rainy season ceased and moisture was not available for the plants to

continue the normal growth and development. Fortunately, hail storm of that magnitude rarely occurs more than once every 3 to 4 years.

**Poor soil fertility:** top soil in the Ethiopian highlands has been eroded away by centuries of torrential rains aided by poor soil management and lack of proper erosion control practices. Therefore, the fertility of most farm land is not satisfactory. The better part of any farm land is devoted to cereals, and pulses are assumed to do better if planted on marginal lands without proper agronomic management. Research has proved this practice wrong. Much higher yields can be obtained when planted on deep fertile soil with proper land preparation and weeding. On fertility depleted soils application of 100 kg/ha DAP as starter fertilizer during planting is practised on research plots and is also recommended to farmers.

## GENETIC RESOURCES

### Germplasm Collections

Ethiopia is considered a center of diversity for faba bean. The crop is grown in almost all administrative regions. The Ethiopian Biodiversity Institute has acquired some 1495 accessions of faba bean of which 3 are donations, 509 are from other institutions, and 904 accessions (when the figure for Eritrea is deducted) were collected nationally up to the early 1990s by the Institute (Dawit et al. 1994). These collections were made from Arsi, Bale Gamo Gofa, Gojam, Gonder, Harargie, Ilubabor, Kefa, Shewa, Sidamo, Tigray, Wellega, Welo and some unknown places in the country. Most of the collections, 186, 164, 138, and 110 accessions were collected from Welo, Gonder, Shewa and Gojam, respectively, at altitudes between 2350 and 2550 m.

Gaps in collection exist in terms of both species and region. Diversity that exists in each region has something to offer and it is essential to utilize the existing genetic resources effectively and to minimize the hazard of genetic vulnerability that may result from disease epidemics, outbreaks of insect pests, drought and other factors.

Collections from Arsi, Ilubabor, Harerge, Kefa, Sidamo, Tigray and Wellega do not seem adequate. Altitudes above 2550 and below 2350 m asl. are not adequately covered. Even in the regions where more collections were made than others, coverage usually follows major highways and dry weather roads.

Internationally the following are accessions available in major biodiversity centers across the world:

Center	# of accessions	# of accessions from Ethiopia
ICARDA, Syria	1931	370
Bari, Italy	1469	95
BGRC, Fed Rep. of Germany	804	211
ZGK, German Dem. Rep.	746	73
N I Vavilov, USSR	2525 ( <i>Vicia</i> sp.)	unknown
Wageningen, the Netherlands	700	unknown
Czechoslovakia	500	unknown

Source: Wilcombe 1982

\*Some years later, Van Der Maesen et al. (1988) listed higher figures of faba bean collection at some of these institutions i.e. ICARDA= 5000, Gatersleben, DDR= 1300, Bari, Italy= 2000.

In the international collections, Iran, China, and India are said to be seriously under-represented although having indigenous varieties.

## **Diversity in Ethiopian Collections**

### **Morphological Diversity**

The Ethiopian Biodiversity Institute, according to Dawit T. et al. (1994), has performed simple descriptive statistics for some agronomic characters for faba bean samples collected from most of the administrative regions. Number of flowers/plant (30.2 for samples from Arsi and 62.0 for samples from Ilubabor) and number of pods/plant (7.0 for samples from Gonder and 17.1 for samples from Welo) varied the most compared to other characters. Days to flower ranged from 44.6 (collections from Tigray) to 66.9 (collections from Arsi). Days to maturity goes from 105.5 (for samples from Ilubabor) to 147.5 (for samples from Gojam). Collections from Gonder, Tigray and Illubabor flower and mature earliest and within few days of each other, and those from Arsi, Gojam and Shewa are late flowering and maturing. These characters are influenced by altitude rather than by region anyway. In plant height, the shortest plants (87.1 cm) came from Arsi while the tallest ones (138.0 cm) came from Welo. In general it is soil fertility rather than agroecology that influences plant height.

Diversity in size and seed color was not reported. However, black, grey, green and pale green seed color and small and medium seed sizes are known to exist. Most faba bean seed when stored over a period of about six months turn brown unless the original color is black. Color of seed when purchased from the local market could, therefore, be very misleading unless harvesting date is roughly known. Large seed sizes, if encountered, are likely of recent introductions.

