

Soybean: A potential option for crop diversification

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Soybean cultivation offers a promising pathway for crop diversification in the context of climate change, contributing to environmental sustainability and food security. Being leguminous crop, it enhances soil fertility by fixing atmospheric nitrogen biologically which decreases the need for chemical fertilisers. Its relatively short growth cycle allows for easy integration into multiple cropping systems, enhancing the overall farm profitability. Soybean also requires considerably less water compared to wheat and rice crops, making it an ideal choice for regions facing water scarcity. In addition to its ecological benefits, soybean provides high value products, including edible oil and protein-rich meals for humans as well as livestock. Incorporating soybean into crop rotations helps break pest cycles, further strengthening its resilience in the cropping system. Thus, promoting soybean cultivation can significantly support sustainable agriculture and economic stability amid changing environmental conditions.

Keywords: Climate resilient, Economic stability, Farm profitability, Soil resilience

SOYBEAN known as wonder crop has become a vital oilseed crop in India owing to its versatile applications and rich protein content. It typically contains roughly 20% oil and 40–50% protein, serving as an essential component in diverse culinary items including sweets, bread, milk and pastries. Its seeds also provide essential amino acids, carbohydrates, vitamins (thiamine and riboflavin), and minerals, reinforcing the need to integrate soy into Indian diet. Oil of soybean serves as a key raw material for manufacturing *vanaspati ghee* and various industrial goods. It is also used for preparing nutritious food for children and manufacturing of pharmaceutical products. It thrives on slopes and terraces, grown both as a pure crop and intercropped with maize, *ragi* and *arhar*. Crop's productivity has surged with advanced production technologies, making it a preferred choice for farmers. It enhances soil fertility through biological nitrogen

fixation in root nodules and nutrient recycling from leaf litter. It provides highly nutritious feed for livestock and poultry, offering a valuable source of protein and energy for animal growth and health. Its higher production potential compared to other legumes makes it a key crop for addressing protein-calorie malnutrition.

Soybean, originated in China, reached India through the Himalayan routes, and is now widely grown across multiple states like Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Uttar Pradesh, and Rajasthan. Package

of practices for soybean cultivation in different regions is formulated to ensure healthy crop, which is primarily grown for its seeds, making it India's second-largest oilseed after groundnut. Significant export value, particularly for de-oiled cake (DOC), has boosted India's economy. Recently, domestic use of soybean DOC has increased, positively impacting the soybean economy. Soybean has played a crucial role in India's Yellow Revolution, with crop alone contributing ~20% to domestic vegetable oil production among nine major oilseeds. Despite



Crop diversification experimentation at the ICAR RCER Patna

Table 1. Recommended varieties for different states of India

State	Recommended variety	Maturity duration (Days)	Average yield (t/ha)
Madhya Pradesh	JS 23-03	93	2.3
	JS 22-12	90	2.1
	JS 22-16	91	2.1
	JS 23-09	92	2.1
	NRC 142 (Ahilya-6)	97	2.0
	NRC 150	91	1.8
	MACS 1520	98–120	2.2
Maharashtra	MAUS 725	92–96	2.4
	KDS 753 (Phule Kimaya)	96–97	2.5
	KDS 992 (Phule Durva)	101	2.7
Rajasthan	JS 22-12	90	2.1
	JS 23-03	93	2.3
Gujarat	GS 4	-	-
	JS 23-09	92	2.1
Uttar Pradesh	NRC 165	90	1.9
	JS 20-94	94–101	2.1
	AMSMB 5-18	100	2.0
Bihar	RSC 10-71	107	1.9
	RSC 10-52	101	2.0
	MACS 1407	104	2.1
	MACS 1460	97	2.3
	NRC 128	110	2.3
Jharkhand	Birsa Soybean-4	115–120	2.0
	RSC 11-07	107	1.7
	MACS 1460	104	2.1
	NRC 128	110	2.3
Odisha	RSC 10-52	101	2.0
	RSC 10-71	107	1.9
	MACS 1407	104	2.1
West Bengal	RMC 11-35	107	2.4
	RCS 1-9	98–105	2.5
	NRC 10-71	107	1.9
Punjab / Haryana / Delhi	SL 1074	124	1.9
	SL 1028	124	2.1
	PS 1670	122	2.3
Karnataka	DSb 34	95	2.7
	DSb 21	90–95	3.0
Telangana	ALSB 50	99	2.4
Chhattisgarh	RSC 11-07	107	1.7
	NRC 128	110	2.3

Source: ICAR-Indian Institute of Soybean Research, Indore and AICRP on Soybean

challenges, soybean continues to be an integral part of cropping systems in central India, contributing to the socio-economic upliftment of farmers and showing promising growth in other states. Remarkable journey of soybean in India

underscores its potential to drive agricultural and economic progress. It stands as a 21st century crop due to its extensive applications across food, agriculture and allied sector, and industrial sectors, including biofuels, adhesives, paints, and bioplastics.

