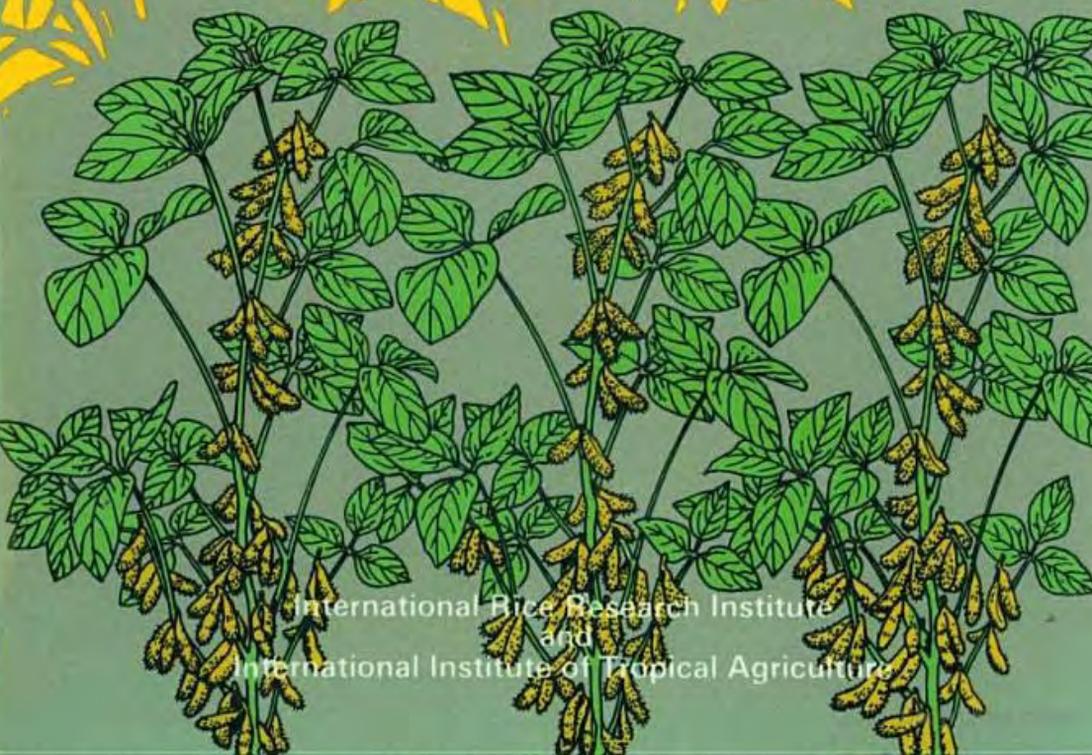


# A FARMER'S PRIMER ON GROWING SOYBEAN ON RICELAND

R.K. Pandey



International Rice Research Institute

308

International Institute of Tropical Agriculture

**A FARMER'S PRIMER  
ON GROWING  
SOYBEAN  
ON RICELAND**

R.K. Pandey

**International Rice Research Institute  
and  
International Institute of Tropical Agriculture**

**1987**

International Rice Research Institute  
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# Foreword

Soybean is a high-value crop in temperate zones where, with appropriate inputs, it is grown on a large scale. But soybean has been little exploited in the tropics because of constraints such as seed viability, free nodulation, and seed shattering. Other impediments are the lack of processing facilities and poor marketing structures.

Yet soybean has great potential — even for small farmers with limited resources — to fit into the rice-based cropping systems that dominate so much of the agricultural area in the tropics.

A soybean crop generates farm income in the off-season after the rice harvest. It enriches the soil and helps break the pest and disease cycle associated with continuous rice cropping. Nutritionally, soybean makes an excellent protein complement to the largely carbohydrate diets of farm families. Its unusually high oil content also puts soybean in demand both as a source of edible oil and as a raw material for the food and feed industries.

Soybean responds markedly — even dramatically — to its environment. To realize the full yield potential of soybean, farmers must know how the plant grows, what its critical growth stages are, and how to prevent stress at each stage. Although a large volume of literature is available on soybean farming in temperate zones, little has been published on growing soybean in the tropics. The International Institute of Tropical Agriculture (IITA) has recently developed soybean lines that combine seed longevity, free nodulation, and non-shattering with superior agronomic characters suitable for tropical agriculture.

*A Farmer's Primer on Growing Soybean on Rice Land* is intended specifically for farmers in the tropics whose productivity and income could be significantly increased by raising soybean.

Patterned after *A Farmer's Primer on Growing Rice*, which had been published in 33 languages by mid-1987, this Primer is designed for inexpensive copublication in developing countries. The English text has been blocked off from the line drawings. The International Rice Research Institute (IRRI) makes complimentary sets of the illustrations available to cooperators, who may translate, strip text onto the prints, and print translated editions on local presses.

This soybean Primer was made possible through a collaborative project sponsored by IRRI and IITA. A companion volume is *A Farmer's Primer on Growing Cowpea on Rice Land*.

Ms. Vrinda Kumble of Editorial Consultants Services, New Delhi, India, edited both the soybean and cowpea Primers. The illustrations were drawn by John Figarola, senior illustrator, IRRI Communication and Publications Department; and free-lance artists Joseph Figarola and Oscar Figuracion.

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Director General  
International Institute  
of Tropical Agriculture



# The soybean crop

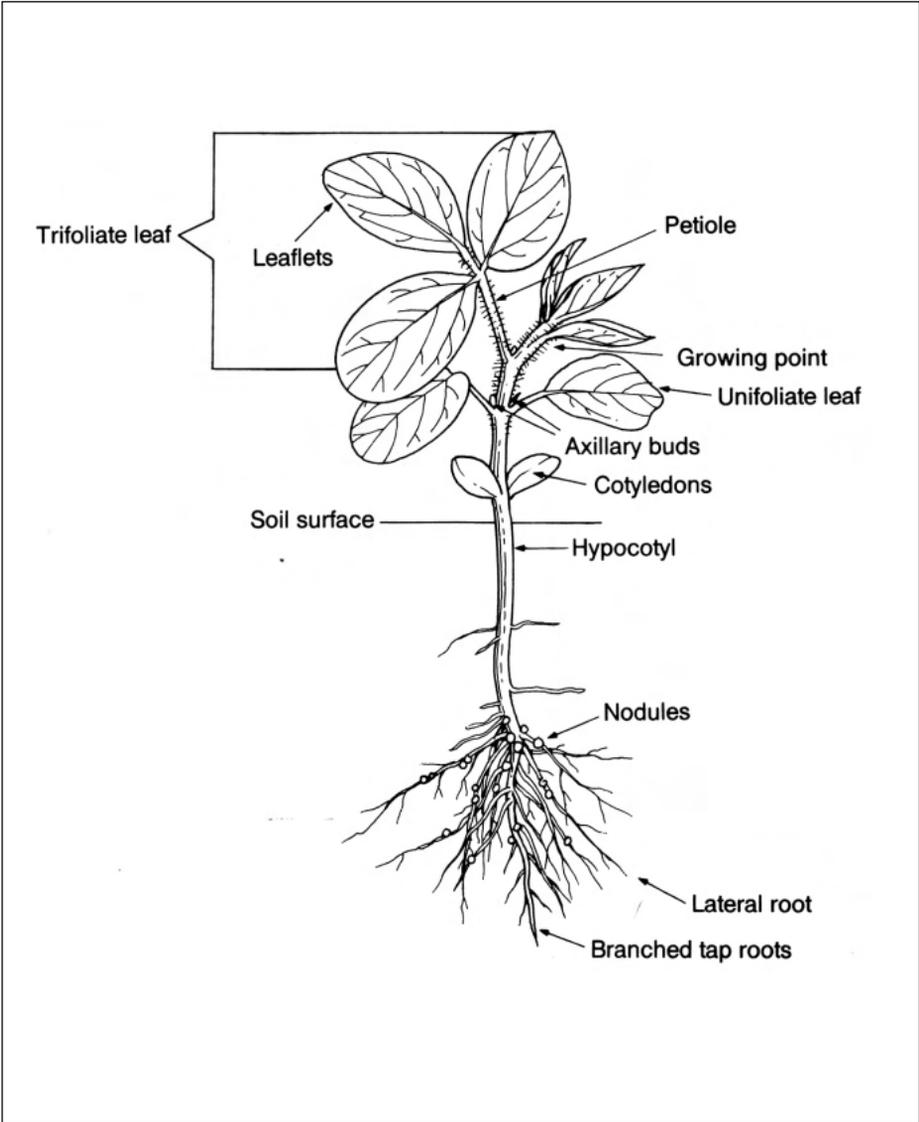


# The soybean crop

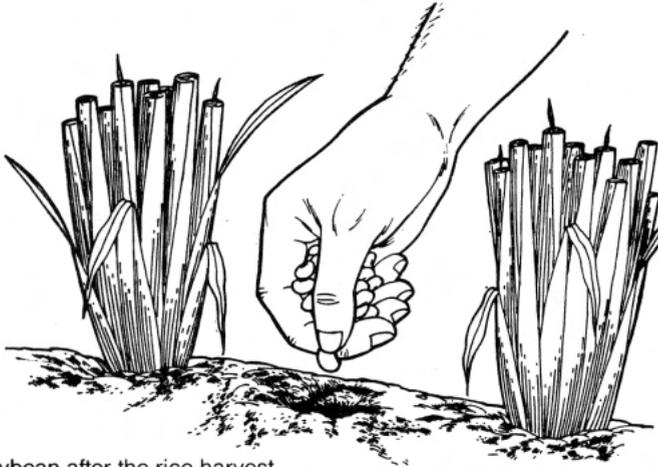
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# The soybean plant



# Why grow soybean

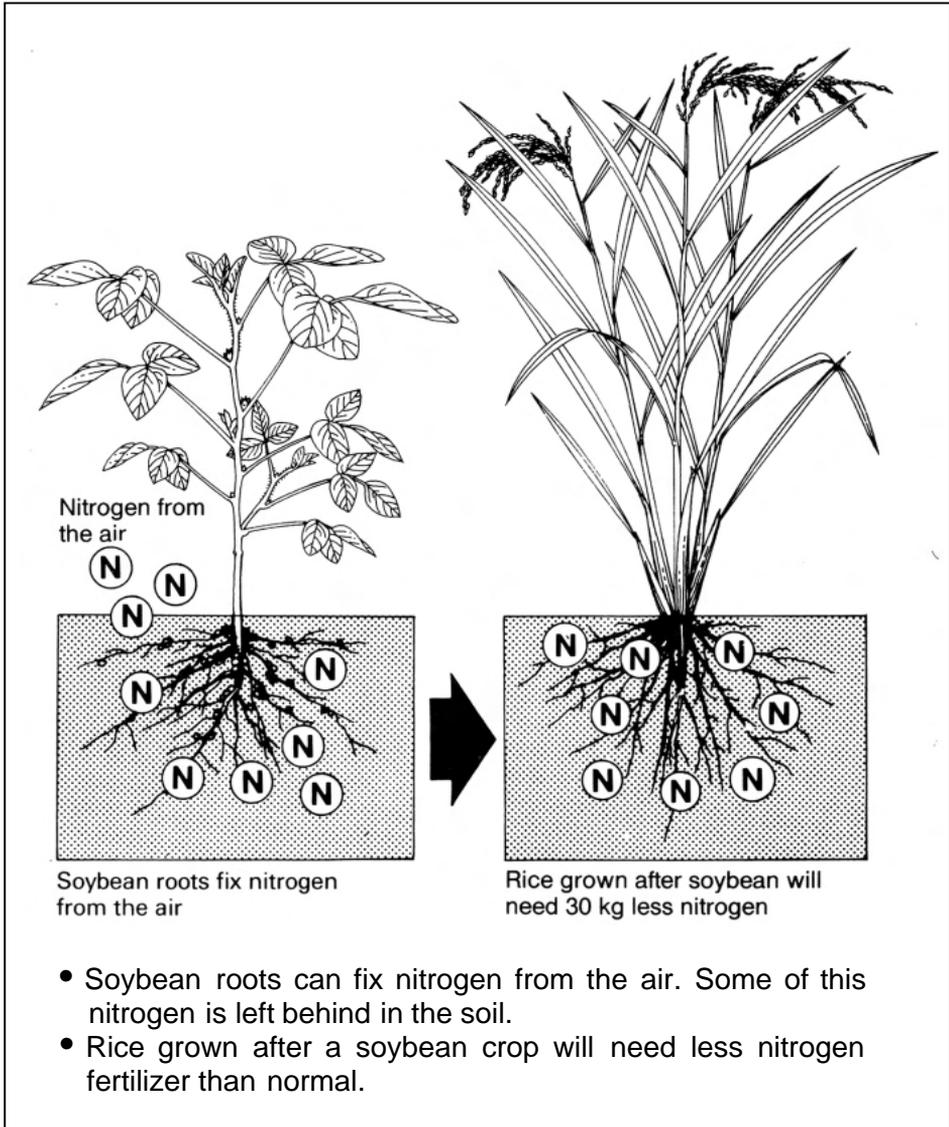


Planting soybean after the rice harvest



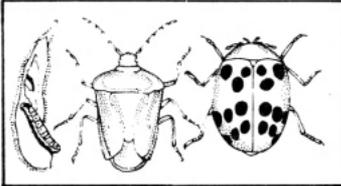
- Soybean is an annual legume crop that can be easily grown on riceland after the harvest of rice.
- With good management it can give high yields and profits.

