

High Density - Cotton and Legume Intercropping Systems for Rainfed Areas



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Introduction

Cotton (*Gossypium spp.*) is a major fibre and cash crop in India, often called “white gold” because of its central role in the textile industry and rural livelihoods. It contributes lint for cloth, oil from seed, and protein-rich cake for livestock, linking fibre, food, and fodder within the same production system. Yet, despite having the largest area under cotton, India’s average lint yield remains below the world mean, mainly due to insect pests, diseases, erratic rainfall, nutrient imbalances, and sub-optimal crop management in many regions.

The commercialization of Bt cotton hybrids has successfully reduced damage from bollworms and increased yields, but it has not fully solved issues of low resource-use efficiency and production risk. Bt cotton is typically grown at wide row spacing (90-120 cm) and has relatively slow early growth, so a large portion of the soil surface between rows remains unoccupied during the first 40-50 days after sowing. This unused space represents a missed opportunity in conventional monocropping, especially for small and marginal farmers who need to maximize returns from limited land and inputs.

Intercropping, the practice of growing two or more crops together on the same piece of land for most of their growth period, offers a biologically sound way to make better use of these spatial and temporal niches. In cotton-based systems, component crops such as pulses, oilseeds, fodder crops, and small millets differ in canopy structure, rooting depth, growth duration, and nutrient needs, allowing them to complement rather than simply compete with cotton when carefully arranged in space and time. Short-duration legumes like greengram, blackgram, cowpea, clusterbean, soybean, and groundnut not only utilize the vacant inter-row space in the early season but also fix atmospheric nitrogen, add organic matter, and improve soil structure and biological activity. When residues are incorporated, these intercrops can enhance soil fertility and benefit subsequent crops in the rotation. A wide range of experiments across irrigated and rainfed ecologies has shown that properly designed cotton-based intercropping systems increase overall productivity and profitability compared with sole cotton. Under irrigated conditions, hybrid Bt cotton intercropped with fodder maize, fodder cowpea, summer mungbean, or long melon in 1:1 or 1:2 row ratios produced seed-cotton equivalent yields significantly higher than the sole crop, with Bt cotton + fodder maize (1:1) recording about 40–45% higher equivalent yield and almost 70% higher net returns than sole

Bt cotton. In rainfed situations, cotton intercropped with short-duration pulses such as greengram, blackgram, clusterbean, soybean, and cowpea has delivered higher land equivalent ratios and better system productivity, with only modest or no reductions in seed-cotton yield per hectare. Recent work on paired-row geometry and multi-tier systems, where Bt cotton is combined with redgram, greengram, and foxtail millet, indicates that farmers can further intensify land use and diversify income without compromising the main crop when plant population and intercrop density are optimized.

Beyond yield and income, cotton intercropping contributes to more resilient and environmentally friendly production systems. Diversified plant canopies modify the microclimate, support higher populations of natural enemies, and can reduce the incidence of key pests and diseases, thereby lowering dependence on chemical pesticides. Legume intercrops help maintain or improve soil nitrogen status and organic carbon, which is critical in many cotton soils with low fertility and declining organic matter. Intercropping with pulses and oilseeds within existing cotton area also offers a practical strategy to increase national production of protein and edible oil without expanding cultivated land, helping to address nutritional security and reduce import pressure.

However, the advantages of cotton intercropping are contingent on careful system design. Unsuitable crop combinations, excessive intercrop density, or poorly chosen planting dates can intensify competition for light, moisture, and nutrients, reducing cotton growth, boll number, and yield, as seen when vigorous fodder pearl millet or too many rows of legumes are introduced in narrow spaces. Labour requirements for sowing, weeding, and harvesting are generally higher than in sole cotton, and some farmers face difficulties in using mechanical weeders and selective herbicides in mixed stands. These constraints have limited widespread adoption in some traditional cotton belts, despite strong experimental evidence of benefits.