### **Diversity in Disease Resistance**

Among the faba bean accessions screened for disease resistance only one Ethiopian landrace (PGRC/E 27276-87) was found resistant to chocolate spot and four local landraces (PGRC/E 25044-1, PGRC/E 25073-1, PGRC/E 25154-1, PGRC/E 25162-1) were found resistant to rust disease (Dereje and Beniwal 1987). Most of genetic resistance to chocolate spot came from introductions. Several Ethiopian faba bean lines (over 25 accessions) have been found resistant to black root rot disease by the Holetta highland pulses breeding program of IAR. This are valuable sources to be used directly as varieties if their yield levels are satisfactory or in the hybridization program to transfer genes for resistance to susceptible but high yielding varieties.

### **Unique Traits in Ethiopian Germplasm**

Tripping is the process when insects on entering the flower cause the release of the stamens and style from keel petals and thereby help the transfer of pollen from the anther to the stigma. This phenomenon is quite wide spread in faba bean causing, on average, about 35% outcrossing. The lack of tripping requirement is said to be auto-fertility. Auto-fertility has been reported to be more prevalent in materials originating in the Mediterranean areas including Ethiopia (Filippetti 1979).

Autofertile cultivars are believed to have the advantage of being able to yield well, resulting in improved yield stability. This trait is also advantageous in that it is easy to keep varietal purity than in highly outcrossing faba bean types. Highly outcrossing varieties however, have greater flexibility to changes in the environment through the maintenance of heterogeneity within populations and in the exploitation of heterosis.

Some Ethiopian materials also have high pod clusters of 4 to 5 pods/node. These are known as the IVS types (independent vascular supply) in that each flower and pod is believed to have its own vascular system with its own nutrient supply which enables each flower that is formed to have a higher chance to be developed into a pod. This is a desirable character in increasing the production and productivity of faba bean if more such clusters could be developed per plant resulting in more pods/plant and more seeds/pod.

## **HISTORY OF FABA BEAN RESEARCH IN ETHIOPIA**

A brief account on the early history of the highland pulses including that of faba bean has been given by Million Eshete and Beniwal (1987) and by Amare Gizaw and Beniwal (1987).

Initial work on faba bean research was said to have started at Jima Agricultural and Technical School in 1961 with some cultivars imported from Mexico and at Bako Research center. Why adaptation trials at Jima had to start with imported material when the country is a center of diversity for faba bean may be a puzzle to many but the reason is unknown. However, strong foundation for faba bean and field pea breeding was laid down in Arsi by the CADU (Chilalo Agricultural Development Unit) of the Swedish government at Kulumsa which collected some germplasm from the area and started adaptation trials in 1966. Soon the program was integrated with lowland pulses improvement programs of IAR at Nazret which became a coordinating center for all pulses. Some important germplasm collections were done by the joint expeditions of staff of both institutions in the major faba bean and field pea growing areas of North Shewa, Gojam and Gonder. In 1967, the Debre Zeit Experiment Station which was then under Addis Ababa University, started doing some work on highland pulses and reported good adaptation of 10 faba bean lines in Adaa wereda. Between 1967 and 1970 several agronomic and yield trials on faba bean were conducted by CADU. During this time, important steps and progress were made. Faba bean cultivars like CS-20-DK, Kuse 2-27-33, Kasa and NC 58 and field pea cultivars such as Mohanderfer, NC 95 Haik, FP ex DZ and G22763-2C were recommended which served as the only improved cultivars we had offer the farmers until the mid 1990's.

In 1972 the lowland and highland pulses improvement programs were separated and coordinated national research program on highland pulses started with action initiated by the Pulse Subcommittee of the then NCIC (National Crop Improvement Committee). For a short period of time Debre Zeit Experiment Station coordinated research on faba bean, field pea, chickpea and lentil. Faba bean and field pea programs then moved to Holetta Research Station which assumed full responsibilities for the improvement of the two crops.