# Soybean enriches the soil

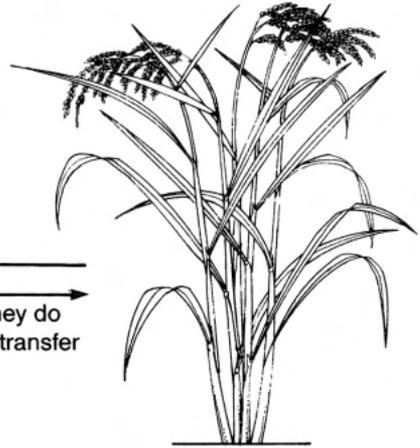
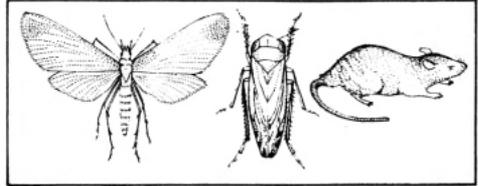


# Breaks the pest and disease cycle

Most soybean pests and diseases



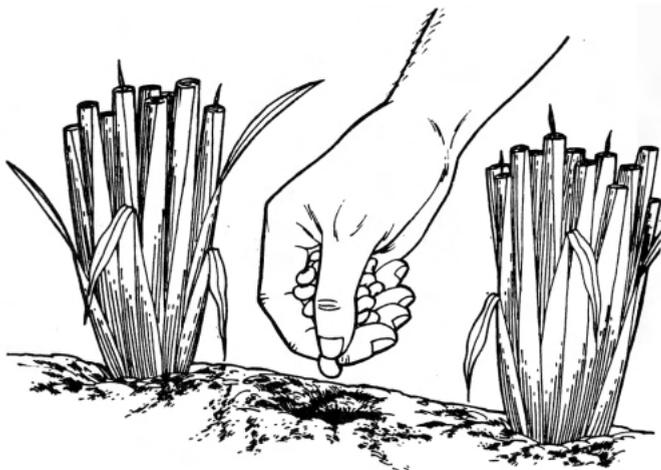
Most rice pests and diseases



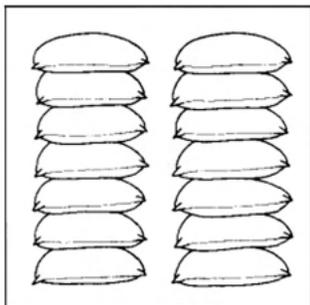
←  
→  
They do  
not transfer

- Growing soybean in rotation with rice reduces pests and diseases on both crops because
  - most soybean pests and diseases do not transfer to rice;
  - most rice pests and diseases do not transfer to soybean.

# Adds to income



Planting soybean after the rice harvest



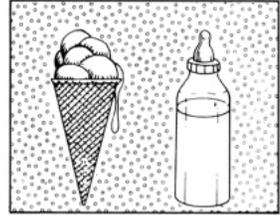
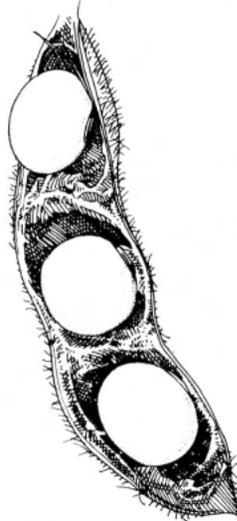
Adds to income

- Growing soybean can provide jobs in the off season after the rice harvest and add to farm incomes.

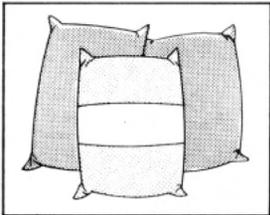
# Soybean is a nutritious food



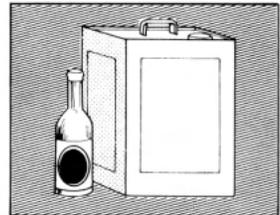
Soy sauce



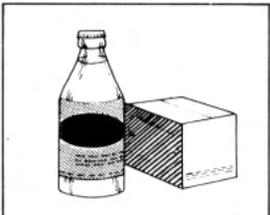
Ice cream and soy milk



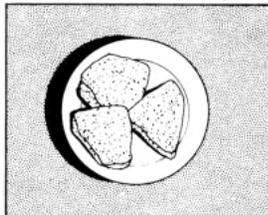
Soybean flour



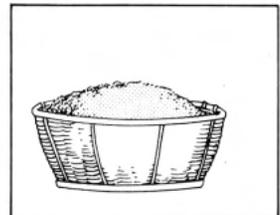
Soya oil



Soy paste used as a flavoring



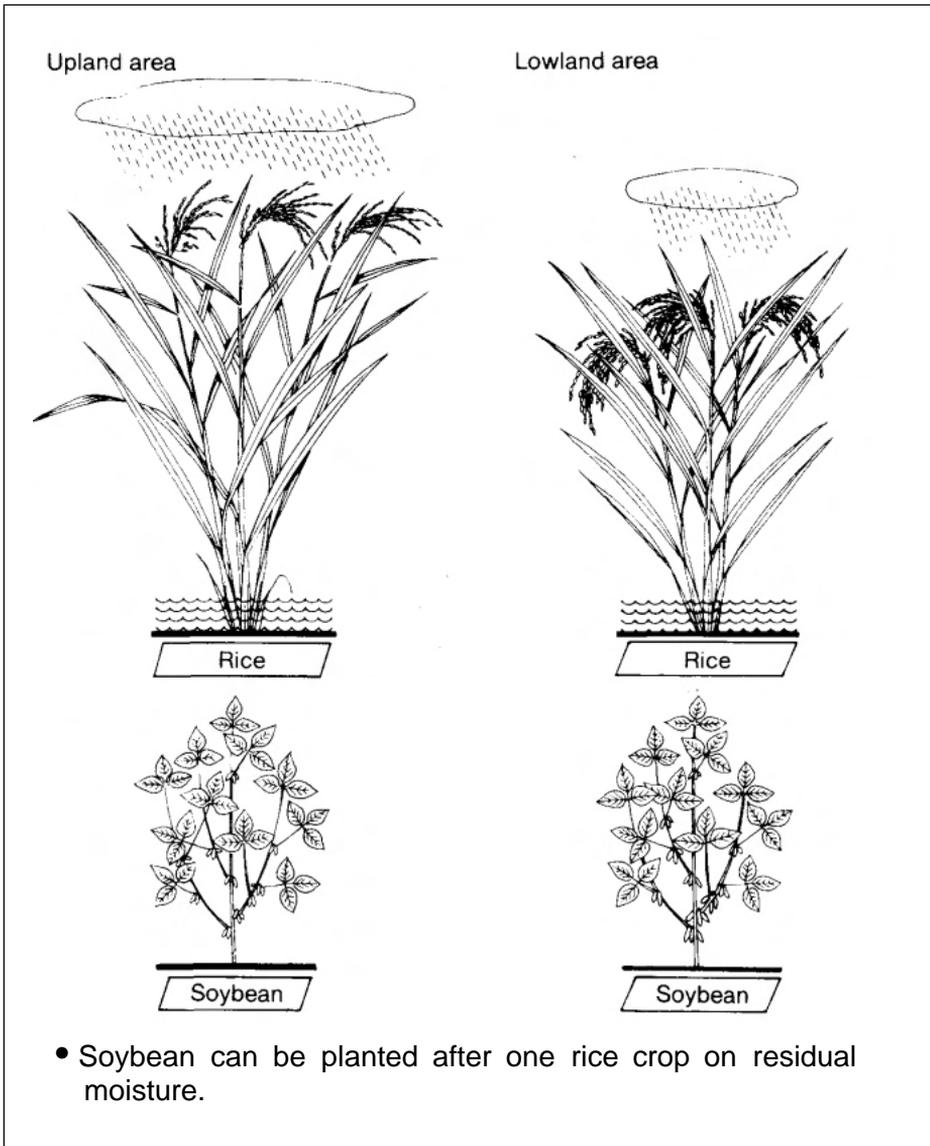
Dishes like "tofu"



Soybean meal

- Soybean is high in protein and is used for making many tasty and wholesome foods.
- Oil from soybean can be used as a cooking oil. It also has many industrial uses.

