Intercropping:

Intercropping is the cultivation of two or more crops simultaneously on the same field. It also means the growing of two or more crops on the same field with the planting of the second crop after the first one has completed its development. The rationale behind intercropping is that the different crops planted are unlikely to share the same insect pests and diseased-causing pathogens and to conserve the soil.

Advantages:

1. Reduces the insect/ mite pest populations because of the diversity of the crops grown. When other crops are present in the field, the insect/mite pests are confused and they need more time to look for their favorite plants.
2. Reduces the plant diseases. The distance between plants of the same species is increased because other crops (belonging to a different family group) are planted in between.
3. Reduces hillside erosion and protects topsoil, especially the contour strip cropping.
4. Minimizes labor cost on the control of weeds. A mixture of various crops gives often a better coverage of the soil leaving less space for the development of weeds.
5. Utilizes the farm area more efficiently.
6. Results in potential increase for total production and farm profitability than when the same crops are grown separately.
7. Provides 2 or more different food crops for the farm family in one cropping season.

Things to consider when intercropping:

1- Crop choices

Farmers should pick two crops that will mature at roughly the same time, or can wait while the other crop matures.

2- Seeding
   Farmers can seed each crop in its own row, known as strip intercropping, or mix the crops.
3- Fertility
4- Spraying
   Intercropping systems can control weeds.
5- Harvest
   When it comes to harvesting lentils and flax, farmers should take care not to chip lentils during threshing.
6- Rotation

Types of intercropping

1- Mixed intercropping
   Such as planting the seeds of broad bean with barley seeds or chickpeas with wheat
2- Intercropping in rows. Cultivation of each crop in a line.
3- Intercropping in the form of strips
4- Relay intercropping

Example of intercropping

Soybean + Corn

Kidney bean + Corn

Mung bean + Cotton

Broad bean + Barley

Chickpea + Wheat

Faba bean (*Vicia faba* L.)

North Africa, southwest and south Asia are the native of faba bean. The common names of faba bean are also broad bean, hours bean, field bean.

Faba bean growths in winter. China is largest producing countries for faba bean that account for more than 50% of the cultivated area in the world.

Nutritional Value, and Use of Faba Bean

Faba bean seeds contain antinutrient compounds. Soaking, dehulling, boiling, pressure-cooking are the main processing methods used to reduce the amounts of these compounds in faba bean seeds, in order to limit their adverse effects on human health. Dehulling is efficient in eliminating the tannin and polyphenol content, while soaking inactivate trypsin inhibitor activity.

The inclusion of plant-based proteins in human diets has a beneficial effect on human health. Faba bean protein content is reported to vary between 17.6 and 34.5% of seed dry matter, while acid detergent fiber (ADF) ranges between 10.1 and 13.7% (Table 3). Faba bean is also a valuable source of amino acids, being particularly rich in the essential amino acids arginine, lysine, and leucine, at up to 67 g kg^{-1} dry matter. As faba bean also provide macro-, micro-, and non-nutrient phytochemicals, it has been noted to have potential as a functional food. For example, report that faba bean seeds contain L-3,4-dihydroxyphenylalanine (L-DOPA), the precursor to the neurotransmitter catecholamine and a drug used to treat Parkinson's disease.

Faba bean also contains antinutritional compounds such as saponins, lectins, tannins, vicine, convicine, and phytic acid. Tannins are known to reduce protein digestibility, while the absence of tannin in zero-tannin faba beans is controlled by either of the two genes zt-1 and zt-2. The consumption of faba bean products containing high levels of vicine and convicine causes favism in humans, which is associated with glucose-6-phosphate dehydrogenase deficiency.

Faba bean seed size is an important trait in determining market and consumption form. Large-seeded varieties (broad beans) are widely used for food, either as a fresh green vegetable or (dehulled) dry seeds. Varieties with small- to medium-size seeds are mostly used for animal feed. Faba bean can also be used in the bakery industry; for example, a combination of faba bean and wheat flour improves the nutritional properties of bread. In Spain, small faba bean seeds (<12 mm) are currently highly accepted in the industry. Small-seed genotypes are generally preferred by the frozen faba bean and canning industries; the ability to use a microwave oven encourages the consumption of this legume, because seeds are much more easily cooked, and bags can be stored for up to 10 days at 5°C.

TABLE 1. Nutritional value of faba bean dry seeds in comparison with two other important legumes widely cultivated in Europe.

