

Crop Management and Therapeutic Efficacy of Soybean (Glycine max) on Health

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Review Article

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ABSTRACT

Soybeans (Glycine max) are traditionally used as nutritious foods all over the world because of high protein and oil content. It is the fourth most important crop in the world as far as area harvested and production is concerned. This article illustrates the soil, water, temperature requirement, and growth of soybean along with nutritive value. Soybean is the important oilseed and one of the most important and least expensive protein, multivitamin, micronutrient, is flavone sources. Volatile compounds are flavones, various micronutrients present in soybean, their role and impact on nutritional value. The maximum credit for a healthy life in human as well as in animals goes to appropriate and well-managed nutritional ingredients available in soybean. It is easy to cultivate, requiring least water, fertilizers, and pesticides. Yield is better as compare to other legumes.

INTRODUCTION

A soybean is classified as a legume. It is self-pollinated crop belongs to family Leguminoceae sub-family Papilionoideae (fabaceae). Its scientific name is Glycine max [1]. The soybean plant is native to East Asia. Soybean has been traced to the eastern half of North China in the eleventh century B.C. Soybean is cultivated across the continents except Europe and Australia over an area of about 120 million ha. USA, Brazil, Argentina, China, Paraguay and India contribute about 90% of the total soybean production in the world. They are generally grown in a crop rotation with corn [2]. This creates a good risk management for both crops by breaking disease, insect, and weed cycles. Soybean is the fourth most important crop in the world in terms of area harvested and production. Soybean (Glycine max) is abundant source (35%–50%) of protein depending on its origin. It is a major source of

vegetarian protein in the human diet and equally useful for animal nutrition. Soybean is the most important oilseed and one of the most important and least expensive protein sources produced worldwide.

Crop management becomes more complicated as technology becomes more precise. Soybean oil is the second most widely used vegetable oil in the world, and soybean meal accounts for 70% of global protein meal consumption [3]. Soybean is one of the most planted field crops in the United States, and the second most important crop that contributes to the total crop revenue in the country.

Soybean plant cultivation

Whole cultivated soybeans constitute major parts hulls, cotyledons, hypocotyl and plumule. Cotyledon of soybean comprises 90% with the highest percentage of both protein and oil. Hull comprises 8% of cultivated soybean, whereas hypocotyl is the only 2 percent [4-10]. This composition of soybean and structure depends upon the variety, growing season, Drought, temperature, land, soil fertility, and agricultural practices.

To develop proper crop yield the understanding of the plant is necessary:

- Selection of most suitable varieties
- Seedbed preparation
- Row spacing and plant population
- Timing of planting, weed control, irrigation and harvesting

Selection of most suitable varieties

The first step to successful soybean planting and subsequent harvest is seed selection. Fungicide treatment may be desirable according to soil condition. Beans can be treated with fungicide and pesticide products. Also insecticide seed treatment is required if the field is known for insect pests.

Seedbed preparation

Soil moisture is most essential factor to germinate soybeans. Yield will be better for well-draining and loose types of soil. Ideal pH level for soil is between 6-6.8. Compost and organic matter will provide good nutrients to soybean seeds. The weather should be in a warming trend [11]. The temperature should be 50 °F. Ideal seed depth for most conditions is 1¼ to 1½ inches, but beans can be planted up to 2 inches deep in sandy soils, or in dry conditions. If planting 2 inches deep to access uniform moisture, make sure the variety has an excellent emergence score. Optimum sowing time is mid of June to end of June subject to receipt of minimum rainfall of 100 mm.

Row spacing and plant population

Seed depth mostly depends on soil type and soil conditions at the time of plantation. Ideal seed depth for most conditions is $1\frac{1}{4}$ to $1\frac{1}{2}$ inches, but beans can be planted up to 2 inches deep in sandy soils, or in dry conditions. If planting 2 inches deep to access uniform moisture, make sure the variety has an excellent emergence score.

Depth of planting influences the length of time from planting to emergence. Seedlings from deep-planted seeds have a greater depth of soil to penetrate [12]. In addition, temperatures are cooler at greater depths and growth is slower. Soybeans planted at greater depths have more difficulty breaking a crust than those planted closer to the soil surface. Never plant soybeans deeper than 2 inches 1 to $1\frac{1}{2}$ inches is better.