# When to grow soybean



# When to grow soybean

Irrigated land



June

Rice



October

Rice

90-day variety

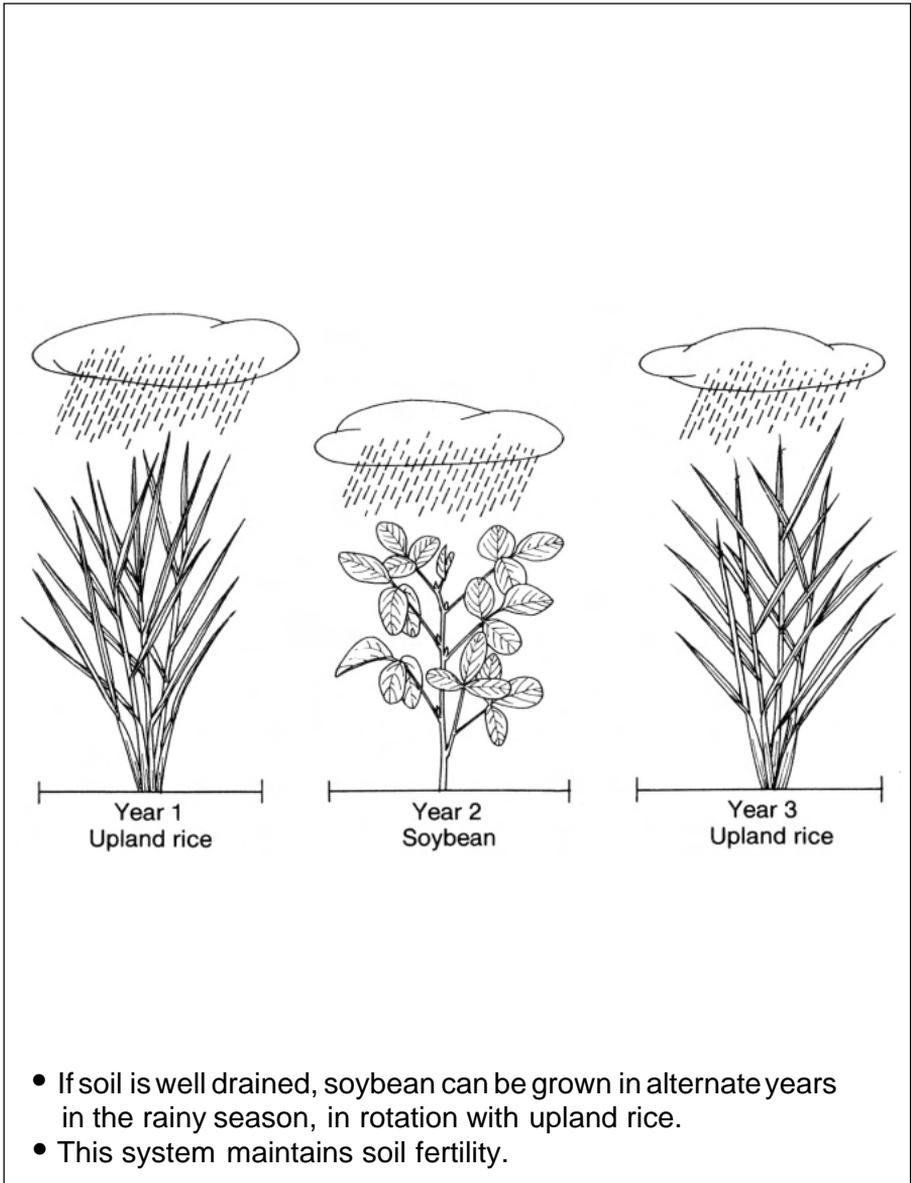


Feb-May

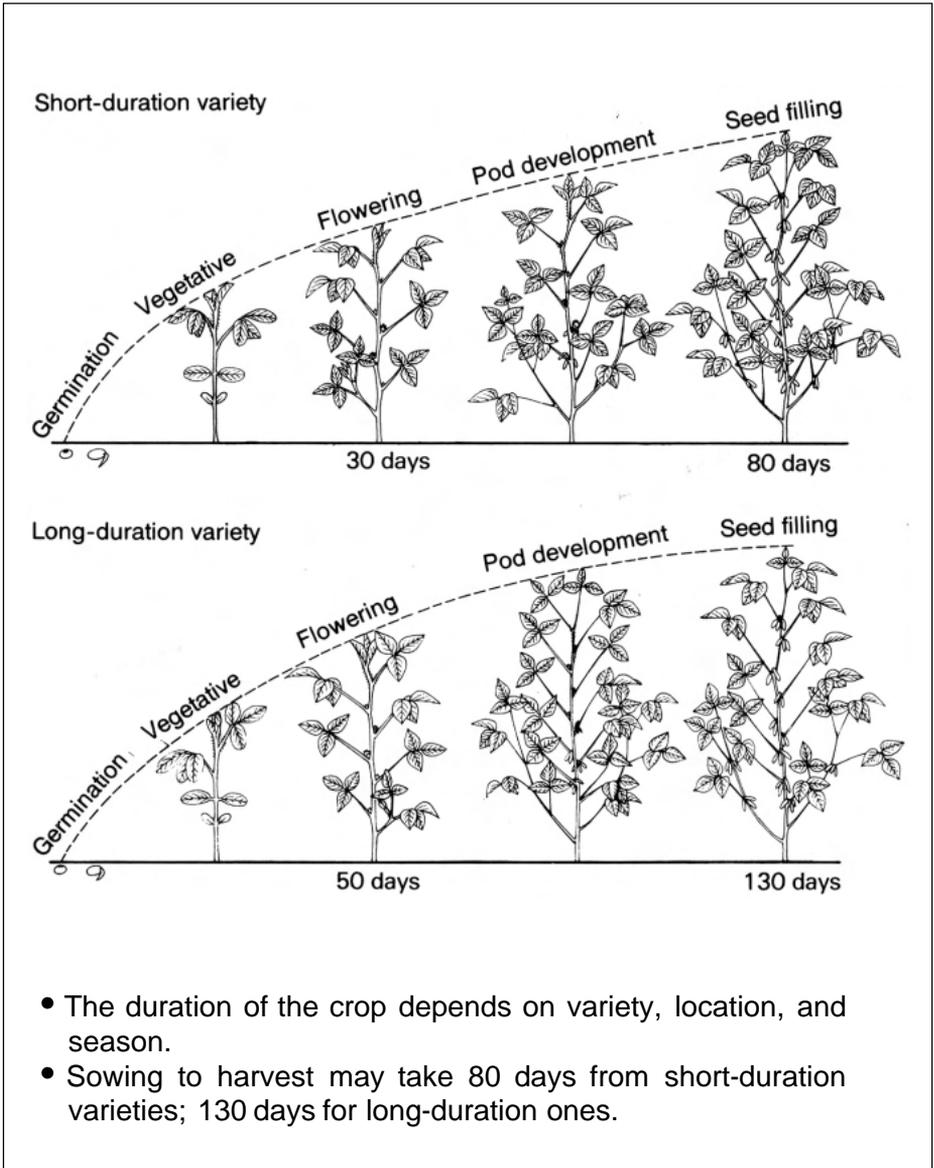
Soybean

- Short-duration varieties can be planted after two rice crops on irrigated land.
- Yields are high when the crop is irrigated.

# When to grow soybean



# Duration of the crop



# The seed

The soybean seed **17**

Parts of the seed **18**

Germination **19**

Conditions needed for germination — water **20**

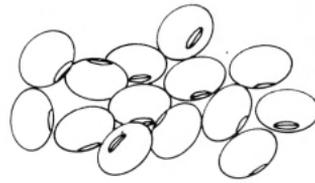
Conditions needed for germination — air and warmth **21**

Conditions needed for germination — seed quality **22**



# The soybean seed

Seeds vary in size, shape, and color



Large seeded  
(25 g per 100 seeds)



Black



Brown

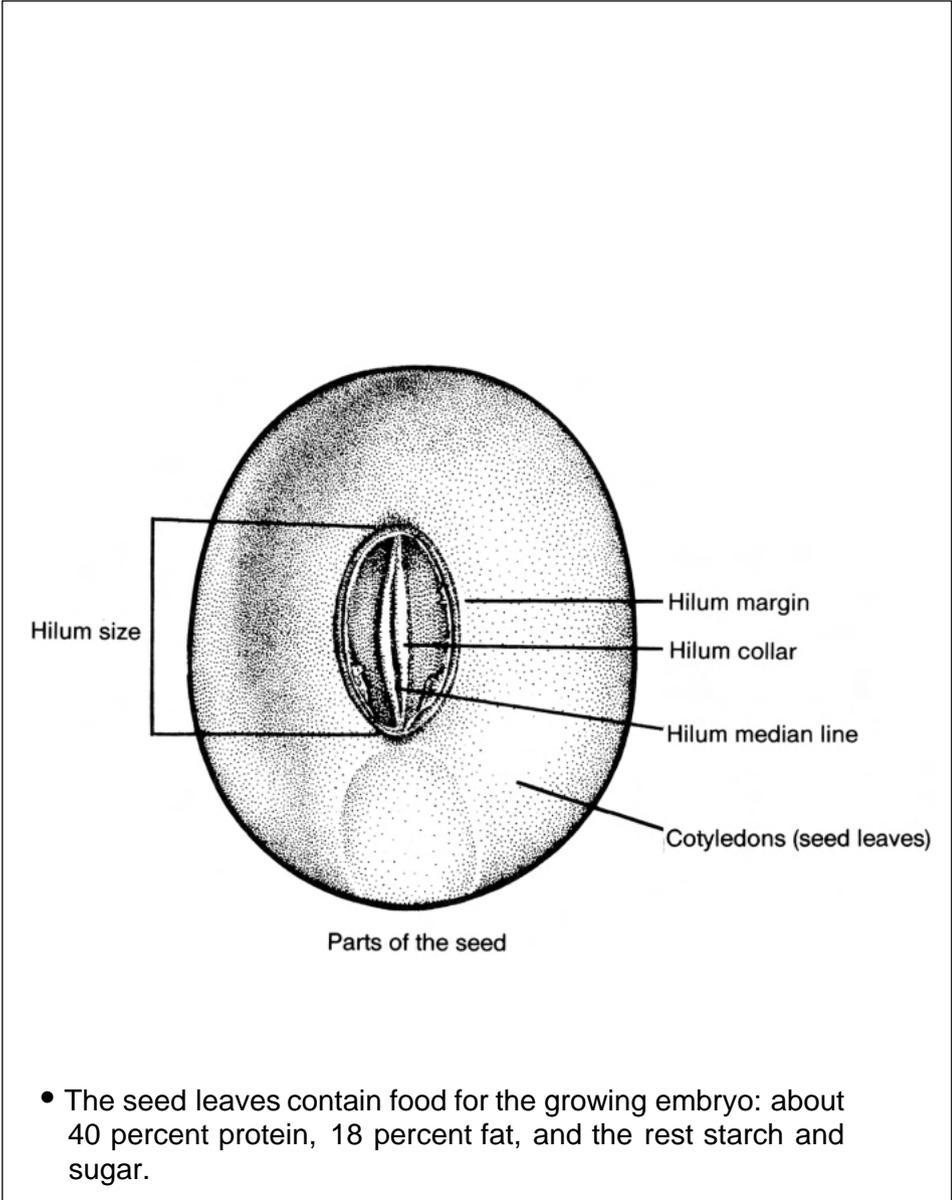


Cream

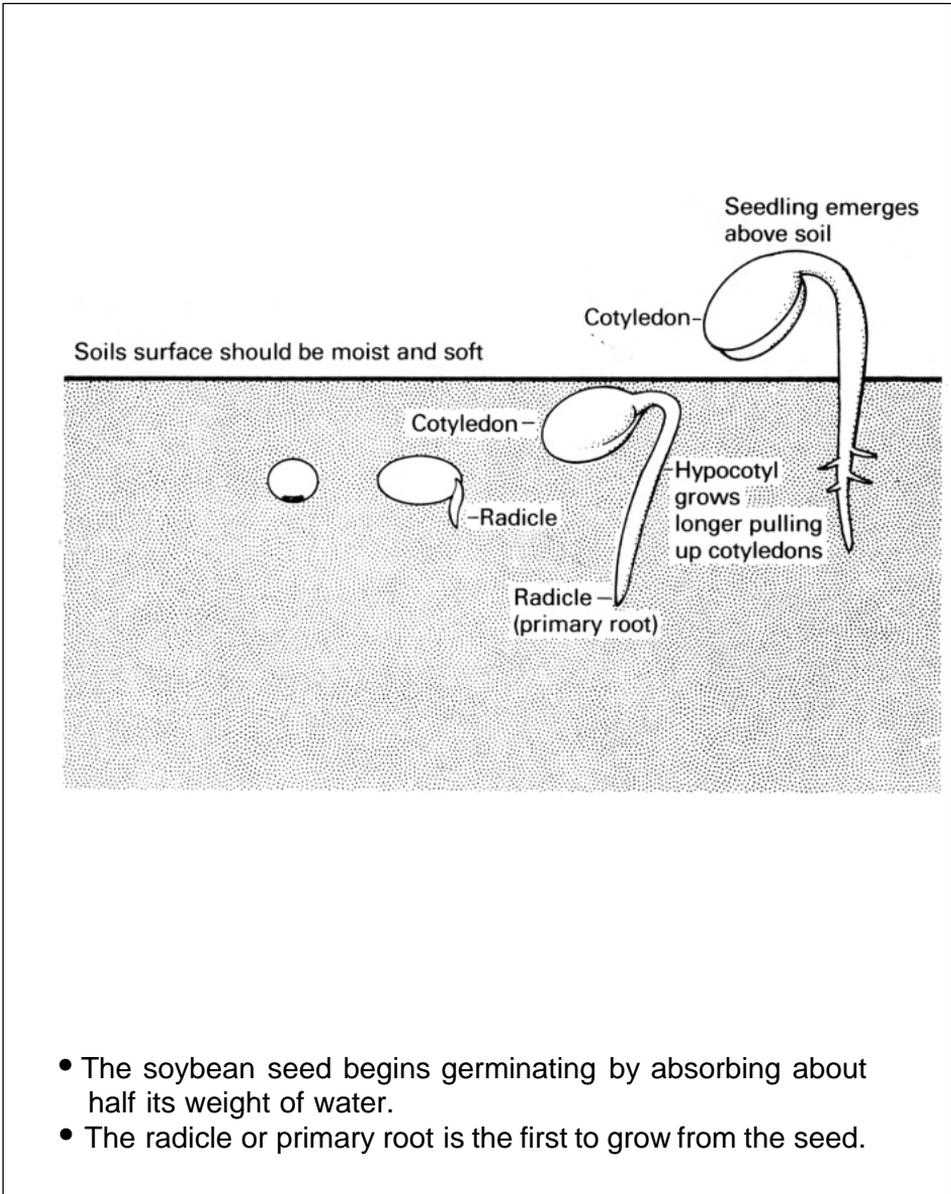


- Soybean seeds vary in size and shape.
- Color may be white, cream, yellow, green, brown, or black.

