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Cultivation of French bean useful for food and fodder

French bean also known as *Rajmah*, is valued for its protein rich (23%) seeds. The antimetabolite of dry beans needs removal by cooking and soaking in water. Besides dried seeds, the green leaves, pods and seeds also can be used for 'daal' and 'sabji' in the human diet and as a forage crop for the animal's health. This crop is suitable for round the year cultivation July–September (rainy season crops) and December–January (dry season crop). The main crop season of December–April is high yielder. This bean crop is less efficient in fixing atmospheric nitrogen than other legumes because of no nodulation but improves the soil health by symbiotic relationship with the soil and *Rhizobium* bacteria.

FRENCH bean (*Phaseolus vulgaris* L.) is identified by multiple names like common bean or green bean or kidney bean or string beans or snap beans or fine beans or haricot bean or navy bean according to their location and has high demand around the world. India is leading country in the world with largest production and consumption of *Rajmah*. The crop is grown by both large and smallholder farmers and easy to grow in small gardens, because the growth habit of this crop is both dwarf and climbing type. There are many different varieties of French beans primarily grown for their green pods and fodder than dried seeds and consumed with their enclosing pods. Green pods and dried seeds are also rich in protein, fat, calcium, iron, phosphorus, vitamins (A, B, D, K), antioxidant, carbohydrate and starch. French beans are delicious, their fresh pods and green leaves are used as vegetable. This crop is grown for both fresh consumption and processing generally after canning and freezing. Fresh green crop of this bean is utilized as forage for cattle. Chop the vines well to make the coarse-stemmed material more palatable to the cattle while preferably mix the bean vines with other forage at feeding. French bean can be used as organic manure after ploughing with soil at both green and dry stages. This crop also fixes nitrogen but less efficiently than other legumes. It is also associated with several rhizobia and makes the soil healthy.

Commercial varieties of beans in India

On the basis of region, there are two types of popular varieties of French bean, i.e. hills and plains. The hills popular varieties of beans are Ooty 1, Ooty (FB) 2, YCD 1, Arka Komal (Sel.9), Premier, Arka Sampoorna, Arka Bold, Arka Karthik and Pusa Himalaya, etc. Whereas, the plains popular varieties of beans are Arka Suvidha, Arka Komal, Premier, (Sel.9), Arka Samrudhi, Arka Anoop, Arka Suman, Deepali, Kankan Bushan, Dasara, Phule Gauri, Azad Rajmah 1, Pusa Parvati, etc. While, two varieties of ICAR-IIVR, Varanasi, viz. Kashi Rajhansh and Kashi Sampann can be grown in both hills and plains region.

However, based on growth habit of plant, this crop is categorized in bush and pole types of varieties. Among the bush type are Kashi Rajhansh, Kashi Sampann, Swarna Priya, VL Boni Bean-1, Pencil Wonder, Contender, Pusa Parbati, Arka Komal, Arka Suvidha, Arka Suman, Arka Bold, Arka Sharath, Azad Rajma-1, Jampa, Phule Suyash,

Bush type French bean

Pole type French bean

Bountiful, Prider, HUFB-30, HUR-15, etc. While, the pole type varieties are, Kentucky Wonder, Premier, VPF–191, Swarna Lata, Pusa Himalaya, Pusa Parwati, Arka Anoop, Lakshmi, HAFB-3, RCMFB-1, etc.

Climatic conditions and best seasons

French beans can be grown in areas of tropical and temperate regions with an ideal temperature range around 20-25°C. Generally, it can also be grown in temperature ranging between 14 and 24°C. Growth of plant ceases if temperature falls below 10°C because it is highly susceptible to frost. Temperatures above 30°C causes dropping of buds and flowers, result in the poor yield but if temperature reaches above 35°C then bean seeds may not be formed. French beans mature faster in warmer climatic areas. The crop is generally raised in areas receiving 50-150 cm annual rainfall. Water logging at any stage adversely affects its yield because heavy rains causes flower drop and spread of leaf spot diseases. This crop is suitable for round the year cultivation July– September (rainy season crops) and December–January (dry season crop) but in the main season (December–April) crop has given better results.

Suitable soil and preparation

French bean can be grown in wide range of soils from light sand to heavy clay, but well drained loams are the best. Soil *p*H around 5.2-6.0 is optimum. The crop is sensitive to salinity. It is better to have organic matter in soil for better yield and promotes more vegetative growth. Adding Farm Yard manure (FMY) or any other compost can make the soil rich during preparation of field. The main field of French bean should be prepared thoroughly by giving 4 to 6 deep ploughing by 23 harrowing and planking is adequate to obtain required tilth. Crop requires fine seedbed and adequate soil moisture for good germination.

Seed rate, sowing methods and spacing

Recommended seed rate of French bean for bush types varieties is 65 kg/ha and 25-30 kg/ha, for pole types varieties. However, sometime seed rate varies with seed size because bold seeded varieties (with a test weight of 350-450 g) need 120-140 kg seed/ha, while in small seeded varieties, it varies from 80-100 kg/ha. The seed rate may vary with row proportions during intercropping. This crop is generally sown in northern plain on spacing of 45 × 20 cm. In bush type varieties, rows 45-60 cm apart and 10-15 cm away from seed to seed while in pole type varieties they are often sown in hills about 90 × 30 cm apart. The seed may be sown by dibbling, drilling and broadcasting at a depth of 2.0 to 3.0 cm. The seeds should be inoculated with rhizoidal culture before sowing.