Soil requirement

For successful soybean cultivation, well-drained, fertile loamy soil with a pH of 6.0–7.5 is ideal, as it ensures good aeration and nutrient availability. Saline or sodic soils hinder germination, while waterlogging restricts root growth and increases disease risk. Proper drainage and soil structure are essential for achieving good yields.

Climatic requirements

Soybean seeds germinate effectively when soil temperatures reach 15–20°C with optimal growth occurring between 25°C and 30°C. Crop thrives in warm, moist conditions and requires 600–650 mm of well distributed rainfall during its growth cycle. Water stress around flowering leads to significant flower and pod abortion, while excess moisture at pod maturity promotes seed discolouration and quality loss.

Land preparation

Soybean cultivation starts with deep summer ploughing, after which the field should be well levelled to ensure even moisture across plot. Forming ridges and furrows at proper intervals helps improve drainage and encourages strong root growth. Use seed drill for sowing to maintain the correct row spacing and a uniform plant stand. Apply basal fertilisers at sowing and give a light irrigation to help the seedlings establish, and avoid any waterlogging.

Time of sowing and seed rate

Sowing should preferably be carried out from mid-June to the end of June, using a recommended seed rate of 55–65 kg/ha to ensure proper crop establishment, optimum plant population, and healthy crop growth.

Spacing

Row spacing generally ranges from 30–45 cm but using broad-bed and furrow or ridge-furrow systems allow for slightly narrower spacing while providing better drainage. These planting layouts help conserve rainwater, reduce



Soybean crop under diverse cropping production system mode at ICAR RCER Patna

soil erosion, and can increase yields by 8–30% compared to flat sowing under rainfed conditions.

Method of sowing

To reduce seed-borne fungal infections, seeds of soybean should be treated with thiram or carbendazim @ 2 g/kg of seed, one day prior to sowing. Use a seed drill for line sowing, as it requires fewer seeds per hectare and facilitates convenient weeding and hoeing.

Irrigation schedule

Irrigation is not necessary for *kharif* crops. However, in summer when soybean is planted, crop requires 5–6 irrigations. To conserve water, irrigation should be applied at critical growth stages of soybean: germination, flowering, pod initiation, and seed filling, as these stages are crucial for achieving higher yields. Irrigation in soybean should be scheduled primarily according to soil-moisture status, effective rainfall and soil water-holding capacity, rather than by a fixed calendar schedule. Under moisture-deficit conditions, priority should be given to the flowering through seed-filling period, to protect reproductive growth and yield formation. Waterlogging should be strictly avoided because soybeans are highly sensitive to prolonged soil saturation.

Manures and fertilisers

For optimal soybean cultivation, application of manures and fertilisers is essential. It is recommended to apply FYM @ 10–15 t/ha to enhance the soil fertility. Nitrogen should be applied at 20–30 kg/ha to promote healthy plant growth. Phosphorus,

necessary for root development, should be applied @ 60–80 kg/ha with potassium @ 40–60 kg/ha, important for overall plant health and disease resistance.

Weeding

To achieve higher crop yields, soybean fields must be maintained weed-free until 60 days after sowing (DAS). This can be achieved by performing one or two hoeing operations along with manual hand-weeding conducted at 20 and 40 DAS. Pendimethalin @ 0.75 kg a.i./ha applied as pre-emergence and hand weeding at 40 DAS eliminates escapes, minimising competition and boosting seed yields.

Pest management

Soybean is susceptible to several defoliators, pod feeders and diseases details of which are described below.

Bihar hairy caterpillar (*Spilosoma obliqua*): Early instars scrape the chlorophyll from lower leaves, causing initial yellowing, while later instars cause extensive defoliation, leaving only leaf veins.

Cultural measures, including avoidance of pre-monsoon sowing, removing and destroying infested plant parts, along with installing light traps, help suppress initial pest populations. For chemical intervention, Spinosad 45 SC @ 125–150 mL/ha, Indoxacarb 14.5 SC @ 300–350 mL/ha and Lambda-cyhalothrin 5 EC @ 250 mL/ha are effective.

Gram pod borer (*Helicoverpa armigera*): Its larvae initially skeletonise the foliage and later feed on flowers and developing pods, causing direct yield losses. Integrated management strategies include deploying pheromone traps (5 traps/ha) for regular monitoring of pest activity. In addition, timely clipping of terminal shoots after 100 DAS along with installation of light traps helps in reducing adult moth population. Chemical management should be based on economic threshold levels, using modern insecticides such as Emamectin benzoate 5 SG @ 220–250 g/ha and Indoxacarb 14.5 SC @ 300–350 mL/ha.

