

PRESENT STATUS, CONSTRAINTS AND STRATEGIES TO INCREASE SOYBEAN PRODUCTION IN SRI LANKA

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ABSTRACT

Soybeans [*Glycine max* (L.) Merr.] are unique among the other food legumes and which being used as a cheap source of protein with a high potential as a commercial crop in Sri Lanka. It can be classified as an oil crop due to the high oil content (15-20%). Soybean can be cultivated in dry and intermediate zone in Sri Lanka, although it is limited to the Anuradhapura and Mahaweli system H. Compared with the other legumes, soybean can be easily grown under rainfed conditions in *maha* season and in *yala* season under supplementary irrigation in the paddy fields. In 2011, extent of cultivation was 2,451 ha with 3,847 t of total production and average yield was 1.57 t/ha. Constraints to increase the soybean production was identified as biotic and abiotic constraints such as drought and temperature and social constraints including lack of organized marketing channels, non-availability of quality seeds, low consumer preference, low number of value added products and lack of high yielding varieties. Increasing the extent of cultivation and increasing the productivity are the main strategies to increase the local production of soybean. The main objectives of the soybean breeding program in Field Crops Research and Development Institute are development of varieties with yield potentials of 6 t/ha under irrigated conditions and 3 t/ha under rainfed conditions by 2015, with early to medium maturity, high seed quality, shattering tolerance, lodging tolerance, pest and disease tolerance with determinate growth pattern.

KEY WORDS: Breeding objectives, Constraints, Present status, Soybean, Strategies.

INTRODUCTION

Soybean [*Glycine max* (L.) Merr.] is unique among the other food legumes because it would be used as a cheap source of protein. It has a good potential to promote as a commercial crop in Sri Lanka. It can be processed in to a wide range of food products for human consumption, such as textured vegetable protein (TVP), soy curd (tofu), soy ice cream, soy source, soy milk and soy oil. It is widely used as a vegetable protein among Sri Lankans. Soybean contains 35.1 % of protein while the green gram and cowpea contain only 22.9 % and 21.7 % of protein, respectively. It is highly nutritious and beneficial to human health and used in production of poultry feed as a raw material in supplementing the protein. The major constituents of soybean seeds are protein and oil. Soybean oil is made up of approximately 12 to 14 % saturated fatty acids. The saturated fraction consists primarily of palmitic and stearic acids. The unsaturated fraction includes approximately 30 to 35 % Oleic acid, 45 to 55 % linoleic acid and 5 to

10% linolenic acid. The protein is moderately well balanced in the essential amino acids, but is somewhat low in methionine and cystine. Soybean protein is higher in Lysine and Tryptophan than in the common cereals. Growth of young children and animals may be slow if their diets do not contain sufficient amounts of these two amino acids (Hinson and Hartwig, 1982b). On a protein cost- per kilogram basis, the soybean is today the cheapest source of dietary protein (Judd, 1970). In addition to that, soybean can be classified as an oil crop too because of its high oil content (15-20 %). Given this background, the objective of this paper is to review the history of cultivation, present status of the industry, biotic, abiotic and social constraints of expansion production of soybean. The paper also identified the breeding objectives for soybean in Sri Lanka.

History of the soybean in Sri Lanka

Cultivation of soybean is a relatively new to Sri Lanka. However, information is available to support the idea that soybean has been growing from ancient times in Mathurata in the upcountry region of Sri Lanka (Shurtleff and Ayoyagi, 2004). In 1957, a study was carried out by the Food and Agriculture Organization (FAO) and World Health Organization (WHO) to find out the problems associated with food production, nutritional needs and calorie deficiencies of the population in Sri Lanka. The report was published and created a new awareness on the need for introducing low cost sources of protein and calories to the people. Based on the recommendations of the study, FAO started the Freedom from Hunger Campaign (FHC) in Sri Lanka in 1960's. One of the focus areas identified by FHC was the introduction of cultivation of soybean in Sri Lanka.