# Parts of the seed

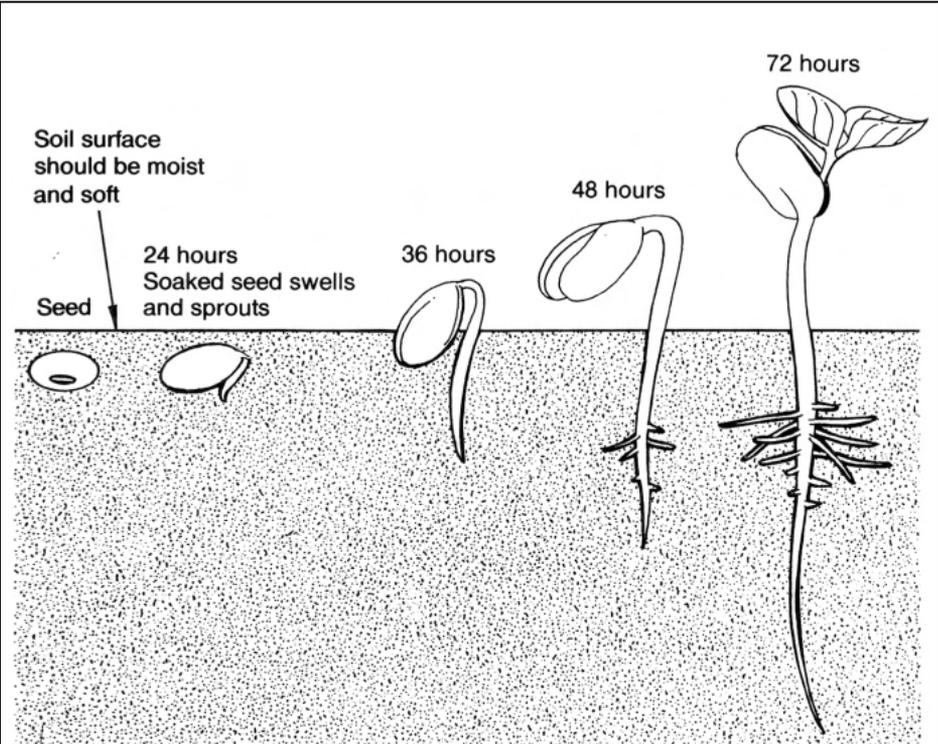


# Germination



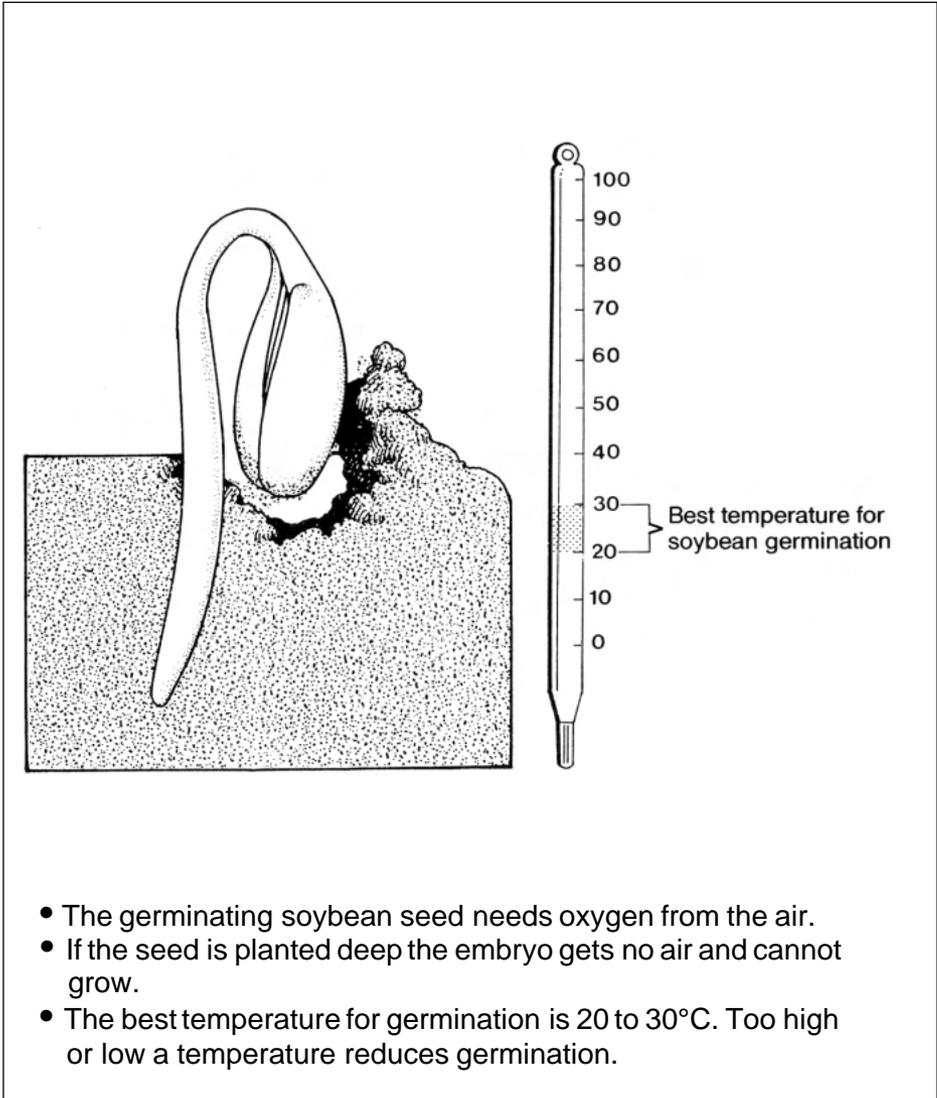
- The soybean seed begins germinating by absorbing about half its weight of water.
- The radicle or primary root is the first to grow from the seed.

# Conditions needed for germination — water



- Water is the first need of a seed for germination.
- Many activities go on inside the germinating seed. Starch, proteins, and fats stored in the seed are changed into simple foods for the growing embryo.

# Conditions needed for germination — air and warmth



- The germinating soybean seed needs oxygen from the air.
- If the seed is planted deep the embryo gets no air and cannot grow.
- The best temperature for germination is 20 to 30°C. Too high or low a temperature reduces germination.

# Conditions needed for germination — seed quality

Mixed sizes

Uniform size

Cracked seed coat

Weed seed

Mold

Pest

Poor

Good

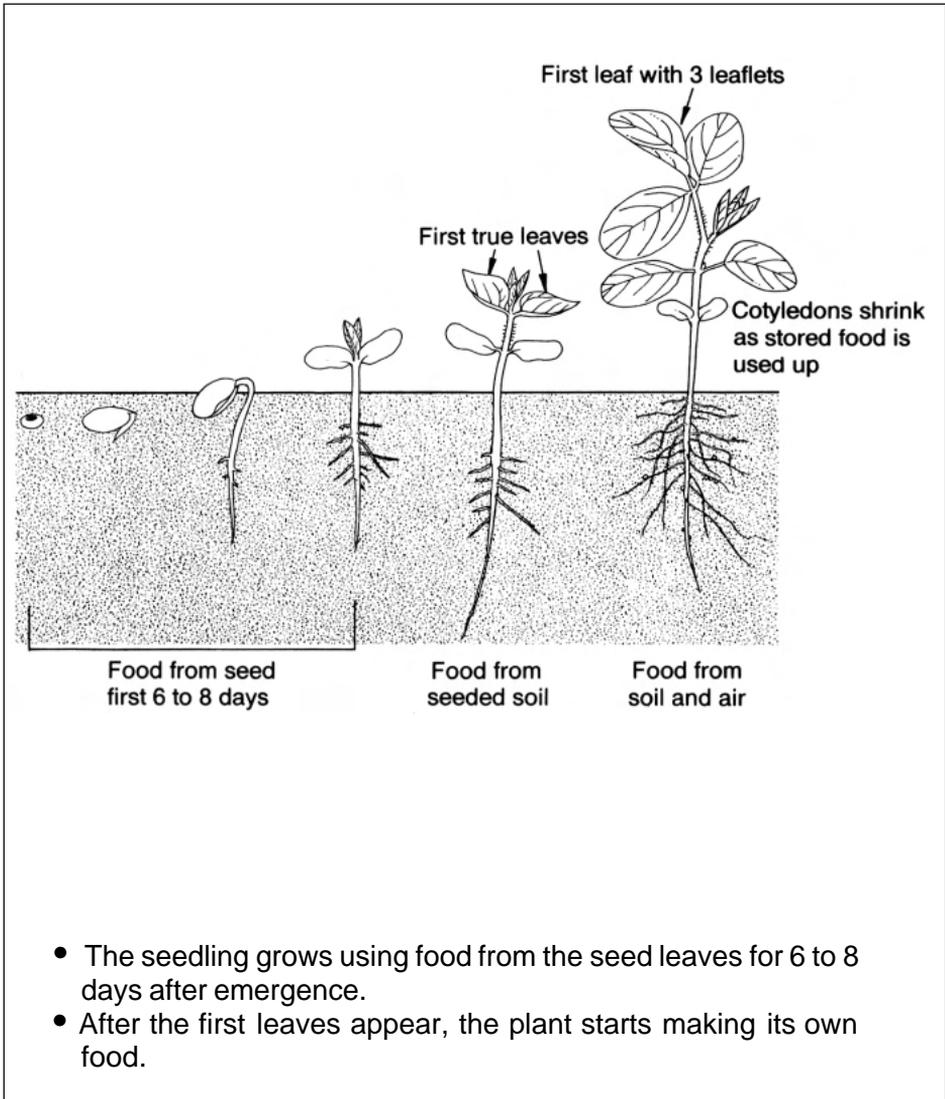
- For good germination and plant stand, seed planted should be clean and free of pests and diseases.
- Seed for planting should be stored no more than 4 months unless it is kept in cold storage.
- Seed for planting should have more than 70% germination.

# Seedling growth

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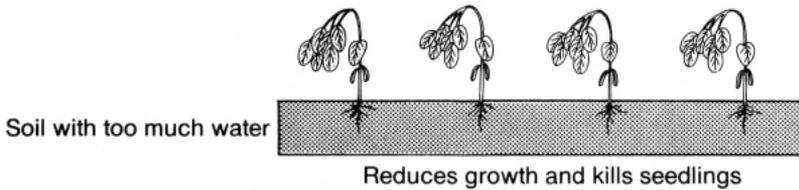
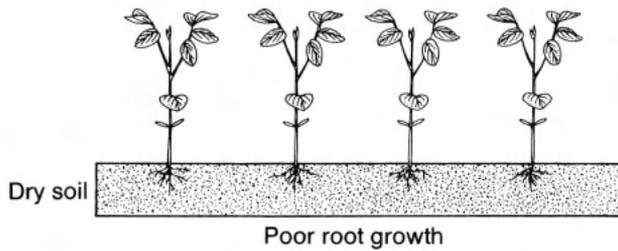
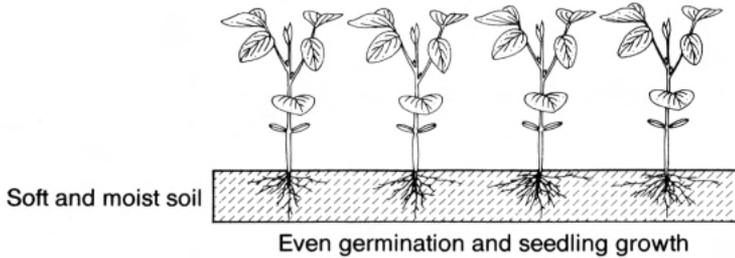