Timing of planting, weed control, irrigation and harvesting

Soybean should be directly sown when the soil is warm and there's no longer a chance of frost. Germination is quick, as with other bean types. Weed control is the primary concern through the early stages of plant growth. Weed may result into losses up to 70% if not controlled. They can be a big issue when they start popping up around soybean fields. As soil dries, potassium levels decline. So provide soil with potassium. Regular watering is important. Giving the plants even amounts of water is especially vital when soybeans begin to produce flowers and pods. A decreasing trend in yield in a soybean monoculture was observed as late as the fourth year of the experiment. It was also found that infection of soybeans with fungal diseases was greatest in 2020.

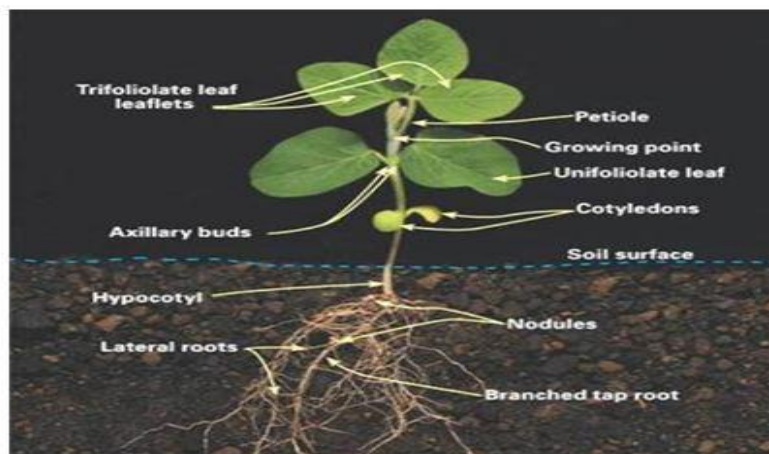
Germination

If the soil is warm enough soybeans will take about two days to germinate and grow up from the ground. If the soil is colder, it could take up to about four weeks. That is because the sprout must grow through the tougher soil. This is harder to do when the ground above them is cold and compacted.

The seed is made up of two halves called cotyledons. Between the cotyledons and attached to them is the plumule (young leaves and stem) and radicle (root). The seed absorbs moisture and the young plant begins to grow, usually emerging in 5 to 10 days after planting.

Upon germination, the radicle or primary root emerges from the seed and grows downward deeper, and is anchored in the soil. The first true leaves to appear above the cotyledons are the two unifoliolate (single) leaves [13]. These leaves have a single blade per petiole and appear on nearly opposite sides of the same point on the stem (Figure 1).

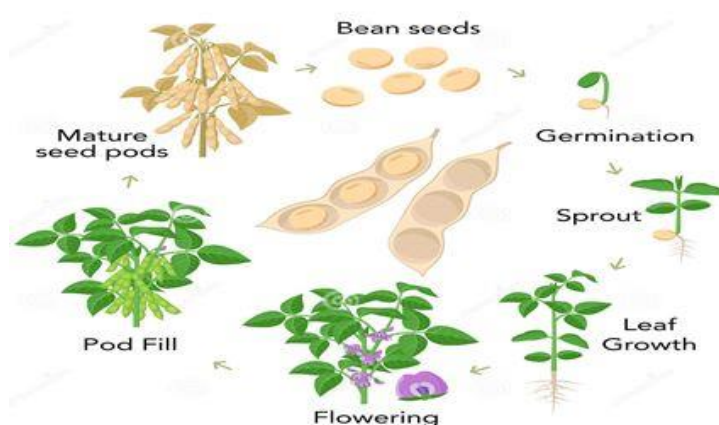
Figure 1. Soybean plant.



If a soybean plant is grown without competition from other plants, it will branch profusely and have a large number of pods per plant. If competition from other plants increases, yield decreases. The optimum plant population is different for different varieties and in different environments.

Soybeans are generally picked when immature and the beans are not yet wholly dry inside the pod. This stage is achieved 70-160 days after planting. Size is a good indicator of when it's time to pick (Figure 2).

Figure 2. Nutritive value of soybean.



