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Novel Managing Practices for Faba Bean Cultivation

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INTRODUCTION

Faba bean (*Vicia faba* L.; 2n = 2x = 12, 14; Family: *Fabaceae*) is known by many names like broad bean, horse bean, winter bean, windsor bean, pigeon bean and popularly known as bakla and kala matar in India. It is a hardy plant, which can tolerate extreme cold temperature. Faba bean is the only bean which grown as winter crop. It is widely believed to have originated in the North Africa and South Caspian Sea and introduced in India by Arab traders. In 2020-21, faba bean ranked 6th with respect to production worldwide, after the common bean, pea, chickpea, cowpea and lentil with total production of 4.5 M tons, while the area harvested was 2.5 M ha. China is a leading growing country of faba bean with respect to area and production. In India, the area and production of faba bean is low and that is why it is still categorized as minor crops. It is a traditional legume crop of Bihar that is why in India, faba bean have maximum area in Bihar. In India, faba bean cultivated in Madhya Pradesh, Odisha and Uttar Pradesh.

Faba bean have great role in world agriculture due to its high performance with respect to yield, compared to alternative grain legumes. It can also be used as break crop in area where cereal based mono-cropping system is dominated. It is a highly profitable crop because of its biologically nitrogen fixation capacity and enhanced weed and disease control in subsequent crops are considered. According to a study, faba bean can fix up to 200 kg N ha^{-1}, while the incorporation of legume residues into the soil improves soil properties such as organic matter content, bulk density, porosity, and field capacity.

Faba bean is a dual-purpose crop, green pod is used as vegetable, whereas, dry seed are used as grain legume. The seeds of faba bean are good source of protein (29.4%), carbohydrate (51 to 68%) and fat (1.5%).

Among the most commonly cultivated crops, faba bean has not only the highest crude protein content but also has the highest yield of protein per hectare. In 100g of edible portion, it contains 7.2g carbohydrate, 4.5g protein, 0.1g fat, 0.08mg thiamine, 12.0mg ascorbic acid, 50mg calcium and 1.4mg iron.

Morphological Description and Botanical Characterization

Faba bean is a cool season annual legume that forms coarse, upright hollow, and unbranched stem(s) from the base, and grows between 0.1 and 2 m tall. Stem growth is indeterminate, and some cultivars are prone to lodging. The leaves are alternate, pinnate and consist of two to six leaflets, which are up to 8 cm long without tendrils. The flowers have a typically papilionaceous structure and are grouped in inflorescences; they are either pure white in color or with diffuse anthocyanin pigmentation on all petals, while black spots are often present on the wing petals. Seeds, which vary considerably in size, are oblong to broadly oval with a prominent hilum at the end; their color can be yellow, green, brown, black, or violet and sometimes seeds are spotted.

Faba bean is generally considered day-neutral, while some accessions require long-day conditions in order to flower. However, thermal time is the most important contributor to flowering progress in faba bean, with approximately 830–1000 days above 0^{*}C being required; winter faba bean genotypes require vernalisation. Faba bean is a self-pollinated plant with significant levels of cross-pollination. The main pollinating insects are honeybees (*Apis* spp.) and bumblebees (*Bombus* spp.); the benefits of insect pollination for yield.

Crop Sowing and Rotation

The main tillage operations during the sowing period include MB ploughing (20–40 cm depth) and harrowing, followed by light duty ploughing, 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 10–30 cm apart, 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 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.