In 1967, soybean varietal trial and agronomic trials were started on a limited scale in the dry zone areas of the country at the Agricultural Research Station at Mahalluppallama, under the guidance of Dr. G.W.E. Fernando. This work gave a great impetus to growing interest in the cultivation of soybean and consumption of soy food in Sri Lanka. Subsequently these investigations acted as a springboard for the commencement of the UNDP-FAO International Soybean Project (INTSOY). As a result, Sri Lanka Soybean Development Program was initiated in 1975 to expedite the possibilities of utilizing soybean for food as well as for feed purposes. Therefore, it is believed that soybean was reintroduced to Sri Lanka by the INTSOY in 1975 with funding from the UNDP (Shurtleff and Ayoyagi, 2004). Until 1981's, it was executed by the FAO in collaboration with INTSOY headquartered at the University of Illinois, USA.

The objective of the INTSOY program was to improve human nutrition around the world through the expanded use of soybeans both as human and animal feed. This program was expected to address a wide range of issues related to the cultivation of soybean and its uses. This included the introduction of small – medium scale processing units for extraction of soybean oil as a viable alternative by solvent extraction method, promotion and developing new markets for soy foods and integration of soybeans into traditional diets and food recipes of Sri Lankans. In 1979, a fully equipped pilot scale processing plant for carrying out product development research and human resource development was established at Central Agricultural Research Institute at Gannoruwa (Shurtleff and Ayoyagi, 2004) with the assistance from UNDP, UNICEF and CARE.

Cultivation and present status of soybean industry in Sri Lanka

Soybean can be cultivated both in the Dry and Intermediate zones of Sri Lanka, but cultivation is limited to Anuradhapura district and System H of the Mahaweli Irrigation scheme. This crop is cultivated on a limited scale in paddy fields as well as in up lands in both *yala* (dry) and *maha* (wet) seasons. *Yala* season is the main soybean growing season and most of the farmers cultivate under supplementary irrigated conditions in paddy fields whereas in *maha*, it is cultivated under rainfed conditions in uplands. The demand for soybean in the open market is very limited and therefore, majority of farmers cultivate this crop by signing a forward sales agreement with the soybean product manufacturing industries.

In 1984, during the INTSOY project period, the cultivated extent of soybean increased to about 11,120 ha whereas in 2000 it decreased to about 694 ha. The main reason for this decline was unorganized marketing system and importation of soy based products including defatted soy flour, soy oil and soy sauce at relatively lower prices (Figure 1). However, after the year 2000, due to the expansion of the soy based product manufacturing industries, the cultivated extent had gradually increased with a few exceptions (Figure 2). As a result, in 2010 the cultivated extent increased to about 4,500 ha while production was nearly 7,521 mt (Agstat, 2011).

Constraints to increase the soybean production

Biotic constraints

Due to the scattered cultivation and comparatively very small extent cultivated the impact of biotic constraints to soybean production is relatively small in Sri Lanka.

However, pod bugs, *Nezara viridula* (Linnaeus, 1758), *Riptortus dentipes* (Fabricius, 1787) and *Anaplocnemis curvipes* F. Riptortus have been identified as important pod sucking pests. Both nymphs and adults suck the sap from the developing seeds through the pod wall. If the damage is caused in the early podding stage, a 100 % yield loss could be expected.