A team approach was used in the program where various disciplines were represented and working together. Beginning in the mid 1980's the faba bean improvement effort was strengthened when ICARDA (International Center of Agricultural Research in the Dry Areas) started to work with the



program and secured fund from IFAD (International Fund for Agricultural Development) and the Italian Government through its Nile Valley Program (NVP) on cool season food legumes. ICARDA was interested in faba bean, chickpea and lentil. Debre Zeit Research Center of the then Alemaya College of Agriculture also joined the program with chickpea and lentil. The overall responsibility of coordinating research on highland pulses nationally was given to IAR. Team members were sent for higher education and short term training, expatriates were assigned on temporary basis to assist the program while Ethiopian scientists were on training leaves and the germplasm basis was widened with materials coming from abroad through ICARDA for screening along with local landraces.

In 1989, ICARDA's NVP was upgraded to NVRP (Nile Valley Regional Program) and more fund was secured for the highland pulse research from SAREC (Swedish Agency for Research Cooperation with Developing Countries). This continued until the end of 1993 the end of which was marked by the first national cool season food legume review conference and papers presented by team members and invited resource persons were published in a book: "Cool-season Food Legumes of Ethiopia".

Since 1994 the bulk of highland pulses research program has been sustained solely with the national budget with a minimal technical and financial backstopping from ICARDA. Now through ICARDA's coordination a network has been established under the Nile Valley and Red Sea Regional Program (NVRSRP) with its headquarters in Cairo, Egypt involving Ethiopia, Sudan, Egypt and Yemen with Eritrea said to join soon. Through this program, fund has been obtained from the Royal Netherlands Government to solve the most critical production bottlenecks in cereals and food legumes common to these countries whereby information generated in one country is furnished to all member countries.

## Breeding

### Genetics of Faba bean

*Vicia faba* is a diploid species,  $2n=12$ . Its center of origin is South-west Asia with Ethiopia being one of the centers of diversity. So far, attempts made any where in the world to cross *Vicia faba* with its wild relatives has failed. Therefore, progress made in the improvement of the crop came from genetic manipulations and selections within the species itself.

*Vicia faba* shows a high degree of outcrossing. Figures reported for outcrossing in faba bean vary widely and is between a minimum of 5% and maximum of 70%. The average reported is about 35% (Bond and Poulsen 1983). The long tongued bumble bees and honey bees are the major

pollinating insects known. The process by which insects enter flowers and carry pollen from the anthers to the stigma of either the same flower or another flower is known as tripping.

The implication of high degree of out-crossing is that if occurs between different accessions, can result in genetic contamination and if this continues for a number of generations, can result in the loss of identity between the accessions. Therefore, distance isolation between entries, using breeding cages to keep insect pollinators out, or planting tall plants such as *Brassica napus* as physical barriers between accessions or plots are some of the measures that need to be taken in the breeding strategy of faba bean to keep varietal purity.

Isolation of plots at a distance of 50 m is believed to ensure that genetic contamination is less than 5% and it is said to be possible to reduce out-crossing further by discarding the plot borders and seed on the lower nodes of the plant (Hawtin 1982).

Due to the intermediate breeding system of the species, which stands between full autogamy (completely self-pollinated) and full allogamy (completely cross pollinated), and due to its indeterminate nature of the growth habit (continuation of growth and flower formation on the upper part of the plant after pod formation on the lower part begins), and the existence of dehiscent pods, faba bean is considered by many as an incompletely domesticated crop (Hawtin 1982).

### **Breeding Objectives**

The overall breeding objective has been to develop improved high yielding faba bean cultivars adapted to high and mid-altitude areas. The specific breeding objectives were aimed at solving biological, biotic, and abiotic faba bean production constraints.

### **Logistics**

To achieve the breeding objectives, the faba bean growing agroecologies where divided into high and mid-altitude areas, the mid ranging from about 1800 to 2300 m and the high ranging from 2300 to 3000 m asl and germplasm screening is done separately for these zones. This was done because it easier and quicker to identify and develop faba bean lines that are adapted to a narrower rather than wider range of environments. The following testing sites were thus established as representatives of these agroecologies:

Site	Region	Altitude (m)
<i>High altitude sites</i>		
Holetta	Shewa	2390
Sheno	Shewa	2850
Bekoji	Arsi	2750
Sinana	Bale	2500
<i>Mid-altitude sites</i>		
Denbi	Shewa	1900
Kulumsa	Arsi	2130
Asasa	Arsi	2300
Adet	Gojam	2080
Mekele	Tigray	1970

Starting from the 1997 season Debre Tabor, a high altitude testing site in Gojam/Gonder, will be added

Screening for black root rot on black clay soil is done at Enewari (North Shewa), Ginchi (Central Shewa) and Ambo (West Shewa). Screening for chocolate spot is done at Holetta.