Traits	Faba bean	Field pea	Lentil	References
Protein content (%)	17.6–34.5	19.9–27.6	25.8–28.6	Gharibzahedi et al., 2012; Duc et al., 2015a; Koivunen et al., 2016; Çalcskantürk et al., 2017; Lepse et al., 2017; Li and Ganjyal, 2017; Bodner et al., 2018
Ash (%)	3.4–3.7	2.9–3.2	3.4–3.6	Gharibzahedi et al., 2012; Koivunen et al., 2016; Çalcskantürk et al., 2017
ADF (%)	10.1–13.7	7.5–8.6	5.6–5.7	Gharibzahedi et al., 2012; Jeziemy et al., 2017
NDF (%)	12.6–16.5	10.5–12.6	8.2–8.7	Gharibzahedi et al., 2012; Jeziemy et al., 2017
Starch (%)	42.1–45.6	41.5–53.5	43.5–50.0	Jeziemy et al., 2017; Li and Ganjyal, 2017
Minerals (mg kg^{-1})				
Fe	29.7–96.3	47.7–58.1	66–100	Gharibzahedi et al., 2012; Baloch et al., 2014; Ray et al., 2014
Zn	10.4–49.3	27.4–34.0	36.7–60.6	Gharibzahedi et al., 2012; Baloch et al., 2014; Ray et al., 2014
Mn	15.5–29.2	9–15.6	12.2–14.8	Gharibzahedi et al., 2012; Baloch et al., 2014; Ray et al., 2014
K	4500–19,300	9265–11,874	8802–10,240	Gharibzahedi et al., 2012; Baloch et al., 2014; Ray et al., 2014

ADF, acid detergent fiber; NDF, neutral detergent fiber.

Adaptability of Faba Bean to Abiotic Stress

Drought and heat are considered major constraints in faba bean growth and production. The most drought-sensitive growth stages are flowering, early podding, and grain filling, however, faba bean varieties differ widely in drought tolerance. One of the mechanisms apparent in drought-tolerant varieties or genotypes is proline accumulation, but a differential root architecture, influencing access to water, which differ varieties in drought tolerance.

Faba bean is susceptible to frost during its reproductive stages. Recent studies, however, have identified some frost-tolerant genotypes, which could be used in breeding programs. Hardening seedlings through exposure to low non-freezing temperatures before the onset of winter may enhance plant tolerance to frost.

Waterlogging, e.g., during flowering, limits faba bean growth and yield. The negative effects of waterlogging on growth and other physiological traits (i.e., chlorophyll a and b) persist even after cessation of soil flooding. However, faba bean is considered the most tolerant to waterlogging of the cool-season grain legumes.

Excess soil salinity affects both growth and nitrogen fixation in faba bean plants, which are considered moderately tolerant of soil salinity. report a yield reduction in faba bean at soil salinity levels of ≥6.5 dS m^{-1}. Root systems are more sensitive than shoots to salinity. In addition, at high salinity levels, nitrogenase activity and nodulation are suppressed. These researchers observe that high salinity treatments of 80 and 120 mM NaCl caused a significant reduction in faba bean shoot biomass of 25 and 49%, respectively. Moreover, nitrogen accumulation in the shoots reduced by 36 and 63% at salinity levels of 80 and 120 mM NaCl, respectively. Measures undertaken to ameliorate the negative effects of salinity on faba bean plants include foliar application of silicon or inoculation with *Pseudomonas fluorescens*. Salinity-tolerant faba bean genotypes are also available; one example is the line "VF112," which has been reported as salt-tolerant because salt stress had no effect on its growth or nitrogen fixation.

Agronomy

Crop Sowing and Rotation

Faba bean is usually planted in the autumn, in areas of Europe characterized by mild winter climatic conditions. In cooler agro-climatic zones, sowing is postponed until the end of winter or early spring to prevent frost damage. In Iraq faba bean is sown at November 15 to December 15.

The main tillage operations during the sowing period include moldboard plowing (20–40 cm depth) and harrowing, followed by light duty plowing, the last of which is commonly performed using a rotary tiller. Several studies also show that reduced tillage and no-tillage are viable alternatives to conventional tillage in faba bean crops.

Faba bean is usually sown in rows 60- 75 cm apart, and 15 cm between seeds using either a spacing drill (placing 2–3 seeds per hole) or seed drill. The required seed amount ranges between 70 and 200 kg ha^{-1}, dependent on seed size and planting density, the recommended sowing depth is 5–8 cm. Germination takes place in 4–12 days, and the optimum temperature for germination is 20°C.

The key agronomic and economic advantage provided by faba bean and other legumes in crop rotation is biological nitrogen fixation BNF. The N benefit provided for subsequent crops is often high; a review has demonstrated substantial savings (up to 100–200 kg N ha^{-1}) in the amount of

N fertilizer required for subsequent crops. Thus, the inclusion of faba bean in crop rotation reduces the need for inorganic N fertilizer, and consequently reduces CO_2 emissions.

Other benefits provided by faba bean in rotation systems include improvement to soil physical properties, maintenance of soil fertility, and disruption of pest and disease cycles.