# Seedling growth



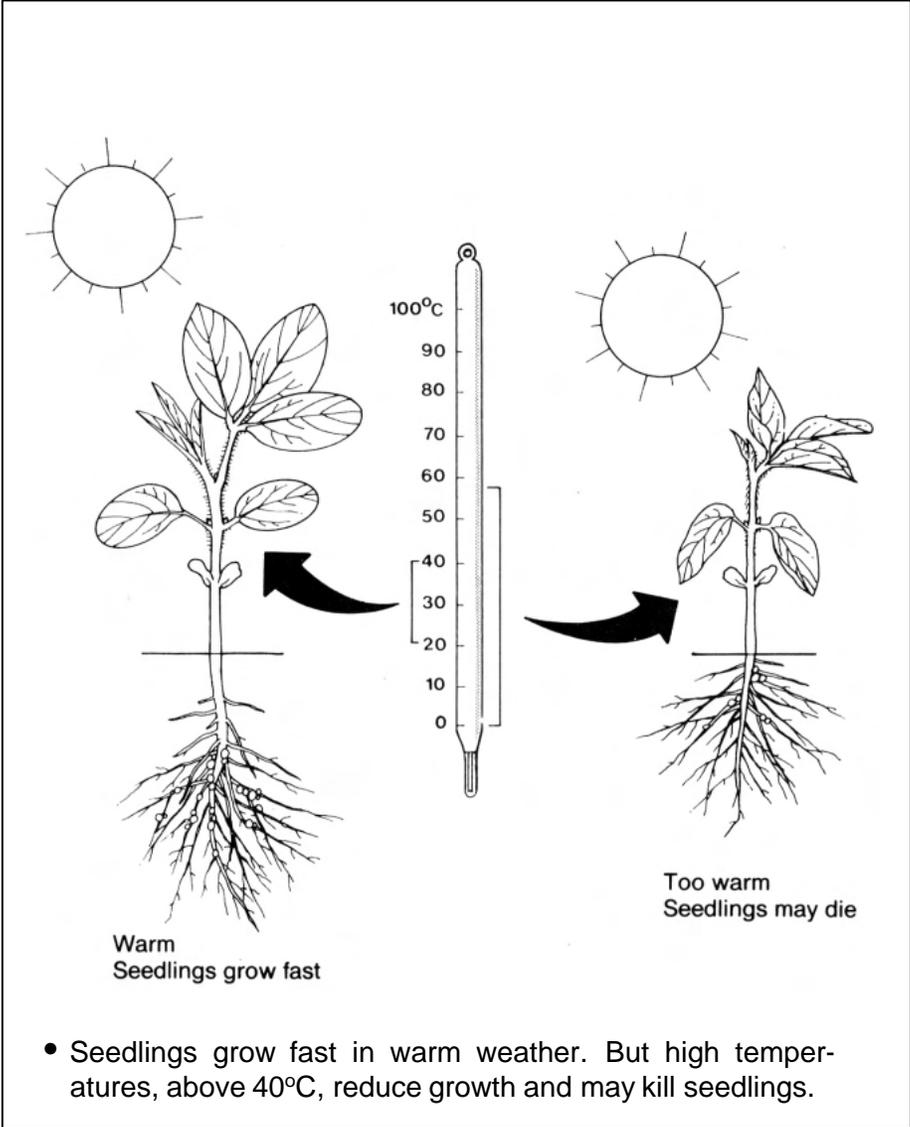
- The seedling grows using food from the seed leaves for 6 to 8 days after emergence.
- After the first leaves appear, the plant starts making its own food.

# Factors affecting seedling growth — water

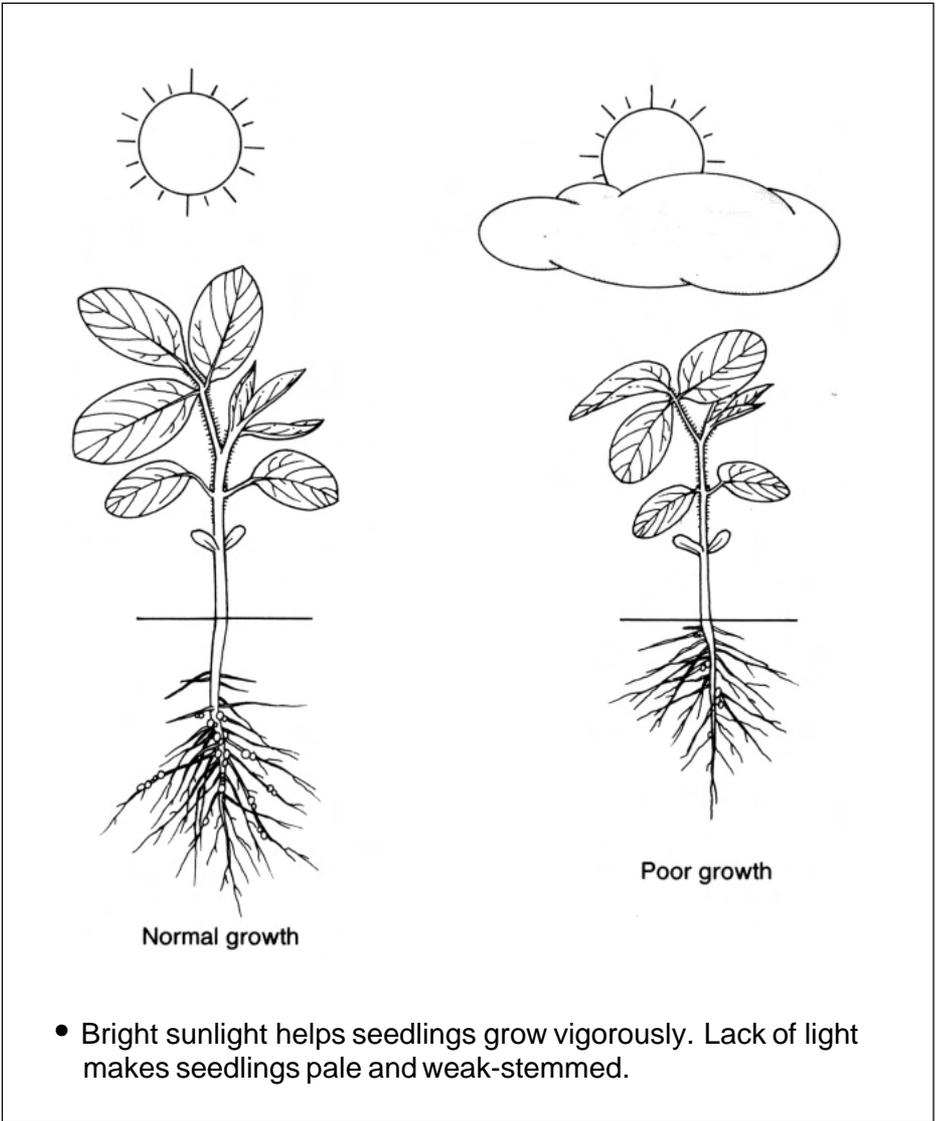


- Soil moisture is essential for even germination and seedling growth.
- Roots grow poorly in dry soil and cannot absorb nutrients for the plant.
- Too much water also reduces growth and may kill seedlings.

# Factors affecting seedling growth — temperature

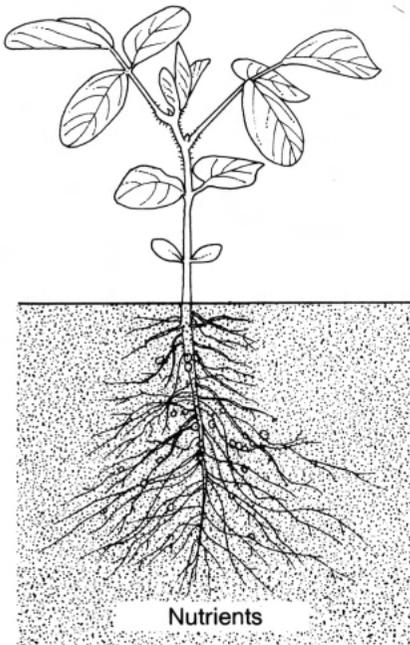


# Factors affecting seedling growth — light intensity



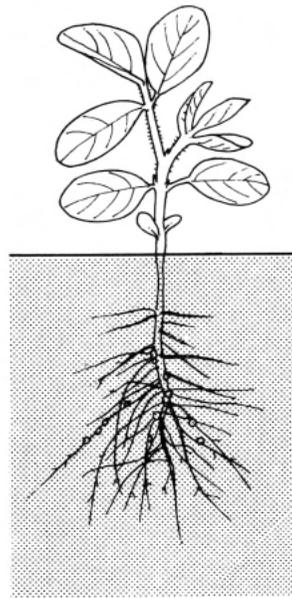
- Bright sunlight helps seedlings grow vigorously. Lack of light makes seedlings pale and weak-stemmed.

# Factors affecting seedling growth — nutrients



Nutrients

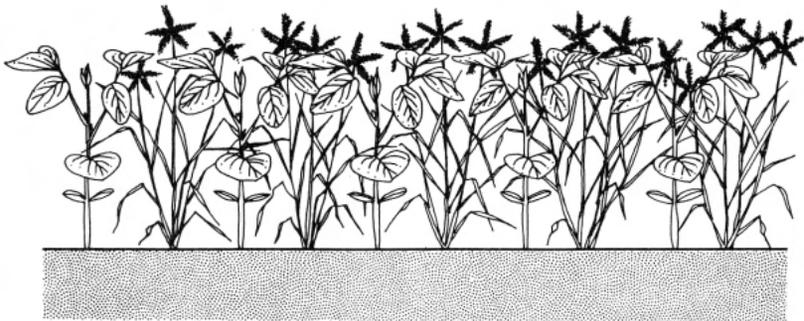
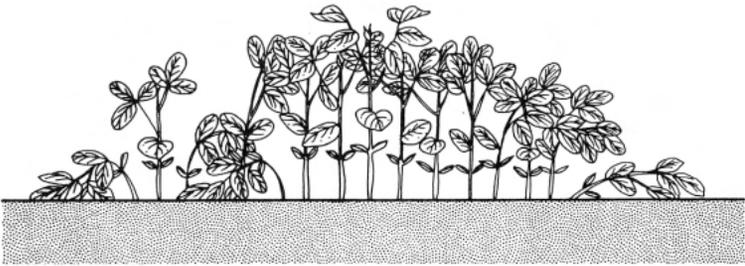
Rich soil



Poor soil

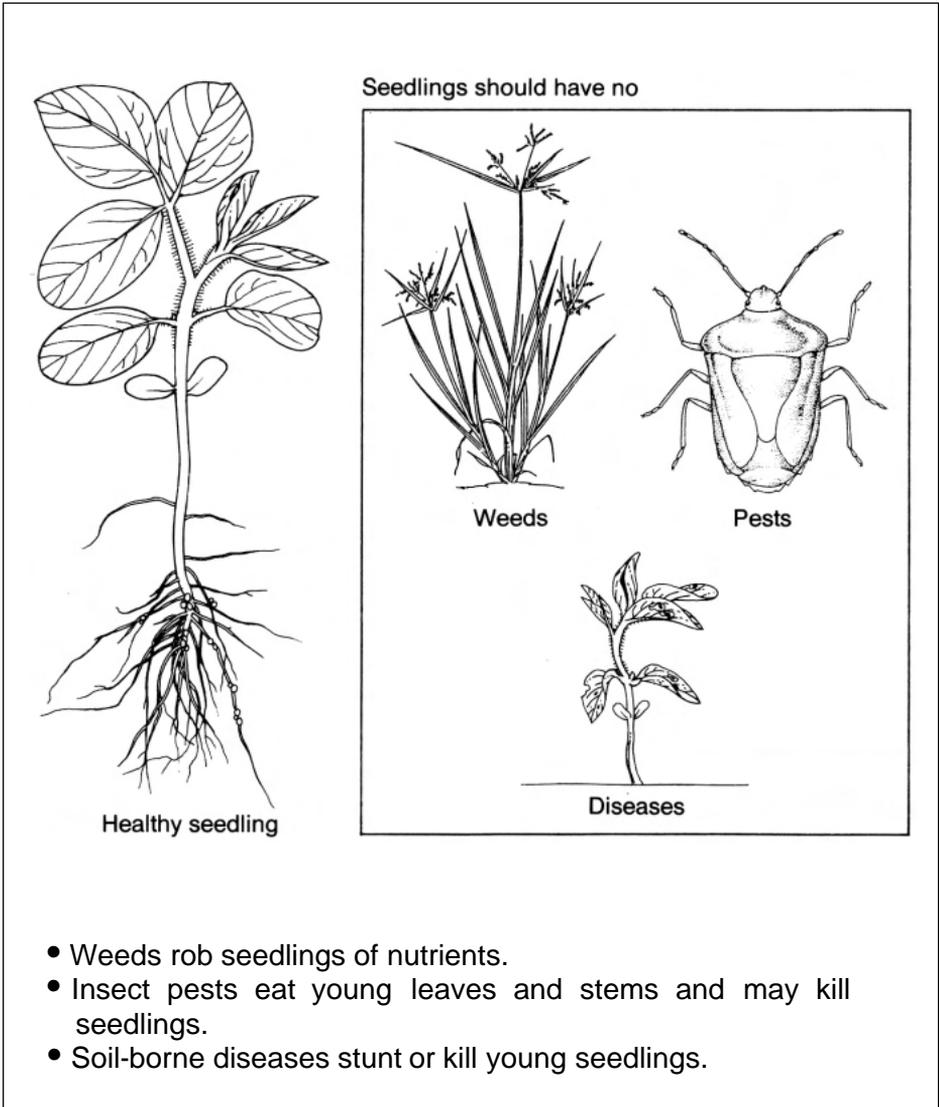
- To grow fast, seedlings need readily available nutrients. In poor soils, fertilizer may be needed at planting to start rapid growth.