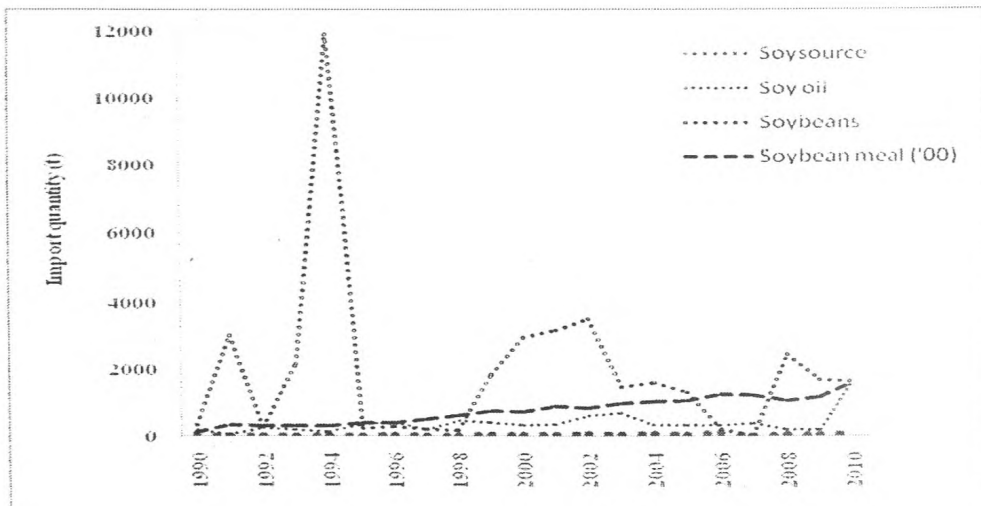


Figure 1. Imports of soybean grains, soybean meal and other soy products (1990-2010).
 Note: Please note that amount of soybean oil meal is given as '00 t.

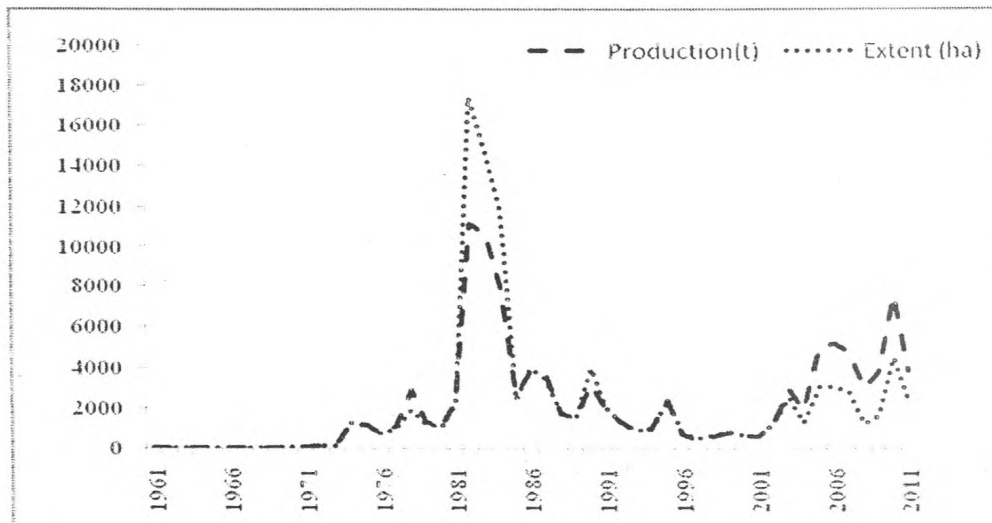


Figure 2. Extent of cultivation and production of soybean in Sri Lanka for 1961-2011

The larvae of pod borer complex (*Helicoverpa armigera* (Hübner) and *Maruca vitrata* (Fabricius 1787)) attack both the flower buds and the developing pods causing heavy yield losses. The insect pests associated with the crops at flowering and pod-filling

stages of the crop are the most destructive and can cause losses up to 35 %. The bean fly (*Ophiomyia phaseoli*) can cause damage to the crop at seedling stage.

Diseases in soybean are rarely observed. The purple seed stain, a seed born disease caused by *Cercospora kikuchii* (EMBL) is the most important seed disease. The severe infestation of *C. kikuchii* at harvesting stage of crop could lead to complete yield loss under the rainy weather (Rajapaksha *et al.*, 2003).

Abiotic constraints

Drought

In general soybean requires relatively less amount of water for cultivation than many other upland crops (Herath, 1976). Annual precipitation in Sri Lanka has not shown any significant changes during the recent decades (Fernando and Chandrapala, 1995). However, the precipitation distribution has changed with a trend for increased number of heavy rainfall events. Thus, the variability in monthly rainfall distribution has made two main cultivation seasons shorter (Costa, 2008). Since pulses including soybeans are mainly grown under rainfed conditions, the erratic rainfall during critical growth stages would not only expose the crop to moisture stress and excess water but also low fertilizer use efficiency and soil erosion affecting the productivity and quality of soybean.