In this context, there is a clear need to consolidate research findings into practical, region-specific guidance for farmers and extension workers. A bulletin on cotton intercropping can play a crucial role by explaining the agronomic and ecological principles underlying successful systems; presenting proven crop combinations and planting geometries for both irrigated and rainfed conditions; summarizing impacts on yield, fibre quality, soil health, and economics; and outlining management practices that minimize competition and operational difficulties. Such a resource will help farmers to use the innate advantages of cotton's wide

spacing and slow early growth to build more productive, profitable, and sustainable cotton-based cropping systems.

Objectives

1. To enhance overall productivity and profitability of cotton cultivation through the adoption of suitable intercropping systems.
2. To improve soil fertility and nutrient availability by integrating leguminous intercrops with cotton.
3. To promote efficient utilization of natural resources such as land, water, sunlight, and nutrients.
4. To reduce pest, disease, and weed incidence through increased crop diversity in the field.

Suitable intercropping system in cotton

Intercropping system	Catogery	Row ratio	Major
Cotton + Greengram	Pulse	1:1	60-70 day crop fits early cotton window; uses early light/moisture; improves LER with pulse yield; no major seed-cotton loss at optimal density.
Cotton + Blackgram	Pulse	1:1	N-fixing legume + residue improves soil N & organic matter; higher seed-cotton equivalent yield & B:C ratio than sole cotton over time.
Cotton + Cowpea	Pulse	1:1	Fast-spreading growth shades soil, controls weeds; attracts natural enemies (reduces aphids); higher net returns with minimal cotton yield loss.
Cotton + Pigeonpea	Pulse	4-8:1	Long-duration deep-rooted pulse; provides extra grain harvest post-cotton; spreads risk & income over two crops in suitable row systems.
Cotton + Cluster bean	Pulse	1:1	Drought-tolerant legume with deep root system; fixes atmospheric N and improves soil fertility; short duration crop gives additional income without significantly affecting cotton yield.
Cotton + Soybean	Oilseed	1:1	Early vigorous growth provides good ground cover and suppresses weeds; fixes nitrogen and improves soil health; increases cotton equivalent yield and overall system profitability.
Cotton + Groundnut	Oilseed	1:1	Low-growing legume/oilseed in paired rows; 30-40% higher land productivity/income; improves N status + high-value pods.

Soil requirements for cotton intercropping

- Soil texture: Sandy loam to clay loam
- Drainage: Well-drained soil is essential (cotton and pulses are sensitive to waterlogging).
- Soil depth: Deep soil (>60 cm) preferred for good root development.
- Soil pH: 6.0–8.0 is ideal.
- Organic matter: Medium to high organic carbon improves productivity of intercrops.

These soil conditions are commonly found in cotton-growing regions of Maharashtra, Telangana, Gujarat, and Madhya Pradesh, making these intercropping systems suitable for rainfed and irrigated conditions.

Soil required for cotton intercropping system

Sr. No.	Intercropping system	Suitable soil type	Remarks
1	Cotton + Greengram	Sandy loam to loam soil, well-drained, medium fertility	Greengram grows well in light to medium soils and performs best in well-drained soils during early cotton growth.
2	Cotton + Blackgram	Loam to clay loam soil with moderate organic matter	Blackgram tolerates slightly heavier soils and improves soil nitrogen through biological fixation.
3	Cotton + Cowpea	Sandy loam to clay loam soil with good drainage	Cowpea adapts to a wide range of soils but performs better in moderately fertile soils.
4	Cotton + Pigeonpea	Deep black soil (Vertisol) or clay loam soil	Pigeonpea has a deep root system and performs well in deep, moisture-retentive soils.
5	Cotton + Cluster bean	Sandy loam to loam soil with good drainage	Clusterbean is drought tolerant and grows well in light to medium textured soils; it fixes nitrogen and improves soil fertility in cotton-based systems.
6	Cotton + Soybean	Well-drained clay loam to loam soil with moderate fertility	Soybean prefers fertile, well-drained soils and contributes nitrogen through biological fixation while providing good ground cover in early cotton growth.
7	Cotton + Groundnut	Sandy loam to light loam soil with good aeration	Groundnut prefers light soils for proper pod development and easy harvesting.