Germplasm screening for frost is done at Ankober (North Shewa) and a frost prone area in Bale.

### **Research Priorities**

In faba bean breeding priorities are given to solving the most urgent needs of the farmer. Some of these are:

- to develop and release high yielding and stable varieties;
- to screen and identify germplasm resistant to chocolate spot and black root rot diseases and to release these as varieties directly if they are also high yielding;
- to incorporate genes for resistance to susceptible but high yielding cultivars; and
- to screen and identify germplasm adaptable to Vertisols i.e. resistant to black root rot and tolerant to water-logging;

### **Activities**

Breeding activities more or less encompass the outline given above in finding solutions to faba bean farming problems. These are:

- Acquisition of germplasm (exotic and indigenous);
- Establishment of nurseries for preliminary screenings;
- Screening for desirable agronomic characters the most important of which are resistance to chocolate spot, black root rot (water-logging) and frost and yield components such as earliness, pods/node, pods/plant, seeds/pod and

thousand seed weight;

- Crossing blocks in which genes for resistance are transferred to established high yielding cultivars that are susceptible to chocolate spot;
- Multilocation yield testing of promising lines in preliminary, regional and national trials;
- Multilocation verification and release of elite lines; and
- Multiplication, purification and maintenance of breeder seeds.

## Achievements

As the result of strong support of the Ethiopian government to the program in annual budget allocations and ICARDA's involvement with the food legumes program significant progress has been made in breeding.

### Varieties Released

Variety Name	Target altitude (m)	Year released
Bulga 70	1800 to 3000	1994/95
Tesfa	1800 to 2300	1994/95
Mesay	1800 to 2300	1994/95

On average, each of these varieties give upto 3-4 t/ha on research plots and 2-2.5 t/ha on farmers fields given the soil is well drained, deep and fertile (very important prerequisites that extention workers and seed agencies fail to realize).

### Other achievements

- Wide bases of variabilities in germplasm has been secured;
- Genetic resistance/tolerance to chocolate spot have been identified and transferring genes to released cultivars is already underway; and
- Genetic resistance to black root rot and tolerance to water-logging have been identified and yield testing of resistant lenes is underway;

## Agronomy

The faba bean crop has sustained successfully cultivation for time immemorial under diverse production systems in a wide range of environmental conditions. But farm tools and agronomic practices are primitive. These are some of the contributing factors to low yields.

## **Objectives**

The main objective of agronomic research on faba bean is to determine optimum agronomic practices to increase production and productivity and study the contribution of faba bean to cereals in the sustainability of the cropping systems.

## **Research Priorities and activities**

To achieve the objectives, priorities and activities in agronomic research are:

- determining optimum tillage practices, sowing date, sowing method, sowing depth, seed rate, fertilizer needs, and pre and post emergence herbicide application etc.;
- testing a mechanical row weeder for faba bean, developed by the Nazret Agricultural Mechanization Department; and
- developing agronomic practices such as BBF and cumber bed which enables to spread of the production of faba bean to potential Vertisol areas but where the crop has not been grown because of lack of such improved technologies.

## **Achievements**

In agronomic research done so far a number of recommendations have been made (Amare and Adamu 1994 and Rezene 1994):

- Well drained deep fertile soil of Cambisol, Nitosol and Vertisols are needed for faba bean;
- Tillage practices of two to three plowings;
- Planting time of 15 June to 1st week of July;
- Application of 100 kg/ha DAP fertilizer on poor fertility soils;
- Seed rate of 175-250 kg/ha (500,000 plants/ha) depending on seed size;
- Inter-row spacing of 40 cm and interplant spacing of 5 cm in row planting
- Seed depth of 5 cm when row planting is practised;
- One to two hand weeding within 3 to 6 weeks after emergence;
- Growing faba bean in mixtures with field pea increases land productivity per unit area; and
- Herbicide recommendations are also available eventhough twice hand weeding are economically advisable (Rezene 1994) and are as follows:

Weed Type	Common names and formulations	Trade names
Annual broad leaves and grasses (Pre-emergence)	1 Terbutryn 2 kg/ha	Igran
	2 Metolachlor + metobromuron 5.0 kg/ha	Galex
	3 Pendimethalin 2.0 kg/ha	Stomp
	4 Terbutryn + metobromuron 2.0 kg/ha	Igran Combi
Annual grass weeds (post emergence)	Fluazifop-butyl @0.25 kg/ha	Fusilade

## Plant Protection

Diseases and insect pests are among the major constraints to the production of faba bean. In the cooler upper highland (>2500 m asl) disease and insect pressures are usually minimal whereby the crop and the pathogen coexist in perfect equilibrium. Here the diseases and insects are always there and farmers get reasonable yields. In the lower ecological zones of the highlands and in the mid-altitude areas however, where the temperatures are warmer, humidity is higher and moisture is less (particularly late in the season) favouring a rapid increase in pest population causing a significant damage on faba bean yields. Problems of field insects on faba bean are less serious than diseases.

### Objectives

The major objectives of crop protection are to identify major crop pests that limit the production and productivity of faba bean and develop sustainable and environmentally acceptable integrated management strategies.

### Research Priorities and Activities

Activities of crop protection have been based on the following priorities.

- Survey and documentation of major diseases and insect pests and their vectors;
- Yield loss assessment of major diseases and insect pests;
- Screening germplasm for genetic resistance to major diseases and insect pests;
- Screening of fungicides and local chemicals for the control of major diseases and insect pests;
- Population dynamics and biological studies for major diseases and insect pests;
- Work-out integrated pest management for the control of diseases and insects;
- Studies for the possibilities of biological control for major diseases (such as trichoderma for black root rot) and insect pests; and
- Studies of crop mixtures that may reduce incidence of diseases and insects.

## **Achievements**

Significant progress and achievements have been made in crop protection research even though solutions to major diseases are yet to come.

- In the survey and identification of diseases and insect pests: chocolate spot, black root rot and rust are major diseases while pod borers and aphids in the field and bean bruchids in storage are major insects of faba bean;
- Crop losses due to major diseases and insects have been done;
- Growing faba bean in mixtures with field pea have been shown to reduce severity of chocolate spot;
- Where chemical protection of chocolate spot is desired, Bravo 500 (Daconil) fungicide @2.5 kg/ha is effective;
- Resistant/tolerant sources have also been identified for chocolate spot at Holetta research center (in cooperation with the breeding section) and crossing program is underway to transfer genes for resistance to susceptible but high yielding varieties;
- Resistant/tolerant lines for black root rot have been identified (in cooperation with breeding section) in germplasm screening and these genotypes are being tested for yield at Ginchi, Ambo and Enewari;
- For chemical control of rust, Fentin hydroxide 60% fungicide @250 g/ha may be used. Few resistant genotypes against rust have been reported and these could be used to transfer resistance to high yielding but susceptible lines; and
- No genetic resistance yet identified for African boll worm, aphids and bean bruchids in Ethiopia, but where insecticidal control is desired recommendations are available. For African bollworm - Cypermethrin chemical (single spray with 150 g a.i.); For aphids - Pirimor 50%; For bean bruchids - Primiphos-methyl (6 and 8 ppm); Lindane (5 and 7.5 ppm); Folithion (5 and 10 ppm); Danfin (8 and 12 ppm); and vegetable oil (20 and 30 ppm). For more details references could be made to Dereje and Tesfaye (1994) and Kemal and Tibebe (1994).

## **Soil Microbiology**

Nitrogen fixing ability is one of the few factors that make faba bean what it is. The endowment of faba bean with this ability gives it importance of many folds among which self reliance in nitrogen needs, supply of residual nitrogen to subsequent crops, improvement in soil physical, chemical and biological characters and thereby holding a high profile in the cropping systems are the major ones. Faba bean in particular, and legumes in general, can be called crops that stand for the well-being of other crops.

With increasing cost and environmental hazards of chemical fertilizers and with the inability of farmers to afford them, the use of legumes becomes even more significant.