High temperature

Air temperature has increased by 0.64 °C over the past 40 years and 0.97 °C over the last 72 years which revealed a trend of 0.14 °C per decade (IPCC, 2007). This trend can cause the change in insect pest population dynamics resulting in sudden pest outbreaks such as pod sucking bugs.

Social constraints

Lack of organized marketing channels

Soybean farmers encounter difficulties in marketing the produce mainly due to the facts that Sri Lanka does not have a well established marketing system for the purchase of agriculture produce. In addition the staggered cultivation of pulses has made difficult for traders to collect the produce from the farmers. In addition, for soybean there

is very little demand in the open market. Therefore, any production program should be linked with a marketing channel/organization.

Non-availability of the quality seeds

Non-availability of quality seeds is a major hindrance for the profitable cultivation of soybean due to loss of germinability within the short period of time. The main reason for loss of viability within short period of time is high oil content of soybean seed. Therefore, seeds cannot be stored for a long period (Norman, 1963). The most adaptable variety, Pb 01 losses its viability within 3-4 months after harvesting. The unsteady market also affected on low availability of quality seeds.

Low consumer preference

The consumer preference for locally produced pulses including soybean is less due to unfavourable odours and flavours as well as difficulties in processing. In Sri Lanka, among different pulses, consumer preference is more towards red and yellow lentils. This is mainly because lentils are considered a delicious curry which is easy to cook and fit well with the urban life style.

Value addition of soybean

Majority of the consumers do not prefer soybean in the boiled form compared to cowpea and mungbean as it is not so delicious. A few value added products, such as Textured Vegetable Protein (TVP), ice cream, sauce and oil are frequently available in the market. Most of those items are imported due to the limited number of soy based food manufacturing industries in the country.

Lack of high yielding varieties

The Department of Agriculture has three recommended soybean varieties for general cultivation by the farmers. But the variety Pb 01 which was introduced during early stages of the Soybean development program is still popular among local farmers and occupy 95 % of the total extent cultivated (Siriwardena, 1994). Variety PM 13 and PM 25 were locally developed and PM 13 is almost similar to the Pb 01 in many characteristics but the demand is low compared to the Pb 01. Among the recommended varieties Pb 01 matures with 80-85 days with a yield of 1,700-2,000 kg/ha. PM 13 matures in 90-95 days with a yield of 1,700-2,100 kg/ha. Variety PM 25 was withdrawn

by the Variety Release Committee (VRC) due to its low demand. In 2012, the new soybean variety MISB 01 was released for general cultivation which yields about 2,800-3,000 kg/ha.

Potentials and economic impact of soybean

Compared with the other legumes, soybean can be easily cultivated under rain-fed condition in uplands during the *maha* and in *yala* seasons under supplementary irrigation in the paddy fields. Due to the fact that there is no demand for soybean in the open market, most of the growers are willing to cultivate this crop only when a contract grower system is available. In most of these contract agreements, the marketing company supply seeds and other inputs while the grower agrees to sell the produce at a fixed price.

Compared to other food crops, the cost of cultivation of this crop is low because the low labour requirement for management (Agstat, 2011) (Table 1). Mechanization can be done easily due to synchronized maturity. Further, water requirement of this crop compared to other crops such as rice, maize, chili and onion is low and therefore, can be cultivated with minimum supplementary irrigation. Normally, average water requirement for soybean cultivation in the dry zone of Sri Lanka is 560 mm in *maha* season and 308 mm in *yala* season (Personal communication, Chamila Perera, FCRDI, 2012). The total amount of irrigation water required for a soybean crop is approximately one third that for a crop of 3 month age rice (Figure 3). The net income from an irrigated soybean crop is almost double that from rice (Herath, 1976) (Tables 1 and 2). It is therefore not too difficult to convince enterprising farmers to raise the soybean. In addition, as a leguminous plant, it fixes nitrogen and enhances the soil fertility. Therefore, Soybean can be used for intercropping and crop rotation.