Soil preparation

Sr. No.	Intercropping system	Soil preparation
1	Cotton + Greengram	Field should be ploughed once with a mouldboard plough followed by 2–3 harrowing to obtain fine tilth. Level the field properly to conserve soil moisture. Raised beds or broad bed and furrow (BBF) system is preferred for good drainage and uniform germination of green gram.
2	Cotton + Blackgram	One deep ploughing during summer followed by 2–3 cross harrowing before sowing. Crop residues or FYM (5–10 t/ha) should be incorporated to improve soil fertility. Proper levelling ensures uniform plant population of both crops.
3	Cotton + Cowpea	Prepare the land with one deep ploughing and two harrowing to create a friable seedbed. Application of farmyard manure (8–10 t/ha) during final land preparation improves soil structure and supports rapid cowpea growth. Ridge and furrow system helps in better root development.
4	Cotton + Pigeonpea	Deep summer ploughing followed by 2–3 harrowing is recommended to break soil clods and control weeds. Broad bed and furrow system helps in moisture conservation and facilitates the growth of both deep-rooted crops. Proper row alignment is essential to maintain the 4:1 ratio.
5	Cotton + Cluster bean	Land should be prepared with one deep ploughing followed by 2–3 harrowing to obtain a well-pulverized seedbed. Incorporation of FYM (5–8 t/ha) during final land preparation improves soil fertility and moisture retention. Ridge and furrow or BBF system ensures proper drainage and uniform establishment of clusterbean.
6	Cotton + Soybean	One deep ploughing followed by 2–3 harrowing to prepare a fine and firm seedbed. Application of FYM (8–10 t/ha) during land preparation improves soil structure and nutrient availability. Broad bed and furrow system is recommended for better drainage and proper growth of soybean with cotton.
7	Cotton + Groundnut	Land should be well pulverized through one deep ploughing and 2–3 harrowing to create a loose soil structure suitable for groundnut peg penetration. Raised beds or ridges improve drainage and promote better pod formation.

Soil preparation

- Deep summer ploughing helps in breaking hardpan and controlling weeds and soil-borne pests.
- Incorporation of FYM or compost (5–10 t/ha) improves soil fertility and moisture retention.

- Broad Bed and Furrow (BBF) or Ridge and Furrow system is preferred for better drainage and intercrop management.
- Maintain proper row spacing according to the recommended row ratio to minimize competition between crops.

Sowing time and instrument used for cotton intercropping

Sr. No.	Intercropping system	Sowing time	Instrument used	Remark
1	Cotton + Greengram	Mid-June to early July (with onset of monsoon)	Seed-cum-fertilizer drill or cotton planter	Allows greengram to complete its 60–70 day life cycle before cotton canopy closure.
2	Cotton + Blackgram	Mid-June to early July	Seed drill or multi-crop planter	Ensures uniform spacing and simultaneous sowing of cotton and blackgram.
3	Cotton + Cowpea	Mid-June to early July	Seed-cum-fertilizer drill or tractor-operated planter	Cowpea establishes quickly and covers soil early.
4	Cotton + Pigeonpea	Early to mid-June	Tractor-drawn cotton planter or multi-crop planter	Wide spacing maintained for pigeonpea rows with cotton as the main crop.
5	Cotton + Cluster bean	Mid-June to early July	Seed drill, multi-crop planter, or seed-cum-fertilizer drill	Clusterbean is drought tolerant and establishes well under rainfed conditions; it improves soil fertility through nitrogen fixation.
6	Cotton + Soybean	Mid-June to early July	Seed-cum-fertilizer drill or multi-crop planter	Soybean germinates quickly and provides early ground cover, helping in weed suppression during early cotton growth.
7	Cotton + Groundnut	Mid-June to early July	Seed drill or groundnut planter	Requires proper depth placement for both crops to ensure uniform germination.