Soybean is usually referred as the 'Golden Bean'. The unique chemical composition of soybean seed which includes about 20% oil and 40% protein, besides number of nutraceuticals compounds such as isoflavones, tocopherols and lecithin has made it one of the most valuable agronomic crops in the world.

A variety of soya food products are being popular and promoted.

- **Soymilk:** Soybean milk can be used in the same way as dairy milk.
- **Tofu:** It is made by coagulating the hot soya milk and used as a substitute of dairy paneer.
- **Soya Nuggets:** These are protein rich (>50%) products made of soybean.
- **Bakery Products:** Soybean can be fortified with wheat flour for making bakery products.
- **Noodles:** Noodles and vermicelli are a form of pasta and popular in India.
- **Soya Flour:** Full fat soya flour obtained by grinding whole soybeans with heat treatment/toasted to minimize enzyme action or defatted flour produced after complete removal of oil from soybeans.
- **Soya Protein:** The defatted soya flakes (after oil extraction) are the basis for different soybean products like soya flour, soya concentrate and soya protein highly digestible source of Amino Acids.
- **Substitute for pulses:** Soybean is traditionally used as pulses in Uttarakhand and as fermented food in North-Eastern region.
- **Soya Lecithin:** Lecithin is obtained from degumming of soya oil.

The legumes are valued cheap and a better alternative for meat, after cereals legumes are considered as the second most important food worldwide because they can be a good source of oil and traditional food. Soybean protein also contains well-balanced amino acid and is a good source of many essential amino acids. Along with these soybean is a good source of carbohydrate conjugates, fatty acids (soybean oil), phytoestrogens, and inorganic materials (minerals). Their nutritional value is enriched by a large quantity of unsaturated fatty acids, B vitamins, and minerals, such as nitrogen, potassium, magnesium, iron, calcium, and phosphorus. Soybeans are also a good source of Isoflavone [14]. Epidemiological and clinical investigations of postmenopausal ladies have proposed that isoflavones diminish their danger of osteoporosis and cardiovascular illnesses while reducing vasomotor symptoms. Soybean commonly available in India is one of the most nutritious pulses and practically feasible for cultivation. It has all macronutrients for better nutrition, protein, fat, carbohydrates, calcium, iron, vitamin B1, and phytoestrogens which are helpful to alleviate the menopausal problems. Soy protein is also of the highest quality. Under guidelines adopted by the Food and Drug Administration and the World Health Organization for evaluating protein quality for children and adults, soy protein isolate receives a score of 1, which is the highest possible score. This means that the quality of soy protein is equal to that of meat and milk proteins. Also soybean is available in many varieties. Soy products of wide varieties have been prepared such as roasted soybean, boiled soybean, soymilk, soy mayonnaise, miso, soy cheese, soy yogurt, tempeh, soy sauce, tamari, Textured Vegetable Protein (TVP), or Textured Soy Protein (TSP) and tofu.

Soybean oil used as cooking oil. Generally cooking oils sold as “vegetable oil” contains soybean oil. Most of the fat in soybeans is unsaturated. Polyunsaturated (primarily linoleic acid), monounsaturated (oleic acid) and saturated (primarily palmitic acid) fatty acids comprise about 63 percent, 23 percent, and 14 percent, respectively, of the total fat content of soybeans. The polyunsaturated fat content of soybeans is of interest because it includes alpha-linolenic acid (7 percent of the total fat content), an essential omega-3 fatty acid. Soybeans are one of the few good plant sources of both essential fatty acids.

Among all the mineral potassium concentration are high following magnesium, sulfur, calcium, chloride, and sodium along with other minor minerals silicon, iron, zinc, manganese, fluorine, chromium, lead, arsenic, mercury, copper, molybdenum, selenium, cobalt, cadmium and iodine.

Various aromatic compounds in soybean

These volatile compounds are made of terpenes derived from fatty acids and aromatic compounds. These volatile compounds act as signals for other organisms and for the plant itself. The main functions of these compounds are to attract pollinators, seed dispersers [15]. They also defend the plants by repelling insects or deterring colonization of pathogenic bacteria and fungi. Soybean is particularly rich in various volatiles, including alcohols, acids, esters, aldehydes, ketones, phenols, furan(one)s, pyrazines, pyrones, and sulfur-containing compounds. Many of these have been linked to the main odor qualities of soybean, namely malty, caramel-like, cooked potato-like, floral, alcoholic, sour, smoky, seasoning-like, and fruity.