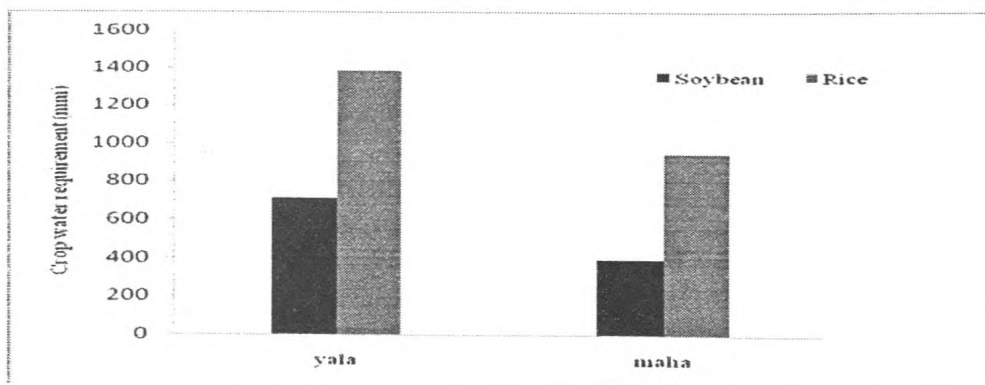


Figure 3. Crop water requirement (mm) of the soybean and rice.

Table 1. Unit costs of the main crops grow and the net return in dry zone of Sri Lanka in *maha* season 2009/10.

<i>Crop</i>	<i>Rice</i>	<i>Soybean</i>	<i>Chilli</i>	<i>Green gram</i>	<i>Maize</i>	<i>Red onion</i>
Unit cost (Rs./kg)	15.27	40.38	64.05	79.60	21.20	38.47
Net return (Rs./ha)	111,896	158,317	312,229	141,293	61,728	256,834

Soybean has a high potential as a commercial crop and it results the expansion of the food manufacturing industries and ultimately, it gives the solution for unemployment. Foreign exchange which have been spent for import the vegetable oil was Rs. 35.58 million (FAO) in 2010. In addition, TVP, sprouted bean can be used as a cheaper protein source to secure the low-income families in the rural areas who cannot bear the cost of animal protein such as meat, fish and eggs which relatively expensive than vegetable protein.

Strategies to increase the local production

It is essential to formulate the policy to restrict the importations by increasing the import price. Therefore, the industry requirement should have to be fulfilled by the local production. Increasing the extent of cultivation and increasing the productivity are important to increase the local production. The extent of cultivation can be increased by increasing the extent of cultivation utilizing lands which are not cultivated so far but could be cultivated in the dry and intermediate zones during *maha* season, and by cultivating during *yala* season with supplementary irrigation. The productivity can be increased by growing high yielding varieties, usage of quality seeds and utilization of advanced management options. Further mechanization at seeding and harvesting would reduce cost of cultivation.

Breeding objectives in developing soybean varieties in Sri Lanka

High yield

In Sri Lanka average yield of soybean is 1.57 t/ha in farmers' fields (Agstat, 2011). However the potential is 5.5 t/ha in research fields at Field Crops Research and Development Institute (FCRDI), Mahalluppallma (Annual report, 2011). Soybean varieties with yield potentials of 6 t/ha under irrigated conditions and 3t/ha under rainfed upland conditions are targeted in the breeding program of FCRDI by the year 2015. The yield of the soybean will be determined by the yield components which are seed size, number of the seeds per pod, number of nodes per plant which are governed by multiple

genes. A close relationship between leaflet shape and number of seeds per pod has been identified in Oklahoma (Hartwig and Edwards, 1970). Both characters are controlled by the same genes. Plants with oval shaped leaflets produces two to three seeds per pod where as plants with narrow leaflets has the potential of producing three to four seeds per pod.

Time of flowering and maturity period

Being a short day plant, soybean flowering occurs when the day-length becomes shorter than critical value for a specific variety. Varieties differ with respect to this critical day length. Based on the photoperiodic response, soybean varieties were classified in to 10 maturity groups, i.e. 00, 0, I to VIII (Hinson and Hartwig, 1982a). Soybean varieties which are suitable to Sri Lankan conditions belong to maturity groups V and VI. These soybean varieties flower in 30 to 40 days and mature in 90-100 days after planting. This trait is very important because soybean is mainly cultivated under rainfed conditions. Therefore, the appropriate maturity period should range from 90-100 days. However, the character of the late maturity is governed by dominant gene (S) whereas early maturity is controlled by recessive alleles (s) (Woodworth, 1923). Owen (1927) has found that maturity is linked with pubescence colour and symbols were given as (E) and (e) for character of maturity.