Sowing equipment's for intercropping

- Seed-cum-fertilizer drill – most common implement for sowing cotton and intercrops simultaneously.
- Multi-crop planter – suitable for maintaining specific row ratios (1:2, 3:1, 4:1).
- Cotton planter (tractor drawn) – used for precise cotton spacing in mechanized farming.
- Manual seed drill or dibbler – used in smallholder fields.

Sowing recommendations

- Sowing depth: Cotton 3-5 cm; pulses/oilseeds 2-4 cm.
- Legume sowing time: 2-3 weeks after cotton
- Seed treatment: Use fungicide or biofertilizers (Rhizobium for pulses).
- Row alignment: Maintain recommended row ratio for efficient resource use.

Intercultural operation in Cotton based intercropping system

Sr. No.	Intercropping system	Intercultural operations	Remarks
1	Cotton + Greengram	One hand weeding or intercultivation at 20-25 DAS followed by earthing-up at 35-40 DAS using a wheel hoe or tractor-operated intercultivator.	Greengram grows quickly and suppresses weeds, reducing the need for frequent weeding.
2	Cotton + Blackgram	Intercultivation with hand hoe or power weeder at 20-25 DAS and 40 DAS. Earthing-up around cotton rows after second intercultivation.	Blackgram improves soil fertility through nitrogen fixation and residue addition.
3	Cotton + Cowpea	One intercultivation at 20-25 DAS using a wheel hoe or intercultivator. Minimal later operations due to cowpea's spreading canopy which suppresses weeds.	Cowpea provides natural weed suppression and soil cover.
4	Cotton + Pigeonpea	Two intercultivations at 20 and 40 DAS followed by earthing-up. Removal of weeds between wide rows using tractor-operated cultivator.	Wide row spacing allows easy mechanical intercultivation.
5	Cotton + Cluster bean	One intercultivation at 20-25 DAS followed by another at 35-40 DAS using a wheel hoe or intercultivator. Earthing-up around cotton rows after second operation.	Clusterbean grows moderately fast and helps suppress weeds while improving soil nitrogen through biological fixation
6	Cotton + Soybean	Two intercultivations at 20-25 DAS and 40 DAS using wheel hoe or tractor-operated intercultivator, followed by earthing-up around cotton plants.	Soybean provides good ground cover during early growth, which helps reduce weed emergence.
7	Cotton + Groundnut	Light intercultivation at 15-20 DAS and again at 30 DAS using hand hoe or	Shallow cultivation is important to protect

		intercultivator. Avoid deep cultivation after pegging stage of groundnut.	groundnut pegs and pods.
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Weed Management Practices

- Deep summer ploughing to reduce weed seed population.
- Application of pre-emergence herbicide (Pendimethalin) immediately after sowing.
- Application of suitable post-emergence herbicides depending on weed type.
- One or two interculture activity at 20–25 DAS and 35–40 DAS using wheel hoe or cultivator.
- Hand weeding at early crop stages to remove escaped weeds.
- Earthing-up after intercultural activity to suppress weed growth.