In summary, the main benefits of including faba bean in crop rotation systems are as follows: (1) reduced use of inorganic nitrogen fertilizers, (2) reduced CO_2 emissions, (3) improved soil physical properties (i.e., bulk density, porosity, and water content at field capacity), (4) maintenance of soil fertility, and (5) higher yield and improved quality in subsequent crops.

Two examples of rotation sequences used in cropping systems that include faba bean:

1. Faba bean (first year), cereal (second year), field or industrial crops (i.e., maize, cotton, tomato, sugar beet, oilseed rape; (third year), and cereal (fourth year);

2. Faba bean – short period vegetable (first year), cereal (second year), field or industrial crops (i.e., maize, cotton, tomato, sugar beet, oilseed rape; (third year), and cereal (fourth year).

Soil Fertilization and Inoculation

Nitrogen fertilization is not generally required, but the application of “starter” nitrogen fertilization at a rate of 20 kg ha^{-1} seems to enhance the nodulation process in faba bean plants. Furthermore, legume BNF is an energy intensive process that requires large amounts of phosphorus (P). Thus, P fertilization at a rate of 40 kg ha^{-1} can often enhance the nodulation process and N_2 fixation, and increase yield.

Several other studies show that faba bean crops also respond to S and K fertilization. Nevertheless, S or K fertilizers are rarely applied, because faba bean is cultivated as a low-input crop. Furthermore, micronutrient (e.g., zinc and boron) deficiencies are rare and can easily be corrected through foliar sprays.

Inoculating faba bean fields or seeds with *Rhizobium* is unnecessary in traditional cultivation areas. However, it is advisable to test their presence in the soil in areas where faba beans or other legumes have not been grown for several years. If absent, the crop can be inoculated with *Rhizobium leguminosarum* bv. *viciae*. Dual inoculation with *Rhizobium* and arbuscular mycorrhizal fungi has been reported to be more effective than inoculation with *Rhizobium* alone in promoting faba bean growth, particularly in alkaline soils; this reflects the existence of synergistic relationships between the two inoculants.

Irrigation

Faba bean usually grows without irrigation, with the exception of crops cultivated in very dry and hot climatic zones. Thus, production is highly dependent on the amount of and variation in rainfall during the growing season. In semiarid regions, climate change can affect water use efficiency and growth in faba bean, given its sensitivity to drought. In the Mediterranean region and similar dry and hot climatic zones, faba bean production without irrigation may be possible if cultivation takes place during the cold season. Moreover, early sowing in autumn is considered an effective strategy for avoiding water stress during the seed filling stage. Alternatively, faba bean crops can be irrigated at the seed filling stage in order to avoid penalties in yield during drought. Additionally, reports that faba bean production is usually increased by irrigating spring crops during the flowering stage and early podding between 231 and 297 mm of water are required to produce 3–4.4 t ha^{-1} of faba bean dry biomass. The development of drought-tolerant faba bean varieties is a key challenge in achieving increased and more stable production levels. Several genotypes are considered tolerant to drought and can be exploited in breeding programs in order to develop drought-tolerant varieties. Recently, some varieties (e.g., CS20-DK and NC-58) have been evaluated as tolerant to water stress.

Weed Control

Weed infestation is a major constraint in faba bean production, and can reduce yield by up to 50%. Thus, early weed removal during the period between 25 and 75 days after sowing is necessary if a high yield is to be obtained. Similar to other winter pulse crops and cereals, the 12 main weeds that compete with faba bean in Europe are the broadleaved species (*Anthemis arvensis* L., *Chenopodium album* L., *Papaver rhoeas* L., *Sinapis arvensis* L., *Fumaria officinalis* L., *Veronica* spp., *Lamium amplexicaule* L., *Cirsium arvense* (L.) Scop., and the grass species *Avena sterilis* L., *Phalaris* spp., *Lolium rigidum* Gaud., and *Alopecurus myosuroides* Huds.). Moreover, in many Mediterranean countries, such as Spain, faba bean can be parasitized by various broomrape species (*Orobanche* spp. and *Phelipanche* spp.); *Orobanche crenata* Frosk (bean broomrape) is the main species infesting faba bean in this area.

Faba bean exhibits a superior ability to compete with weeds compared with other pulse crops, such as chickpea, due to its more vigorous early growth and greater plant height. Nevertheless, the application of herbicides is a primary method in controlling weeds in conventional faba bean production. To our knowledge, the herbicides pendimethalin, clomazone, bentazon, quizalofop-*p*-ethyl, and propaquizafop are registered for use on this crop in the European Union. The first two are applied pre-emergence to control broadleaved and grass weeds; quizalofop-*p*-ethyl and propaquizafop are applied post-emergence to control grass weeds such as *Phalaris* spp. and *Lolium* spp., while bentazon is applied post-emergence to control broadleaved weeds. Crop rotation with spring crops can significantly reduce weed pressure, while allowing field application of herbicides that are not registered for use on faba bean. Residual herbicides can damage faba bean planted in fields where chlorsulfuron (sulfonylureas) and aminopyralid (pyridine carboxylic acids) have previously been applied.