Seed quality

Seed colour, oil content and protein content are the important quality characteristics of soybean seeds. Soybean exhibits a great variation in seed colour and seed coat pattern. Common seed colours are yellow, green and black. Seed colour of soybean is controlled by several genes. Combinations of these genes could produce different seed coat colours. Colour of the seed is an important consideration associated with attractiveness of the soybean oil and meal. Dark coloured seed coats are associated with undesirable colour of the soybean meal which results in low consumer preference. In Sri Lanka, soybean is primarily used for manufacturing of poultry feed and prefers yellow seed coat and cotyledons

Protein content of soybean ranges from 35-50 % whereas oil content range from 15-20 %. Soybean oil meal, a high protein product is used for manufacturing different products such as margarine. Protein content of soybean generally varies inversely with the oil content of the seed (Hartwig and Edwards, 1970). As a result, selection for higher protein content in the seed will tend to develop varieties with lower oil content. The oil content of soybean greatly influenced by the soil and climatic conditions where the crop

is grown. Environmental conditions affecting the oil content affect the protein content inversely (Norman, 1963). At present, there is an enormous demand for high protein products and basically soybean is used for production of protein supplement of the poultry feed and “Thripasha” production in Sri Lanka. “Thripasha” is a cereal product producing in Sri Lanka rich in protein and carbohydrate and is recommended for children and mothers. Therefore, the main objective is to develop varieties having high protein content and low oil content.

Shattering tolerance

Shattering refers to the dehiscence of the seeds from pods before harvest which reduces the harvestable yield. Shattering is influenced by the genotype and environmental conditions at the time of maturity. When the relative humidity is low the percentage of shattering is high. Most of the genotypes shatter before seeds reach 13 % moisture. This character has a greater economic impact on yield especially when the crop is harvested manually. According to the Morse and Catter (1937), none shattering of seeds from pods is controlled by a dominant (Sh_1) and the shattering is controlled by a recessive gene (sh_1). However, Nagai (1926) and Morse and Catter (1937) found that character of the shattering pods (Sh_2) is dominant to the none shattering pods (sh_2)

Growth habit and lodging tolerance

As an annual plant, soybean has different growth habits, namely determinate, indeterminate and intermediate types. Since soybeans are harvested once, the new varieties should be determinate type which allows synchronized maturity. The stem type of a variety is governed by a single gene pair, $Dt dt$, with the indeterminate type is dominant (Woodworth, 1933). Determinate types minimize the harvesting of immature pods which affects the quality of the seeds. This character is very important for machine harvesting of the crop. Lodging is determined by the stem characteristics. Indeterminate type varieties are taller whereas determinate type varieties are shorter, and branch more heavily. The determinate type varieties are less likely to lodge than indeterminate type. Therefore, it important to develop varieties with determinates type.

Pests and Diseases tolerance

In Sri Lanka, compared to other crops no severe outbreaks of pests or diseases have been recorded in soybean. However, pod sucking bugs, *Nezara viridula*, *Riptortus dentipes* and *Anaplocnemis curvipes* are becoming destructive. The disease, purple seed

stain caused by *Cercospora kikuchii* is the most important seed disease. The severe infestation can be expected at harvesting stage, during the rainy seasons.

CONCLUSIONS

As a cheap source of protein and as an animal feed, there is a good potential to promote soybean as a commercial crop in Sri Lanka. Soybean can be easily cultivated under rainfed condition in uplands during the *maha* and in *yala* seasons, under supplementary irrigation in the paddy fields compared with the other legumes. The extent of cultivation can be increased by increasing the extent of cultivation utilizing lands which is not cultivated so far but could be cultivated in dry and intermediate zones during *maha* season and with supplementary irrigation during *yala* season in paddy fields. The productivity can be increased by application of high yielding varieties, usage of quality seeds and utilization of advanced management options.

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