Effects of nutraceuticals compound Isoflavones

Isoflavones are subgroup of flavonoids is highly potent antioxidants. Consumption of soy products has many health benefits, including protection against breast cancer, prostate cancer, menopausal symptoms, heart disease and osteoporosis. Isoflavones are produced from a branch of the general phenylpropanoid pathway biosynthesis. This pathway begins from phenylalanine. It produces flavonoid compounds in legumes and is stored as glucosyl- and malonyl-glucose conjugates. The major isoflavones in soybean are genistein, daidzein, and glycitein. They are available as 50% genistein, 40% daidzein, and 10% glycitein of total isoflavone profiles. The chemical structure of isoflavones is closely resembled to that of the primary female estrogen. Thus, isoflavones are called as “phytoestrogens”. The role of phytoestrogens present in plant is to protect from stress and to act as part of a plant’s defense mechanism. Isoflavones content in soy foods is variable among brands and preparations. Among the phytoestrogens, isoflavones and lignans are commonly used to relieve menopausal symptoms, as they are abundant in fruits, vegetables, legumes, and soy.

Vasomotor symptoms of menopause, including hot flashes, night sweats, and insomnia (as a consequence), are the essential symptoms of postmenopausal estrogen deficiency. Various study showed that soy intake reduced the incidence of hot flashes [16]. During clinical research, a randomized double-blind study in menopausal women found that the administration of 30 mg of genistein for 12 weeks reduced hot flashes by 51% (9.4–4.7/day), whereas, the placebo group experienced only a 27% reduction (9.9–7.1/day).

Studies have also pointed out that the ability of women to produce equol may be the major determinant of whether or not isoflavones can effectively reduce VMS. A systematic review and meta-analysis of RCTs assessed the efficacy of soy isoflavones and equol for alleviating menopausal symptoms (especially vasomotor symptoms) in postmenopausal women who were either equol producers or nonproducers. The result of this meta-analysis revealed a significant benefit of equol for decreasing hot flash scores. This study concluded that supplementing equol to equol nonproducers significantly lowered the incidence and/or severity of hot flashes in menopausal women. Soybean can prevent some major diseases like cancer because of isoflavones contains by soybean.

Its high nutritional value is due to unsaturated fatty acids and these unsaturated fatty acids can prevent atherosclerosis, reduction of total and Low-Density Lipoprotein (LDL) cholesterol and triacylglycerol levels in plasma, and suppression of inflammatory processes.

Soy is used for high cholesterol, high blood pressure and preventing diseases of the heart, blood vessels. It is likewise utilized for type 2 diabetes, asthma, lung function, all kind of cancers (lung cancer, endometrial cancer, prostate cancer and thyroid cancer) and additionally preventing weak bone(osteoporosis) moderating the progression of kidney diseases. Other utilize incorporates treating constipation and diarrhea, and in addition decreasing protein in the urine of individuals with kidney disease, improving memory and treating muscle soreness caused by exercise. For women soy is used to relieve breast pain, preventing breast cancer, preventing hot flashes for breast cancer, menopausal symptoms and Premenstrual Syndrome (PMS).

Soybean seed is abundant in sphingolipids, glycosylceramide. Both phospholipids and sphingolipids have convenient health effect as they both are bioactive components of soybean and the intake of sphingolipids can inhibit the development of colorectal and skin cancer, decrease plasma and liver cholesterol levels, and regulate immune cell function, whereas the consumption of phospholipids shows the reduction of serum cholesterol levels and fat accumulation in the liver of human body. The soybean meal is considered a high-value ingredient as compared to recent low glucosinolate rapeseed foodstuffs because it gives more balanced in essential amino acid contents. Digestible amino acids and protein absorption reduce by excessive feeding of soybean as it contains plant fibers and indigestible oligosaccharides that obstruct digestion enzymes and increase bacterial activity by resulting in the lower degradability of nutrients (Table 1).