Anthracnose or pod blight: This disease results in shrivelled seeds covered with mold, and irregular brown lesions on leaves, stems and pods. In advanced stages, black fungal fruiting bodies become visible.

Management includes field sanitation after harvest by removing plant residues and discarding diseased stubble, treating seeds with thiram or carbendazim @ 2 g/kg, and spraying mancozeb @ 2.5 g/L or carbendazim @ 1 g/L.



Soybean crop under diverse cropping production system mode at FSRHPR Ranchi

Charcoal rot: This disease is more severe under moisture stress, nematode infestation, soil compaction, or nutrient deficiency. Symptoms include chlorosis of lower leaves, wilting, greyish discolouration, and blackening of roots.

Management involves removing infected stubble, treating seeds with *Trichoderma viride* @ 4 g/kg, *Pseudomonas fluorescens* @ 10 g/kg, or carbendazim/thiram @ 2 g/kg, drenching infected patches with carbendazim @ 1 g/L or *Pseudomonas fluorescens*/*Trichoderma viride* @ 2.5 kg/ha mixed with 50 kg FYM.

Collar rot or sclerotia blight: This disease begins at soil line and leads to sudden yellowing, withering, and light brown lesions that later darken. Affected stems dry and often retain brown, dried leaves.

Management includes seed treatment with *Trichoderma viride* @ 4 g/kg, *Pseudomonas fluorescens* @ 10 g/kg, or carbendazim/thiram @ 2 g/kg, along with spot drenching using carbendazim @ 1 g/L or *Pseudomonas fluorescens*/*Trichoderma viride* @ 2.5 kg/ha combined with 50 kg FYM.

Frogeye leaf spot: This disease produces small, irregular to circular grey lesions with reddish-brown margins on the upper leaf surface, which may lead to premature leaf drop. Pathogen can also infect stems and pods.

Management includes removing plant residues through clean ploughing after harvest, treating seeds with thiram + carbendazim (1:1) @ 2 g/kg, and spraying mancozeb @ 2.5 g/L or carbendazim @ 1 g/L.

Harvesting and threshing

Soybean harvesting should begin when plants start shedding leaves and have ~15% or less

moisture. As maturity progresses, foliage turns yellow, drops off, and pods dry quickly. Farmers can harvest crop manually by cutting plants at ground level with a sickle or by using suitable harvesting machinery.

Threshing can be done with a mechanical soybean thresher or by traditional methods used for other pulses. It is important to handle crop gently during threshing, as excessive beating or trampling can injure seed coat and lower seed quality and viability. For mechanical threshing, recommended seed moisture content is 13–14% to ensure efficient and safe operation.

Crop yield

By following recommended package of practices for soybean cultivation, yields can reach up to 2.5–3.0 t/ha under irrigated conditions and 1.5–2.0 t/ha under rainfed conditions.

Crop diversification through soybean

Soybean can play a pivotal role in crop diversification by fitting efficiently into diverse cropping systems, including soybean–wheat, soybean–potato, soybean–mustard, soybean–summer maize, thereby enhancing land-use efficiency, resource utilisation, and farm profitability. Under rainfed conditions, soybean can also be effectively integrated as an intercrop with maize, sorghum, pigeonpea, cotton, and other compatible crops. Its short-to-medium duration, and ability to contribute biologically fixed nitrogen make soybean particularly valuable for improving overall system productivity, soil fertility, resilience while providing an additional and remunerative source of farm income.

Major constraints and their management in soybean production

Soybean production is constrained by erratic rainfall and moisture stress, poor soil fertility, weed competition, insect-pests and disease incidence, and limited availability of quality seed. These constraints can be addressed through timely sowing, suitable varieties, balanced and soil-test-based nutrient management, effective integrated weed management, integrated pest management, and use of quality seed and appropriate seed treatment with rhizobia inoculation. Adoption of integrated crop management practices is essential for stabilising soybean productivity under variable growing conditions.

SUMMARY

Soybean is a promising option for crop diversification due to its nutritional value, soil-enriching ability, suitability for inclusion in diverse cropping and intercropping systems. Successful production requires timely sowing, use of suitable varieties and seeding rates, balanced fertilisation, effective weed and pest management, and harvesting at appropriate seed moisture (15% or less). Major constraints include erratic rainfall, waterlogging or drought, weed competition, insect-pest/disease, and inadequate access to quality seed and mechanisation. With proper management and favourable growing conditions, soybean can provide an expected grain yield of 2.0–3.0 t/ha, while contributing to improved farm productivity, profitability, and sustainability.

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