Currently, the development of resistant faba bean varieties would appear to be the most effective strategy for preventing broomrape infestation. In a recent study conducted in Egypt, Spain, and Tunisia by, some accessions and the variety “Baraca” proved to be the most resistant to *O. crenata*. Several studies have also shown that late sowing and intercropping with cereals can reduce broomrape infection of faba bean, while soil solarization is a non-chemical and effective method for controlling *O. crenata* and other weeds.

Harvesting:

Cultivated Faba bean crops cultivated for fresh seed consumption may be harvested either manually or mechanically once the pods are filled, but before they start to dry. Pods are harvested by hand two to three times during the harvesting period in crops cultivated in small areas for fresh consumption. When faba bean plants are cultivated for their dry seeds, they can be harvested using a conventional cereal combine harvester. Similar to other pulses, proper selection of the harvest stage is critical if seed loss is to be minimized; seeds should be harvested when the moisture content is 14–15%. In some countries (such as Canada), diquat is registered as a preharvest desiccant, and its application is a common practice among pulse growers, as this helps farmers to overcome problems caused by slow ripening and weeds during the harvest period.

Disease and Insect Management

Diseases

Fungal diseases can severely damage faba bean crops, especially in wet weather conditions. Ascochyta blight, chocolate spot, and rust are the three main pathogens affecting faba bean crops globally Ascochyta blight is caused by *Ascochyta fabae* Speg. (teleomorph *Didymella fabae* Jellis and Punithalingam), and is one of the most serious pathogens, causing up to 30% loss in yield. Although the application of fungicides, such as azocystrobin and chlorothalonil, considerably reduces ascochyta blight infection, integrated management practices (e.g., crop rotation, use of resistant varieties, and late sowing) are crucial to successful control. In a recent study report that the faba bean accessions V-26, V-255, V-958, V-1020, V-1085, V-1117, and L-831818 showed good levels of resistance to *A. fabae*.

Chocolate spot is caused by the fungi *Botrytis fabae* Sard. and *Botrytis cinerea* Pers., while *Uromyces viciae-fabae* (Pers.) J. Schröt causes rust disease in faba bean. Rust and chocolate spot infection can cause yield losses of 22–42% and 36–68%, respectively. According to, foliar spraying with fungicides such as the triazoles (difenoconazole, epoxiconazole, or tebuconazole), dithiocarbamates (thiram, maneb, or mancozeb), and chlorothalonil was effective in controlling rust. In addition, procymidone is very effective against *B. fabae*, and chocolate spot severity in faba bean is reduced by frequent application of mancozeb, intercropping with cereals such as barley, oat, triticale, and wheat, and low crop density and wide row spacing. In a recent study also observe that isolates of *Trichoderma viride*, *T. harzianum*, and *Bacillus* *subtilis* reduced chocolate spot severity in faba bean. A key option in the integrated management of *B. fabae* is the cultivation of resistant cultivars. According to , the accessions 132-1, 135-1, 174-1, BPL 710, ILB 4726, and ILB 5284 exhibited a good level of resistance to *B. fabae* infection. Thus, these genotypes constitute an interesting genetic resource for future exploitation in breeding programs for developing chocolate spot-resistant cultivars.

Faba bean is also susceptible to viruses, with the principal sources of infection being faba bean necrotic yellows virus (FBNYV) and bean yellow mosaic virus (BYMV). Other diseases affecting faba bean crops are black root rot [*Fusarium solani* (Mart.) Sacc.], faba bean root rot (*Aphanomyces euteiches* Drechs.), powdery mildew (*Erysiphe pisi* var. *pisi*), and stem rot (*Sclerotinia trifoliorum* Erikss.).

Insects

Several insects have the potential to infest faba bean plants. The black bean aphid (*Aphis fabae* Scop.) is a common pest; aphids infest new leaves on faba bean plants. Foliar insecticide sprays (i.e., thiacloprid, fenvalerate) are very effective against these pests. Moreover, parasitoids play a significant role in the natural control of aphids. *Lysiphlebus fabarum* Marshall (Hymenoptera) is a parasitoid of black bean aphid, and could prove useful as a biological control.

Other insects that infect faba bean crops are the pea leaf weevil (*Sitona lineatus* L.) and broad bean weevil (*Bruchus rufimanus* Boh. *S. lineatus* adults feed on the foliage, while the larvae feed on faba bean and pea root nodules, affecting their ability to fix nitrogen; treating seeds with thiamethoxam could be useful in controlling this insect. Furthermore, storage pests, such as *B. rufimanus*, can cause significant yield losses in legumes; insecticides are however effective against them.