## **Objectives**

The major objectives of this disciplines are to collect, identify, and characterize rhizobia species from major faba bean growing regions; to study faba bean needs for, and response to, inoculation; and to determine effective strains in different soils to increase the production and productivity of faba bean.

## **Research Priorities and Activities**

Priorities and activities of this discipline are based on the objectives and include;

- Nodule collection, characterization, isolation and identification;
- Investigation of inoculation needs;
- Studies of response to inoculation; and
- Studies of soil nutrient status;

## **Achievements**

Achievements and progress in soil microbiology and fertility research in Ethiopia has been accounted by Andaw and Asnakew (1994) and Tekalign and Asgellil (1994) and can be summarized as follows:

- Nodule collections, characterization, isolation and identification have been accomplished in major growing regions;
- Average number of nodules/plant in Ethiopian faba bean is greater than 15;
- Average nodule size is medium (2-10 mm);
- Most faba bean growing soils are acidic and amendment measures are warranted;
- Faba bean, in most soils, responded positively to inoculation;
- In the strain evaluation, 23 rhizobia strains were found promising of which two isolates - isolate # 18 and #64 were highly superior and can be recommended for commercial production; and
- Rhizobia activities were also enhanced with P application.

## **Prospects**

Ethiopia is one of the centers of diversity for faba bean where nearly all faba bean production comes from indigenous landraces that are extensively grown in the country. The future direction of faba bean improvement program should emphasize the following:

Breeders may think that materials that come from outside are always



superior to what we have in the country and tend to neglect local landraces. Improvement program should continue using indigenous landraces as one of the basis of variability and material wealth;

In breeding strategy attentions are usually given to elite lines that came forward through series of selections. In some parts of the country however, local landraces included in variety trials as checks sometimes out-perform elite lines. This indicates the potential of the landraces that should not be neglected. In such cases the landrace should be included in the preliminary trials and released nationally as a variety after subsequent multi- location testings and verifications. It can also be released for that specific region as specific adaptation.

Local landraces can also be enhanced by selecting superior plants with desirable characters from farmers fields or by combining desirable characters from other superior plants using specific breeding methods and release as an enhanced variety. Testing will be done under low input conditions and farmer participation and farmers criteria are used in evaluations and selections. Seed increases and dissemination will also be done by farmers.

In breeding and crop protection, priorities in research should obviously be given to chocolate spot disease, the number one yield limiting factor in faba bean production across the nation. Emphasis will be given to screening large number of exotic and indigenous materials to identify genetic resistance and to control the disease or reduce damage by developing integrated disease management practices.

Faba bean can successfully be grown in Vertisols given the technology of furrow making for proper drainage of excess water and varieties that are resistant to black root rot and tolerant to waterlogging are developed and disseminated. This work is already underway and will be pursued with more emphasis.

Important production regions in the west, south and east and north east have been neglected in the benefits of research so far. Attempts will be made to include regions such as South and Western Welo (through Sirinka Research Center), the Chercher highlands of Harargie (through the Ministry of Agriculture), North Ormo (through Awassa Research Center), highlands of Kefa (through Jima Research Center), the Shambu and Arjo highlands of Wellega (through Bako Research Center). Most of these are in the top ten faba bean producing regions of the country.

Farmers are abandoning faba bean in traditionally important producing areas because of abiotic factors such as frost and hail damages. There is no genetic resistance in faba bean reported to hail damage anywhere in the world. But efforts to identify genetic resistance to frost by screening large amount of germplasm should continue to claim back the lost territories of faba bean areas.

Rhizobia strains that could significantly increase faba bean yields have been identified, isolated, tested, and preserved. Isolates #18 and #64 are examples. Cheap means to commercially multiply these and make them available to farmers at affordable prices should be sought. Then these strains could be included in the recommendation for improved production packages for faba bean.

Faba bean is said to have high demands in the international and neighbouring markets. The breakfast dish "*ful*" is very famous in the nearby oil rich Arab countries where good quality faba bean fetches premium prices. To exploit these markets, in addition to increased production, attention will be given to seed qualities such as size, color, and protein content and improve production practices to keep seeds free from diseases and insect pests, timely and careful harvesting and threshing to avoid mechanical damage and develop and recommend appropriate post-harvest handling.

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