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

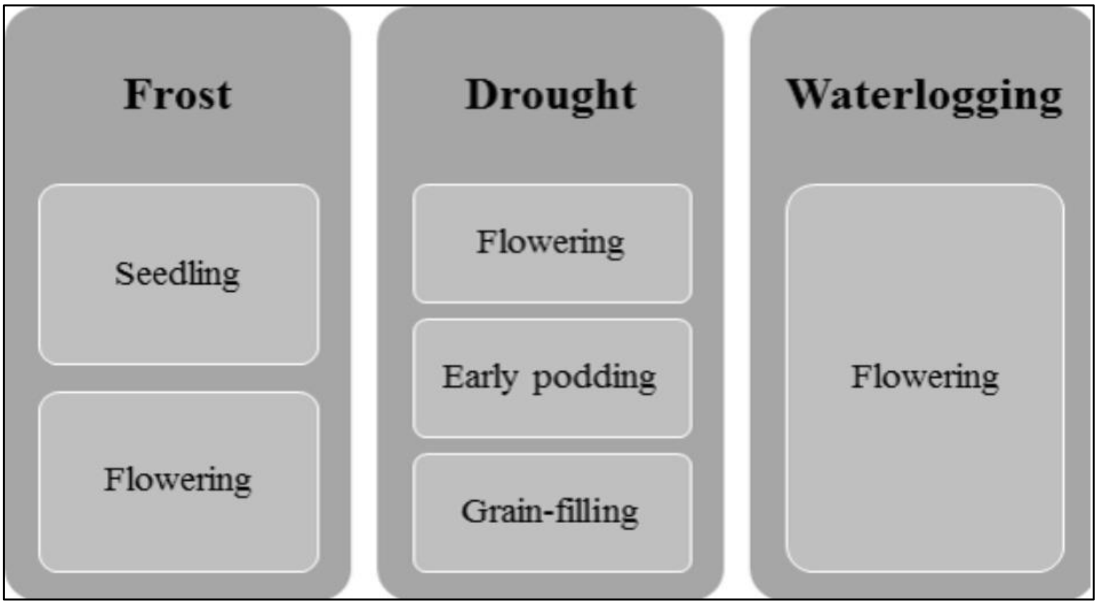

Fig: Critical stages of faba bean growth in responding to the main abiotic stress factors

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 main weeds that compete with faba bean are the broadleaved species. 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. 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. 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.

Disease and Insect Management

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* and is one of the most serious pathogens, causing up to 30% loss in yield. Chocolate spot is caused by the fungi *Botrytis fabae*, while *Uromyces viciae-fabae* causes rust disease in faba bean. Rust and chocolate spot infection can cause yield losses of 22–42% and 36–68%, respectively. 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. Foliar spraying with fungicides such as the triazoles, dithiocarbamates 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, it was observed that isolates of *Trichoderma viride*, *T. harzianum* and *Bacillus subtilis* reduced chocolate spot severity in faba bean. 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).

Several insects have the potential to infest faba bean plants. The black bean aphid (*Aphis fabae*) 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 and broad bean weevil.

Harvest, Processing, Nutritional Value and Use of Faba Bean

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%.

Faba bean seeds also contain antinutrient compounds. Soaking, dehulling, boiling, pressure-cooking, autoclaving and extrusion 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 and autoclaving 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%. 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, 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. 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: Nutritional value of faba bean dry seeds in comparison with two other important legumes

Traits	Faba bean	Field pea	Lentil
Protein content (%)	17.6–34.5	19.9–27.6	25.8–28.6
Ash (%)	3.4–3.7	2.9–3.2	3.4–3.6
ADF (%)	10.1–13.7	7.5–8.6	5.6–5.7
NDF (%)	12.6–16.5	10.5–12.6	8.2–8.7
Starch (%)	42.1–45.6	41.5–53.5	43.5–50.0

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

CONCLUSION

Faba bean is important both as a pulse and a vegetable crop. The dry and fresh seeds or pods are recommended for their benefits to human nutrition as a dietary source of fibre and protein. Moreover, from an agronomical point of view, including faba bean in crop rotation systems improves soil, since this crop can fix atmospheric N_2 to amounts that may exceed 200 kg N ha^{-1}, and increases soil organic matter. Its inclusion in rotation systems therefore contributes to significant improvements in the sustainability of agricultural systems. Production of this legume species is vulnerable to biotic and abiotic stresses, such as ascochyta blight, broomrape infestation, waterlogging, and drought. These constraints require there to be an urgent and increased focus on the development of new varieties that are resilient to these stresses. The new varieties should combine many of the above-mentioned characteristics, with the ultimate objective of achieving a high yield and high protein content.