Weed management in cotton intercropping

Sr. No.	Intercropping system	Pre-emergence (0-2 DAS)	Post-emergence (20-25 DAS)	Mechanical practices
1	Cotton + Greengram	Pendimethalin 1.0 kg a.i./ha	Quizalofop-ethyl 50-60 g a.i./ha (for grassy weeds)	Inter cultivation with wheel hoe at 20–25 DAS and earthing-up at 35 DAS
2	Cotton + Blackgram	Pendimethalin 1.0 kg a.i./ha	Imazethapyr 75 g a.i./ha	Two inter cultivations at 20 and 40 DAS using blade harrow
3	Cotton + Cowpea	Pendimethalin 0.75-1.0 kg a.i./ha	Generally not required; if needed quizalofop 50 g a.i./ha	One inter cultivation at 20–25 DAS
4	Cotton + Pigeonpea	Pendimethalin 1.0 kg a.i./ha	Pyrithiobac sodium 62.5 g a.i./ha	Two inter cultivations at 20 and 40 DAS using tractor cultivator
5	Cotton + Cluster bean	Pendimethalin 0.75–1.0 kg a.i./ha	Imazethapyr 70–75 g a.i./ha or Quizalofop-ethyl 50 g a.i./ha (for grassy weeds)	One intercultivation at 20–25 DAS followed by earthing-up at 35–40 DAS using wheel hoe
6	Cotton + Soybean	Pendimethalin 1.0 kg a.i./ha	Imazethapyr 75 g a.i./ha or Quizalofop-ethyl 50 g a.i./ha	Two intercultivations at 20 and 40 DAS using wheel hoe or tractor intercultivator
7	Cotton + Groundnut	Pendimethalin 1.0 kg a.i./ha or Alachlor 1.5 kg a.i./ha	Imazethapyr 75 g a.i./ha	Light inter cultivation at 20–25 DAS; avoid deep cultivation after pegging

Nutrient Management Practices

- Apply Farmyard Manure (FYM) @ 5–10 t/ha before sowing to improve soil organic matter.
- Use biofertilizers such as Azotobacter and PSB (Phosphate Solubilizing Bacteria) for better nutrient availability.
- Split application of nitrogen improves nutrient use efficiency in cotton.
- Legume intercrops like greengram, blackgram, cowpea, and pigeonpea help in biological nitrogen fixation. Apply micronutrients such as ZnSO₄ @ 25 kg/ha if soil is zinc deficient.
- Under drip irrigation, fertigation can improve fertilizer efficiency.

Nutrient management in cotton intercropping system

Sr. No.	Intercropping system	Recommended nutrient dose (kg/ha)	Nutrient management practices
1	Cotton + Greengram	Cotton: 100–120 N, 50–60 P ₂ O ₅ , 50–60 K ₂ O	Apply 75–100% RDF (90–120 N:60 P:60 K kg ha ⁻¹); reduce N by 25% due to 192–238 kg ha ⁻¹ fixed N from residues. Split N: 50% basal, 25% squaring, 25% flowering; basal P/K full. Incorporate residues at 60 DAS for soil N boost.
2	Cotton + Blackgram		Use 75% RDF (90 N:60 P:60 K kg ha ⁻¹) + biofertilizers (Azospirillum/PSB 2–5 kg ha ⁻¹). Cowpea shades soil, fixes N (150–200 kg ha ⁻¹); add FYM 5 t/ha basal. Minimal yield loss with weed control aiding uptake.
3	Cotton + Cowpea		Full RDF (120 N:60–75 P:60 K kg ha ⁻¹), split N (40% basal, 30% flowering, 30% boll); deep roots access subsoil P/K. 125% RDF optimal for long-duration; residue recycles 100–150 kg N eq.
4	Cotton + Pigeonpea		Apply about 75–90% RDF; cluster bean fixes nitrogen through nodules. Apply FYM @ 5 t/ha and split N application for cotton.
5	Cotton + Cluster bean	Cotton: 100–120 N, 50–60 P ₂ O ₅ , 50–60 K ₂ O	Apply about 75–90% RDF to cotton; soybean contributes nitrogen through biological fixation. Apply basal P and K and split N doses.
6	Cotton + Soybean	Cotton: 100–120 N, 50–60 P ₂ O ₅ , 50–60 K ₂ O; Soybean: 20–30 N, 60–80 P ₂ O ₅ , 40 K ₂ O	75–90% RDF (90–110 N:60 P:60 K kg ha ⁻¹); groundnut fixes 100–150 kg N/ha via nodules.
7	Cotton + Groundnut	Cotton: 100–120 N, 50–60 P ₂ O ₅ , 50–60 K ₂ O	