Table 1. Other effects of Isoflavones.

Symptoms/Disease	Effects of isoflavens
Vasomotor	Reduction of hot flashes, night sweats, and sleep disturbances frequency; as well as depression symptoms and memory loss
Cardiovascular	Reduction of myocardial necrosis, macrophage and serum levels of TNF- α , severity of atherosclerosis, and myocardial infarctions incidence
Obesity	Reduction of serum concentration of total cholesterol, LDL, triglycerides, and HDL
Diabetes	Reduction of fasting glucose concentration, insulin resistance, and improves glycemic metabolism
Cancer	Reduces the incidence of breast, hepatocellular, lung, gastric, and ovarian cancer
Stress responses	Improves 5-HT metabolism, stabilizes MAO activity, and improves turnover ratio of 5-HIAA/5-HT

Also processed soybeans are the world’s largest source of animal protein feed. In addition, soybeans account for approximately 90% of the US’s oilseed production. These legumes are sometimes used to make fuel as an alternative to petroleum.

Addition of fermented soybean reduced the serum insulin and leptin levels, indicating the effectiveness of fermented soybean addition as an anti-diabetic feed ingredient that alleviates hyperleptinemia in rabbits. The Government of India as well as private sector should take aggressive approach and insist to increase the utilization of soybean throughout the country.

Use of soybean in animals

In dairy cow diets supplementation of soybean oil is effective in reducing saturated fatty acid and elevating the level of monounsaturated fatty acid content in milk. The feeding heat-treated soybeans instead of soybean meal or raw soybeans, favored more milk (4.5 L/d), 3.5% FCM (4.0 L/d), and milk protein (0.09 kg/d). Soybean lecithin oil further improves the weaning weight of piglets, immunoglobulin plasma level, milk and colostrums. Replacement of soybean meal in lactating sow's diets by 10%-15% fermented soybean remarkably elevates the nutrients digestibility and biological values and further enhance serum biochemical parameters along with the antioxidant activity of lactating sows and elevate the production performance of suckling piglets [17]. Revealed that even though dry matter intake and growth rate decreased by the addition of 4% soybean oil in the diet, progesterone concentration and the number of goats with functional corpus luteum increased, indicating that soybean oil inclusion in diet stimulated puberty in prepubertal goats.

Future perspectives

Soybean (*Glycine max*) is the world's most important seed legume and it contributes 25% of global edible oil. It has attracted the attention due to its nutritional value. This value is due to presence of proteins, amino acids, fat, carbohydrates, calcium, iron, vitamin B1, and phytoestrogens which are helpful to alleviate the menopausal problem and also cardiovascular, metabolic good effects. This food is popular because flavor, aroma, and overall acceptability by population all over the world [18]. This off flavor is due to the presence of various chemicals like phenols, aldehydes, ketones, furans, alcohols, and amines. Along with this, these flavor compounds interact with protein and cause the formation of new off flavors [19]. More comprehensive research is required to understand the causes for formation of off flavors, mechanisms behind formation of flavors during lipid oxidation, mechanisms of action of volatile compounds.

Obstacles in production of soybean

There are a number of constraints, pertaining to climate, production, and technology aspects as follows.

- Inadequate technological information.
- Presence of anti-nutritional factors in soybean.
- Lower use of mechanization.
- High-temperature stress
- Soil moisture stress
- Uncertainty of of monsoon affecting planting.
- Temporal variability in rainfall.

CONCLUSION

The maximum credit for a healthy life in human as well as in animals goes to appropriate and well-managed nutritional ingredients available in soybean. It is cheap, easily available and vegetable source of protein. It is cultivated all over the world except in Europe. India produces almost 90 percentage of soybean. The cultivation is easy, requiring minimum fertilizers, pesticide and water. Soybeans need three to five months from seed to harvest depending on soil condition, temperature and moisture. Besides the very high protein content, soybeans contains a lot of fibre and are rich in calcium, magnesium, copper, phosphorous like trace elements. The soy protein has a high biological value and contains some of the essential amino acids. Isoflavones in soybean has challenging effects on post-menopausal syndrome. As an alternate fuel source, soybeans can be used as a source of energy to fuel diesel engines. It should be referred as a golden bean.

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