# Factors affecting seedling growth — plant density



- Seedlings growing too close together grow too tall and lodge easily.
- Seedlings growing too far apart allow too much weed growth.

# Factors affecting seedling growth — weeds, insect pests, and diseases



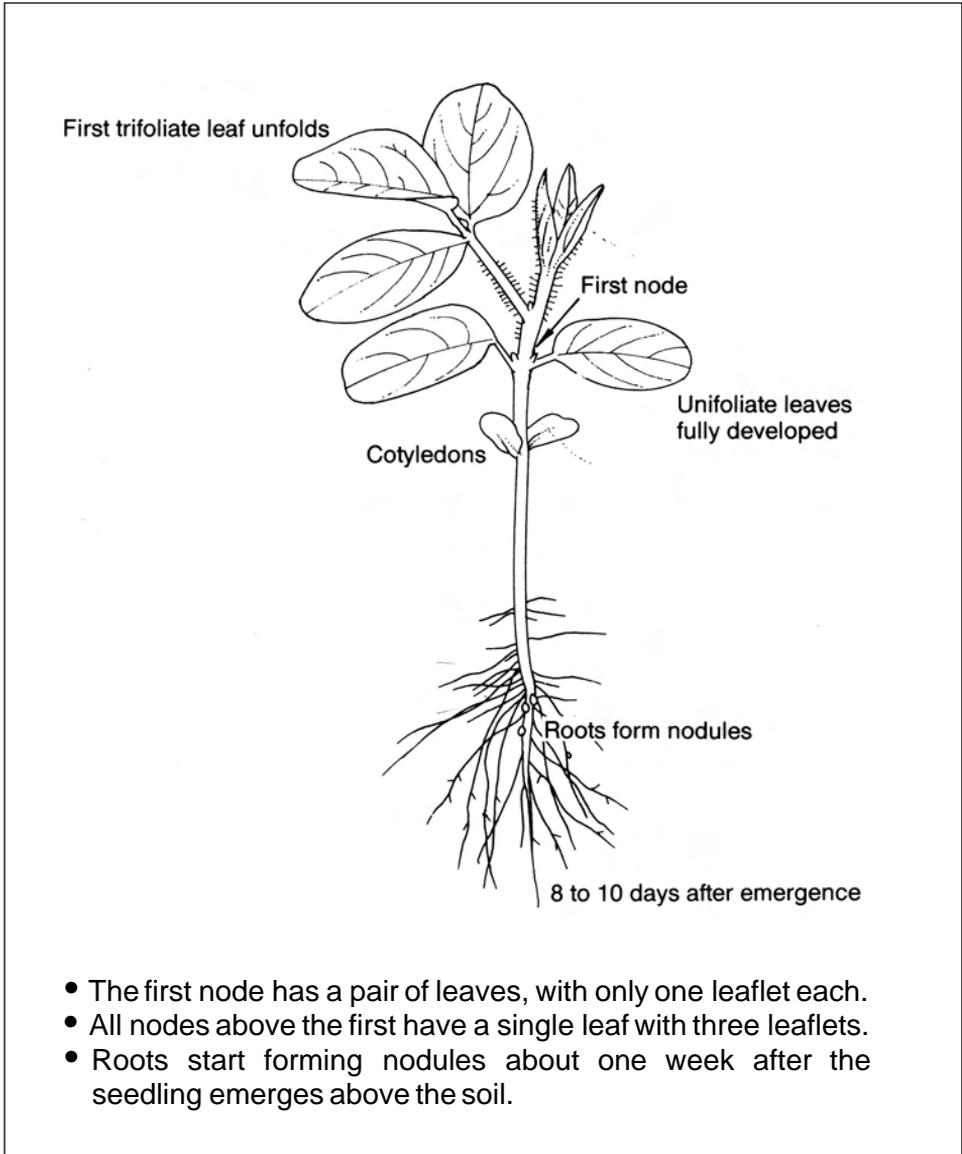


# Growth stages

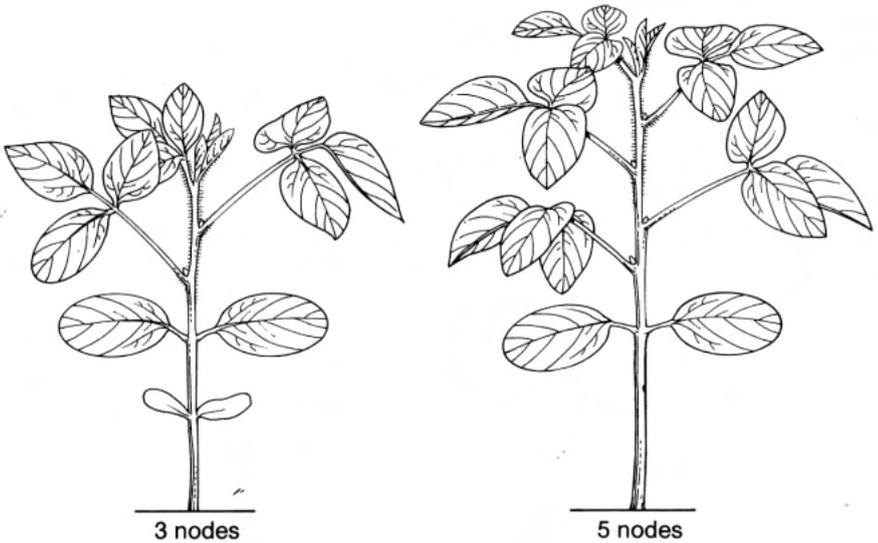
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Branching	<b>38</b>



# Growth stages of soybean — vegetative phase

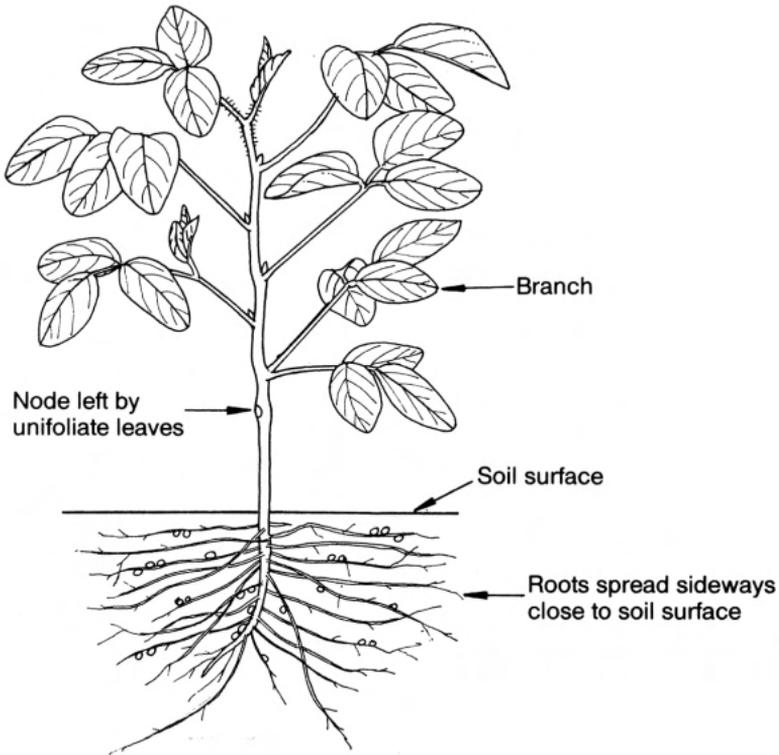


# Growth stages of soybean — vegetative phase



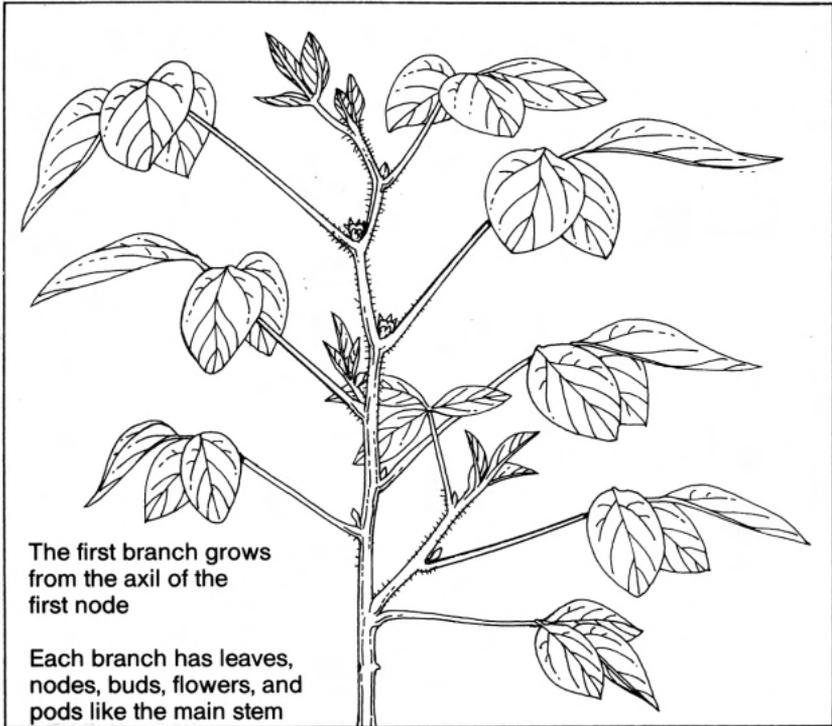
- The stem grows rapidly, with a new leaf unrolling at each node.
- Roots begin actively fixing nitrogen by the time the second or third node has developed.

# Growth stages — late vegetative phase



- Six nodes on the main stem have fully developed leaves.
- The buds in the axils may develop into branches or into flower clusters.

# Branching



- Branching starts when the plant is about 20 cm tall. The number of branches depends on the soybean variety and plant density.
- Branches are useful in making up some yield where plant density is low, or when the main stem tip is damaged.