Cropping systems

In *rabi* season, intercropping of potato with French bean in 3:2 ratio is being practiced in central and eastern Uttar Pradesh and northern Bihar. Sometimes French bean with linseed in 2:1 ratio is also found to be an efficient cropping system. Whereas, in North India, this crop is grown in spring season after potato or mustard. In hilly regions, it is being intercropped between maize and soybean.

Irrigations and intercultural operations

Irrigation in this crop should be given during flowering and pod development stages, while in dry season, frequent irrigation is required at 3-4 days interval during fruiting stage. The soil must have sufficient moisture but avoid excess moisture during seed germination otherwise germination will affected. French bean crop suffers severe competition from weeds in initial stages. Therefore, shallow cultivation keeps the crop free from weeds. First 30-40 days after planting are the critical period for crop. Remove the weeds by hands or mechanically at 30-35 days after sowing, is found beneficial. Herbicides such as dinitomaterial 2-3 kg per acre and sodium salt of pentachlorophenol @ 6 kg per acre as per emergence treatment have been effective in controlling the weeds or in some cases pre-emergence application of pendimethalin @ 1.0 kg/ha or pre-plant incorporation of 1.0 kg/ha of fluchloralin have been found effective for weed control.

Pests, diseases and management

The important insect pests of French beans are Bihar hairy caterpillar, blister beetle, pod borer, leaf hopper bean bug, whiteflies and aphids, etc. Pod borer can be controlled by spraying Carbaryl 50 WP 2 g/L, leaf hopper can be controlled by spraying methyl demeton 25 EC or dimethoate 30 EC at 2 ml/L. However the important diseases are rot (collar, stem and pod), rhizoctonia root rot, yellow mosaic, bean golden mosaic virus, ashy stem blight, angular leaf spot, powdery mildew and anthracnose affected to productivity of French

Pole type crop

Semi-pole type crop

Bush type crop

bean and they can be controlled by spraying captan @2 g/L, blitox or difoliton @ 2 g/L. Powdery mildew can be controlled by spraying wettable sulphur at 2 g/L or dust with sulphur 25 kg/ha and mosaic control by removing the affected plants and spray with systemic insecticides like imidachloprid and monocrotophos 1.25 ml/L to control insect vectors. Rust disease can be controlled by dusting with sulphur @ 25 kg/ha or sulfex 2 g/L. Anthracnose can be controled by removing the affected plants and pods and application of mancozeb 2 g/L.

Fertilizers, manuring and nitrogen fixation for healthy soil

Nitrogen fixing legume French bean (*Phaseolus vulgaris*) is less efficient in fixing N than other legumes because of poor or no nodulation, but it has already been reported that this crop has fixed up to 125 kg N/ha. After that, it can be nodulated with several rhizobia. Hence, it needs of 100-120 kg/ha N, 50-60 kg P_2O_5/ha and 50 kg K_2O/ha is recommended. Half dose of N along with entire dose of P and K, remaining half of N should be applied at the time of earthing up after 30 days of sowing. For this crop, the application of manure like vermi-compost is required for 10-15 t/ha. Some *Rhizobium* legume associations are able to cope with a high content of heavy metals in soils treated with sludge or organic fertilizers. However, the chemical and physical properties of organic fertilizers e.g. sludge application prior to soil is utmost important. Furthermore, the legume root nodule symbiosis can be used as an effective parameter for eco-toxicological evaluation of contaminated soils. Most combined N available to crop legumes is in the form of NO, formed by oxidation of NH from residual fertilizer and mineralization of organic N. Both NO assimilation and N fixation of legumes are strongly dependent on the plant cultivar, bacterial strain, ontogeny, and environmental factors.

Food and fodder for human and animal health

The immature pods of French beans are marketed fresh, frozen or canned, whole, cut or French-cut. The mature ripe beans variously called navy beans, white beans, northern beans or pea beans, are widely consumed. In temperate regions, the green immature pods are cooked and eaten as a vegetable. In lower latitudes, the dry beans furnish a large portion of the protein as needed by low and middle class families. Additionally protein *Rajmah* is rich in fat, calcium, iron, phosphorus, vitamins (A, B, D, K), antioxidant, carotenoid, flavonoid, omega-3 fatty acid, carbohydrate and starch, etc. In some regions of the tropics, leaves are used as a pot-herb, and to a lesser extent the green-shelled beans are eaten. In some places, young leaves are eaten as a salad. Bean crop residues can be fed fresh to livestock because directly grazed in the field, which could be avoided by harvesting it for cut and carry systems. After beans are harvested, straw is used for fodder and can be mixed with small grains in order to increase the protein content of silage.

Harvesting technique and yield capacity

In French bean, the first harvest is obtained after 45-50 days in bush type cultivars and after 60 days in pole type. So, from a season of crops usually three pickings from bush type and five pickings from pole type is taken but delay in harvesting may cause shattering. At the maturity, leaves and pods turn yellowish brown and majority of leaves drop. The harvested crop is kept for sun drying for 57 days and after drying it is threshed. Yield of French bean obtained for bush varieties 50-60 quintals/ha and for pole varieties 80-100 quintals/ha. Sometimes it has been reported that the yield under optimum conditions, 2.0-2.5 t/ha of grain and 3.0-3.5 t/ha straw yield can be obtained.

CONCLUSION

Among the legume crops, French bean are an appreciable and versatile legume because of their various usages in human diet as well as fodder for livestock. Due to rich protein and mineral sources, it can be consumed with green pods and leaves for vegetables as well dry seeds in human diet. Whereas, green pods, leaves and dry straw can be used for animals. Besides food and fodder, this crop can be used as green manure for improving soil health. After considering the importance and utility of French bean crops, it should be promoted by farmers in large or small scale.

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