		K $\square$ O; Groundnut: 20 N, 40–60 P $\square$ O $\square$, 40 K $\square$ O	Paired rows; basal full P/K, split N. Boosts land productivity 30-40%. gypsum @ 250 kg/ha at flowering for groundnut; legume fixes nitrogen
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Integrated Pest Management for Cotton Intercropping

- Yellow sticky traps: 10–12 traps/ha for monitoring whiteflies and aphids.
- Pheromone traps: 5 traps/ha for bollworms (*Helicoverpa armigera*).
- Bird perches: 10–12 perches/ha to encourage natural predators.
- Neem-based sprays: Azadirachtin 1500 ppm @ 3–5 ml/L at early pest stage.
- Biological control: Release *Trichogramma chilonis* @ 50,000 parasitoids/ha against bollworms.

Insect and pest management in cotton intercropping

Sr. No.	Intercropping system	Major pests observed	Preventive / Cultural practices	Chemical / Biological control
1	Cotton + Greengram	Jassids, aphids, thrips, bollworms	Maintain proper plant spacing, install yellow sticky traps (10–12/ha), remove infested shoots	Spray Imidacloprid 17.8 SL @ 0.3 ml/L for sucking pests; Emamectin benzoate 5 SG @ 0.4 g/L for bollworms
2	Cotton + Blackgram	Whiteflies, jassids, thrips	Use resistant cotton varieties, maintain field sanitation, install pheromone traps (5/ha)	Thiamethoxam 25 WG @ 0.25 g/L for sucking pests; Spinosad 45 SC @ 0.3 ml/L for bollworms
3	Cotton + Cowpea	Aphids, jassids, pod borers	Cowpea acts as trap crop; regular monitoring and removal of infested plant parts	Neem oil 2–3% spray for early infestation; Chlorantraniliprole 18.5 SC @ 0.3 ml/L for borers
4	Cotton + Pigeonpea	Helicoverpa, whiteflies, aphids	Install bird perches (10/ha), pheromone traps (Helicoverpa) 5/ha	Indoxacarb 14.5 SC @ 1 ml/L or Emamectin benzoate @ 0.4 g/L
5	Cotton + Cluster bean	Aphids, jassids, pod borers	Maintain proper crop spacing, install yellow sticky traps, remove infested plant parts	Spray Neem oil 2–3%; Emamectin benzoate 5 SG @ 0.4 g/L for borers

6	Cotton + Soybean	Whiteflies, aphids, stem fly	Field sanitation, crop rotation, install yellow sticky traps	Spray Thiamethoxam 25 WG @ 0.25 g/L or Imidacloprid 17.8 SL @ 0.3 ml/L
7	Cotton + Groundnut	Thrips, aphids, leaf miner	Crop rotation, removal of alternate host weeds, balanced fertilization	Fipronil 5 SC @ 1 ml/L or Imidacloprid 0.3 ml/L

Disease Management Practices in Cotton Intercropping

- Use certified and disease-free seed. Seed treatment with Carbendazim/Thiram @ 2–3 g/ or Trichoderma viride @ 4 g/kg seed.
- Maintain proper plant spacing and field sanitation. Remove and destroy infected plant parts to prevent spread. Follow crop rotation with non-host crops.
- Apply balanced fertilization and proper irrigation to avoid disease development.