# Growth stages — flowering

Flowering 41

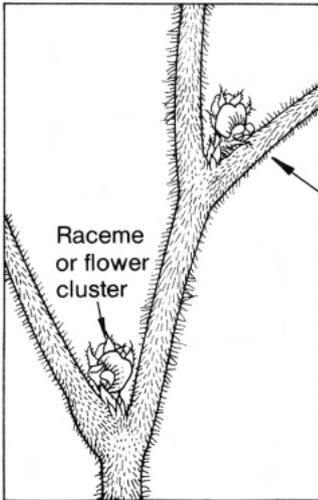
Flowering 42

Flowering pattern — determinate varieties 43

Flowering pattern — indeterminate varieties 44



# Flowering



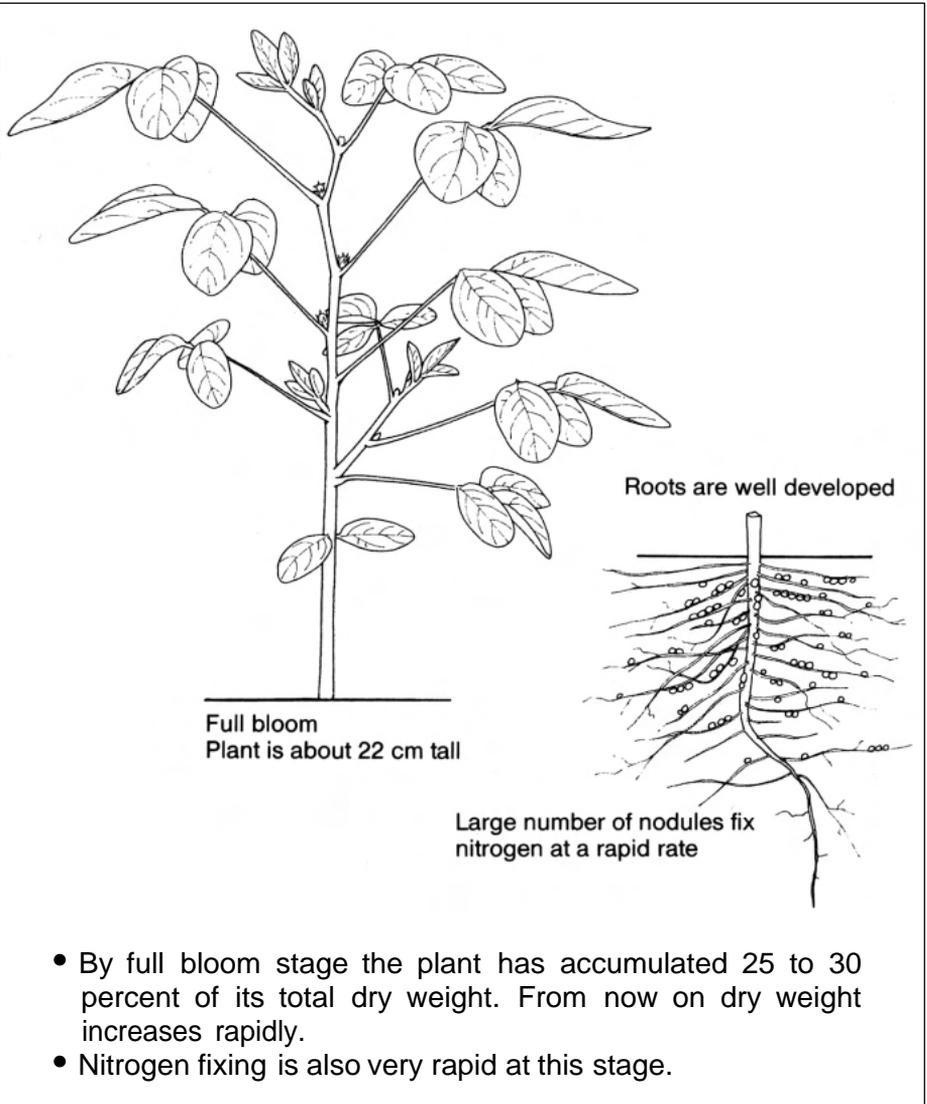
Plant with seven to ten nodes



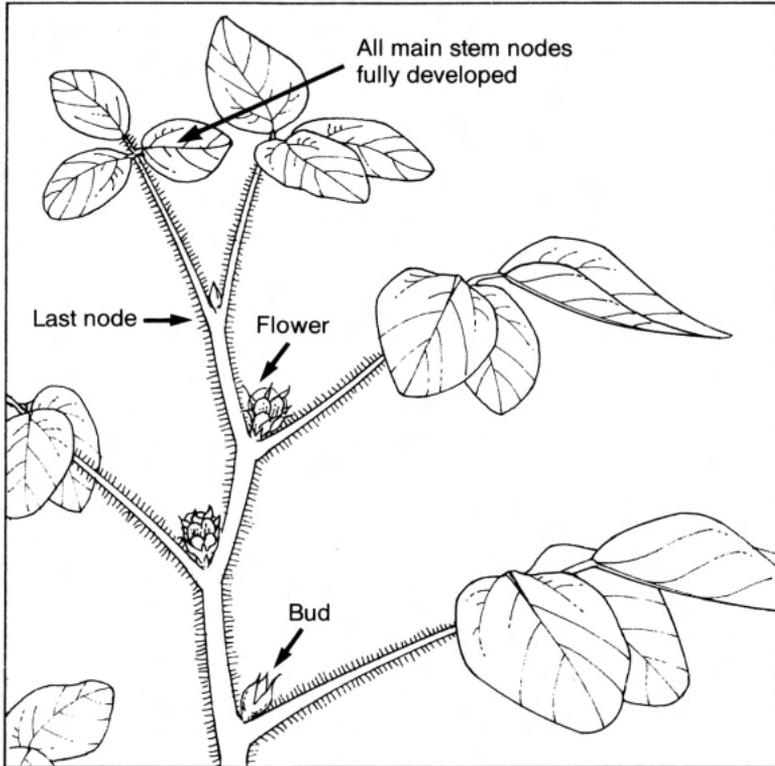
Open flower

- Soybean flowers grow in clusters called racemes.
- Number of days to first flower depends on soybean variety, daylength, and temperature.

# Flowering



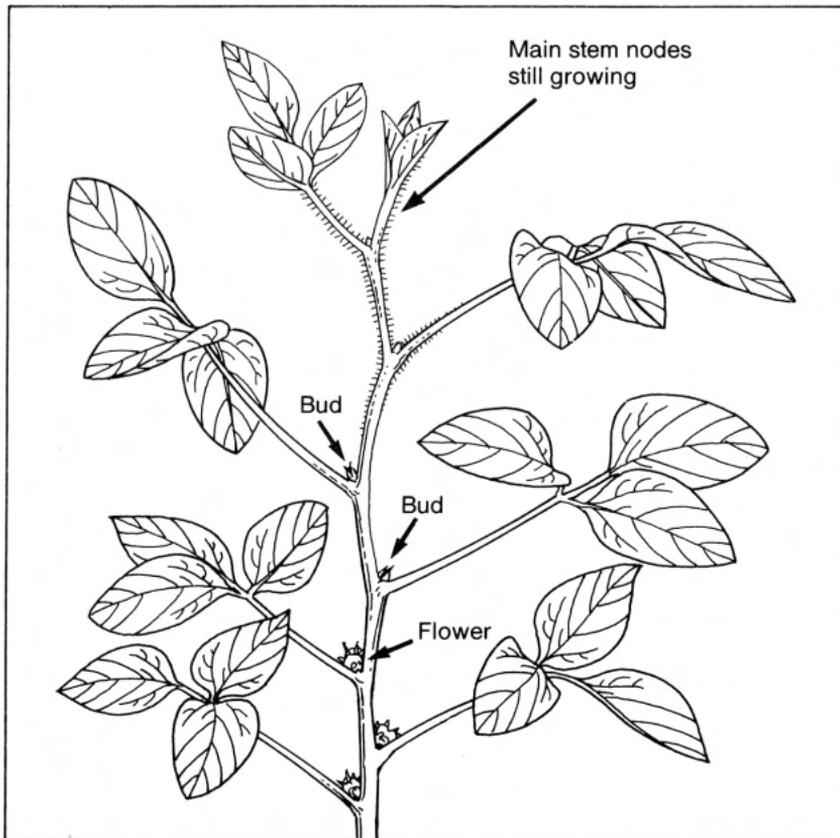
# Flowering pattern — determinate varieties



Determinate variety

- The flowering pattern of the soybean plant depends on the variety.
- Determinate varieties begin flowering when most of the nodes on the main stem have developed. Flowering starts at the upper nodes and progresses downwards and upwards from there.

# Flowering pattern — indeterminate varieties



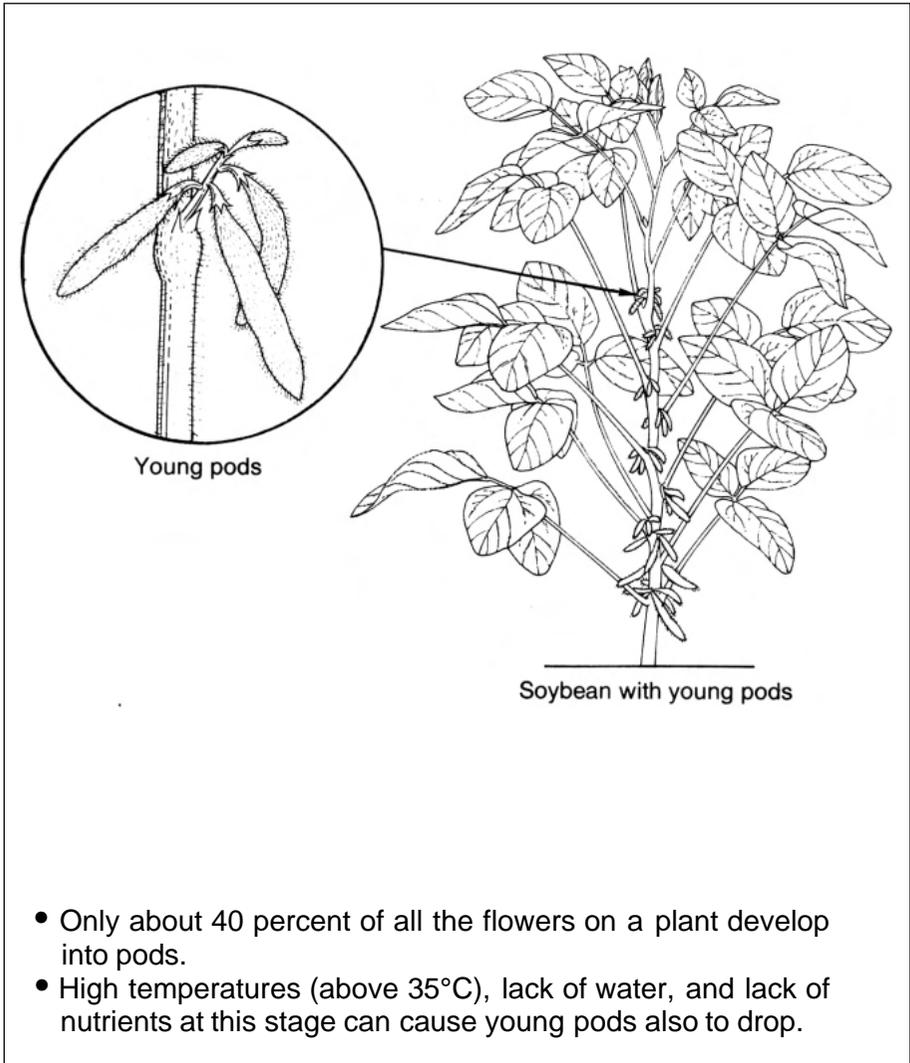
- Indeterminate varieties begin flowering when less than half the nodes on the main stem have developed.
- Flowering starts at the lower nodes, which develop pods while upper nodes are still flowering.

