Cultivation of French Bean for Enriching Soil and Human Health

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French bean also known as Rajmah, is valued for its protein (23%) rich 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 forage crops for the animal's health. Its cultivation may be possible for round the year while the main crop season is December–April (dry season crop). This bean crop is the less efficient in fixing atmospheric nitrogen than other legumes because of no nodulation but improve the soil health by symbiotic relationship with the soil and Rhizobium bacteria.

Introduction

French bean (*Phaseolus vulgaris* L.) identified by multi names like common bean or green bean or kidney bean or string beans or snap beans or fine beans or haricot bean or snap bean or navy bean according to their location and its 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 differing varieties of French beans primarily grown for their green pods and fodder then 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 (Table 1). French beans are delicious their fresh pods and green leaves can be 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 short of 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. Care should for cutting earlier before the leaves turn much in colour. The French bean can be used as organic manure after ploughing with soil at both green and dry stages. This crop is also fixing nitrogen but less efficient than other legumes. It is also associated with several rhizobia and makes the soil healthy.

Commercial verities of beans in India

On the basis of region there are two main categories *i.e.,* hills and plains popular verities of French beans. 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),

Table 1. Nutritional value and calories in French beans and green bean raw (Amount in 100 g)

Nutrients	French Beans	Green beans (raw)
Basic Components		
Proteins	19 g	1.82 g
Water	10.76 g	-
Ash	4.29 g	-
Calories		
Total Calories	342.93 (31 calories)	-
Calories From Carbohydrates	260.87	-
Calories From Fats	16.84	-
Calories From Proteins	65.22	-
Energy	-	31 Kcal
Cholesterol	-	0 mg
Carbohydrates		
Total Carbohydrates	64.13 g	7.13 g
Dietary Fiber	25 g	3.4 g
Fats & Fatty Acids		
Total Fat	2.01 g	0.34 g
Saturated Fat	221.20 mg	-
Monounsaturated Fat	138.04 mg	-
Polyunsaturated Fat	1.2 g	-
Omega-3 Fatty Acids	0.76 g	-
Omega-6 Fatty Acids	441.85 mg	-
Vitamins		
Vitamin A	8.15 IU	690 IU
Vitamin C	4.62 mg	16.3 mg
Thiamin	0.53 mg	0.084 mg
Riboflavin	221.20 mcg	0.105 mg
Niacin	2.07 mg	0.752 mg
Pyridoxine	-	0.074 mg
Vitamin B6	401.09 mcg	-
Folate	398.91 mcg	37 Âµg
Pantothenic Acid	0.82 mg	0.094 mg
Vitamin K	-	14.4 Âµg
Minerals		
Calcium	185.87 mg	37 mg
Iron	3.42 mg	1.04 mg
Magnesium	188.04 mg	25 mg
Phosphorus	303.80 mg	38 mg
Potassium	1.30 g	209 mg
Sodium	17.93 mg	6 mg
Zinc	1.90 mg	0.24 mg
Copper	440.22 mcg	-
Manganese	1.2 mg	0.214 mg
Selenium	13.04 mcg	-

Fluoride	10.33 mcg	-
Phyto-nutrients		
Carotene-ÃŸ	-	379 Âµg
Carotene-a	-	69 Âµg
Lutein-zeaxanthin	-	640 Âµg

Source: https://fdc.nal.usda.gov/fdc-app.html#/food-details/169320/nutrients

Arka Samrudhi, Arka Anoop, Arka Suman, Deepali, Kankan Bushan, Dasara, Phule Gauri, Azad Rajmah 1, Pusa Parvati, etc. While, ICAR-Indian Institute of Vegetable Research (IIVR), Varanasi has been developed some varieties like Kashi Param, Kashi Rajhansh, Kashi Sampann, they can be grown in both hill and plain areas.

However, on the basis of growth habit of plant this crop is categorized in bush and pole types of varieties. Among the bush type, Kashi Param, Kashi Rajhansh, Kashi Sampann, Swarna Priya, VL Boni Bean-1, 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, 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 also can be grown in temperature ranging between 14 and 24 °C. Growth of plant ceases if temperature falls below 10 ^{o}C because it is highly susceptible to frost. Temperatures above 30 °C cause dropping of buds and flowers resulting in poor yield but if temperature reaches above 35 °C then bean seeds might not form. 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 can be suitable for round the year cultivation but for main season this is cultivating in December–April, basically its sowing time is July–September (rainy season crops) and December–January (dry season crop).

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 pH 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 also promotes more vegetative growth. Adding Farm Yard manure (FYM) 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 2-3 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

Seed rate of French bean is recommended for bush types varieties of 65 kg / ha, while for pole types varieties 25-30 kg / ha. However, sometime seed rate varies with seed size because bold seeded varieties (with a test weight of 350-450 g) need from 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 cm × 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 cm × 30 cm apart. The seed may be sown by dibbling, drilling and broad casting at a depth of 2.0 cm 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 but in some time 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 be 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 also is recommended such as dinitomaterial 2-3 kg/acre and sodium salt of pentachlorophenol @ 6 kg/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 and diseases 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/litre, leaf hopper can be controlled by spraying methyl demeton 25 EC or dimethoate 30 EC at 2 ml/litre 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 bean and they can be controlled by spraying captan @ 2 g/litre, blitox or difoliton @ 2g/litre Powdery mildew can be controlled spraying wettable sulphur at 2 g/litre or dust with sulphur 25 kg/ha and mosaic control by removing the affected plants and spray with systemic insecticides like imidachlorprid and monocrotophos 1.25 ml /lit. to control insect vectors. Rust disease can be controlled by dusting with sulphur @ 25 kg/ha or sulfex 2 g/litre Anthracnose can be control by removing the affected plants and pods and apply with mancozeb 2 g/litre.

Fertilizers, manuring and nitrogen fixation for healthy soil

French bean 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 (Table 2). 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. It has been appeared that 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 importance. 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_4 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.

Table 2. Nitrogen fixed by pulses (kg N/ha/year)

Pulses	Average (kg/ha)	Ranges (kg/ha)
Vicia faba	210	45-552
Pisum sativum	65	52- 77
Lupinus spp.	176	145-208
Phaseolus aureus (green gram)	202	63-342
Phaseolus vulgaris (French bean)	125	100-125
Phaseolus aureus (mung)	61	-
Cajanus cajan (pigeon pea)	224	168-280
Vigna sinensis (cowpea)	198	73-354
Canavalia ensiformis	49	-
Cicer arietinum (chickpea)	103	-
Lens culinaris (lentil)	101	88-114
Arachis hypogaea (groundnut)	124	72-124
Cyamopsis tetragonoloba (guar)	130	41-220
Calpogonium mucunoides (calapo)	202	370-450
Berseem Fahl (Single cut)	67	-
Berseem Miskawy (2nd cut)	88	-
Lupine (termis)	138	-
Broadbean	136	-
Fenugreek	105	-
Chickpea	98	-
Lentils	83	-
Groundnut	79	-
Soybean	40	-

Source: Nutman (1976); Wortmann, (2006)

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 middleclass 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. (Table 1). In some regions of the tropic's 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 obtains 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 taking 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 q/ha and for pole varieties 80-100 q/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.

Conclusions

Among the legume crops French bean an appreciating 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 for '*DAAL* and *SABJI*' in human diet. Whereas, green pods, leaves and after 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, should be promoted by farmers in large or small scale.