Disease management in cotton intercropping

Sr. No.	Intercropping system	Major disease observed	Causal organism	Disease management
1	Cotton + Greengram	Leaf spot, root rot	Cercospora spp., Rhizoctonia solani	Use disease-free seed; seed treatment with Carbendazim or Thiram @ 2–3 g/kg seed; spray Mancozeb 2 g/L at early infection stage
2	Cotton + Blackgram	Yellow mosaic virus, leaf spot	Begomovirus (YMV), Cercospora spp.	Use resistant varieties; control whitefly vector using Imidacloprid @ 0.3 ml/L; remove infected plants
3	Cotton + Cowpea	Powdery mildew, leaf spot	Erysiphe polygoni, Cercospora spp.	Maintain proper plant spacing; spray Wettable sulphur 2 g/L or Carbendazim 1 g/L
4	Cotton + Pigeonpea	Fusarium wilt, sterility mosaic disease	Fusarium udum, Pigeonpea sterility mosaic virus	Use resistant varieties; seed treatment with Trichoderma @ 4 g/kg seed; rogue infected plants
5	Cotton + Cluster bean	Powdery mildew, bacterial blight	Erysiphe polygoni, Xanthomonas	Use resistant varieties; seed treatment with Carbendazim @ 2 g/kg seed; spray Wettable

			<i>axonopodis</i> pv. <i>cyamopsidis</i>	sulphur 2 g/L or Copper oxychloride 2.5 g/L
6	Cotton + Soybean	Rust, bacterial pustule	<i>Phakopsora pachyrhizi</i> , <i>Xanthomonas axonopodis</i> pv. <i>glycines</i>	Use disease-free seed; crop rotation; spray Mancozeb or Hexaconazole 1–2 g/L at disease appearance
7	Cotton + Groundnut	Tikka leaf spot, rust	<i>Cercospora arachidicola</i> , <i>Puccinia arachidis</i>	Spray Mancozeb 2 g/L or Chlorothalonil 2 g/L at 10–15 day interval

Harvesting

- Harvest cotton only when bolls are fully open and dry to maintain fiber quality.
- Avoid picking during wet or rainy conditions to prevent fiber discoloration.
- Cotton is generally harvested in 3–5 pickings at 10–15 day intervals.
- Intercrops like greengram, blackgram, and cowpea mature earlier, so they are harvested first without disturbing cotton plants.
- Proper drying and cleaning of produce is essential before storage.

Harvesting of cotton intercropping system

Sr. No.	Intercropping system	Harvesting time of intercrop	Harvesting method	Harvesting of cotton
1	Cotton + Greengram	60–70 DAS when pods turn brown and mature	Harvest manually by picking mature pods or uprooting plants	Cotton bolls are picked in 3–4 pickings starting from 140–160 DAS
2	Cotton + Blackgram	65–75 DAS when most pods become black and dry	Plants are cut or uprooted and dried before threshing	Cotton harvested manually in multiple pickings as bolls open
3	Cotton + Cowpea	60–70 DAS depending on variety	Pods harvested manually at maturity	Cotton picking starts after boll bursting and continues in 3–4 pickings
4	Cotton + Pigeonpea	160–180 DAS when pods dry and turn brown	Harvest by cutting plants and threshing after drying	Cotton harvested earlier in several pickings before pigeonpea harvest
5	Cotton + Cluster bean	90–100 DAS when pods become mature and dry	Pods harvested manually or plants cut and dried before threshing	Cotton picked manually in several pickings after boll opening

6	Cotton + Soybean	95–110 DAS when pods turn yellow and leaves drop	Plants are cut or uprooted and dried before threshing	Cotton harvested in multiple pickings as bolls open
7	Cotton + Groundnut	100–110 DAS when leaves turn yellow and pods mature	Plants are uprooted and pods separated after drying	Cotton picked manually when bolls open fully

Performance of Cotton-Based Intercropping Systems with Different Legume Crops under Varying Planting Geometry (Manikandan et al., 2024)

Treatment	Height (cm)		Boll number (plant ⁻¹)		Boll weight (g)		SCY (kg ha ⁻¹)		LGY (kg ha ⁻¹)		CEY (kg ha ⁻¹)	
	GH*	GA*	GH	GA	GH	GA	GH	GA	GH	GA	GH	GA
C+ Groundnut	104	83	5.61	10.75	2.10	2.30	1297	2723	1060	1130	1824	3285
C+ Soybean	94	78	4.81	10.3	2.10	2.10	1112	2386	808	677	1538	2736
C+ Blackgram	89	99	5.01	9.53	2.06	1.90	1130	1985	510	580	1485	2388
C+ Greengram	95	88	5.24	6.79	2.06	1.80	1181	1344	610	570	1553	1692
C+ Cowpea	92	94	4.15	9.11	2.00	1.95	905	1905	1171	1042	1760	2667
C+Clusterbean	111	83	5.81	10.14	2.20	2.22	1408	2455	684	1117	1908	3272
C+ Pigeon pea	70	89	2.24	4.32	1.50	1.40	370	666	834	763	1035	1274
C+ Dolichos	91	93	4.66	6.77	2.10	1.70	1074	1266	1246	1025	1714	1791
C (0.90 X 0.10 m)	90	87	5.03	9.57	2.05	2.00	1131	2106	-	-	-	-
C(0.45 X 0.10 m)	95	83	3.45	6.59	2.00	1.90	758	1378	-	-	-	-
LSD _{0.05}	NS	NS	0.55	0.48	0.15	0.11	125	234	-	-	209	139

C-Cotton; GH: *Gossypium hirsutum*; GA: *Gossypium arboreum*; SCY-Seed cotton yield; LGY-Legume grain yield, CEY-Cotton equivalent yield

Advantages of Cotton Intercropping

1. Improved land use efficiency

Cotton-based intercropping systems enhance the efficient utilization of available resources such as land, sunlight, water, and nutrients, resulting in higher overall productivity compared to sole cropping.

2. Higher total productivity and profitability

Intercropping cotton with compatible crops increases total system yield and provides additional economic returns to farmers, thereby improving overall farm profitability.

3. Improvement in soil fertility

Inclusion of leguminous intercrops such as greengram, blackgram, and soybean improves soil fertility by fixing atmospheric nitrogen and enhancing soil organic matter content.

4. Reduction in pest and disease incidence

Cotton intercropping systems can reduce the incidence of insect pests and diseases because increased crop diversity enhances the population of natural enemies and disrupts pest colonization, thereby lowering pest abundance compared with monocropped cotton fields.

5. Better weed suppression

Cotton-based intercropping systems can effectively suppress weed growth because intercrops provide better ground cover and increase competition against weeds for light, nutrients, and moisture, thereby reducing weed density and biomass compared with sole cotton cultivation.

6. Risk reduction and income stability

Cotton intercropping reduces the risk of total crop failure because farmers obtain yields from both the main crop and intercrop, ensuring more stable income.

Conclusion

High density cotton and legume based intercropping systems are an effective approach to improve land productivity, resource-use efficiency, and farm profitability of rainfed areas. Cultivation of either hirsutum or arboreum cotton short-duration crops along with the legumes such as greengram, blackgram, cowpea, cluster bean, soybean, and groundnut help in better utilization of space, light, nutrients, and soil moisture during the early growth stages of cotton. Legume intercrops also enhance soil fertility through biological nitrogen fixation and improve soil health. In addition, intercropping helps suppress weeds and reduce pest and disease incidence, thereby lowering dependence on chemical inputs. Adoption of appropriate management practices including balanced nutrient application, timely weed control, and integrated pest and disease management is essential for achieving higher productivity. Therefore, cotton-based intercropping systems can serve as a sustainable and profitable production strategy for farmers, particularly under rainfed conditions.



Cotton + Greengram



Cotton + Blackgram



Cotton + Cowpea



Cotton + Soybean



Cotton + Cluster bean



Cotton + Groundnut

Figure 1. Efficient cotton legume intercropping systems for rainfed areas



Figure 2. High Density Cotton with Legume Intercropping