# Growth stages — pod development

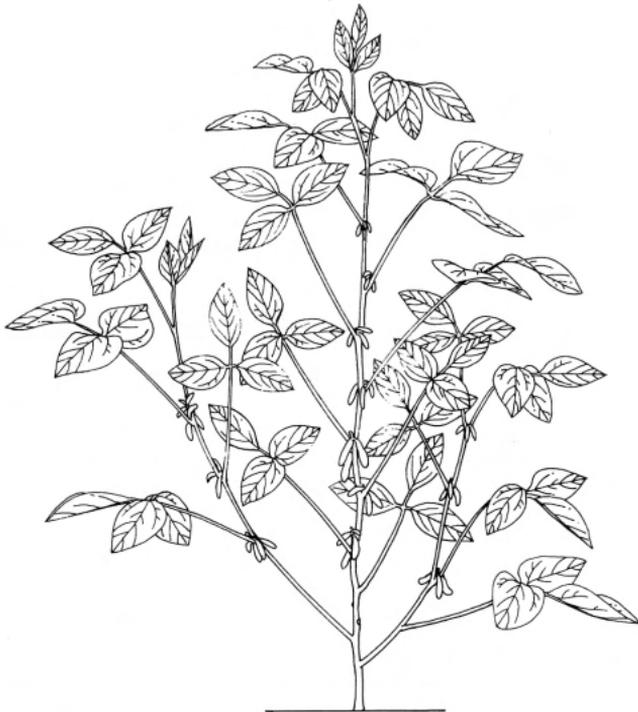
Pod formation	47
Full pod	48
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Seed filling	50
Ripening	51
Full maturity	52



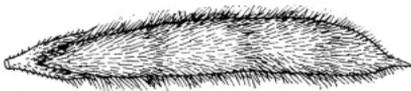
# Pod formation



# Full pod



Full pod stage



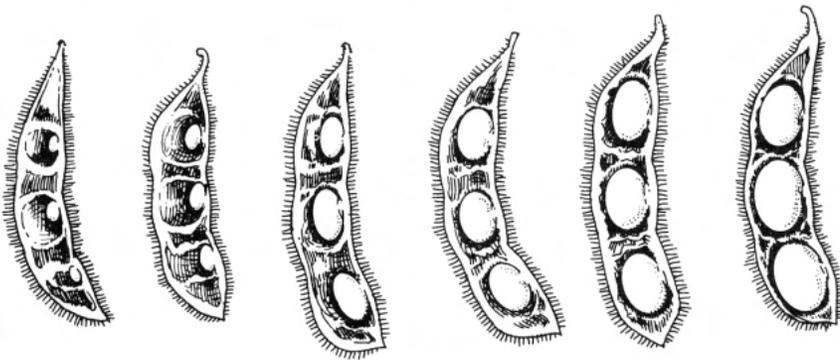
Pod is full grown



Seeds inside have yet to fill

- Pods grow rapidly to their full length and width.
- Full-pod stage is the most sensitive to stress. Lack of water or nutrients or very high temperatures now will reduce yields drastically.

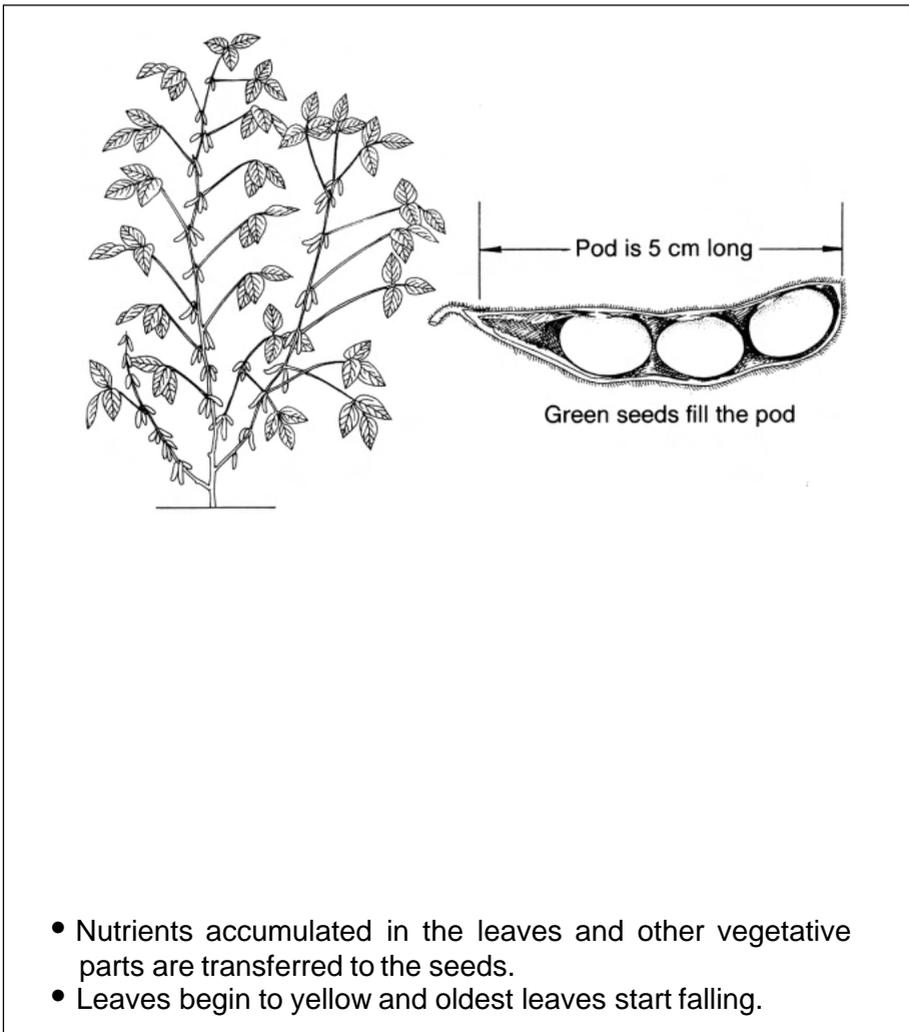
# Seed filling



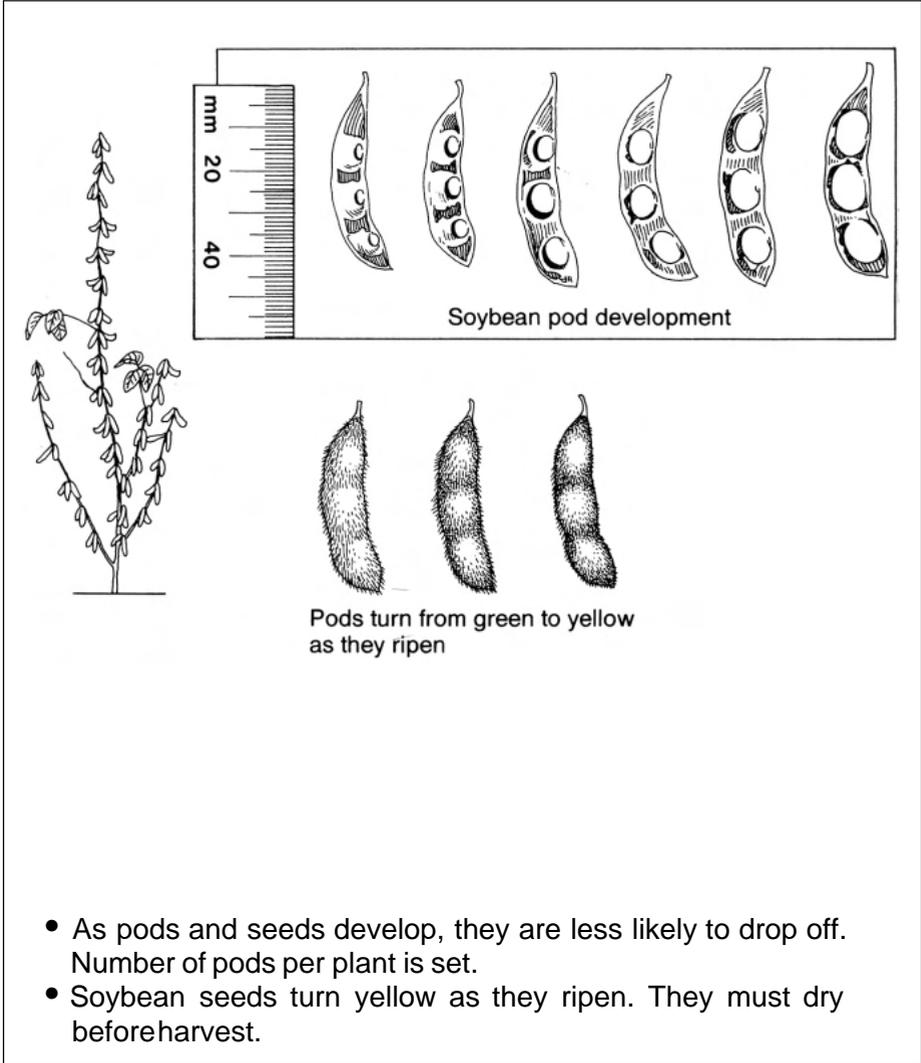
Seeds fill rapidly

- Seed yields depend upon the rate and length of time that dry weight accumulates in the seed.
- Nitrogen-fixing rate is highest at the beginning of this stage but drops sharply later.

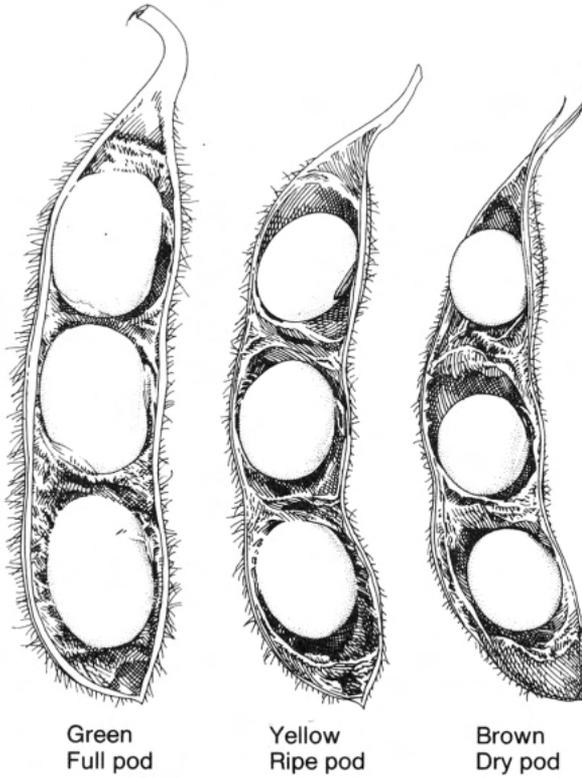
# Seed filling



# Ripening



# Full maturity



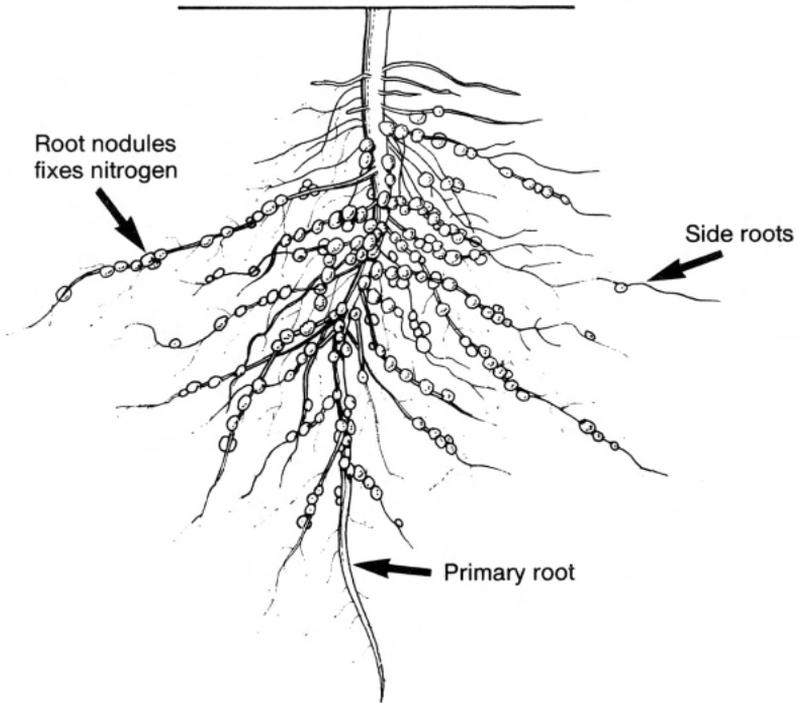
- After 95 percent of the pods have turned yellow, 5 to 7 days of drying weather are needed. Rain at this time can spoil the seeds.
- Timely harvesting is necessary to prevent seed loss in the field.

# The roots

Functions of the roots	<b>55</b>
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Root distribution	<b>57</b>

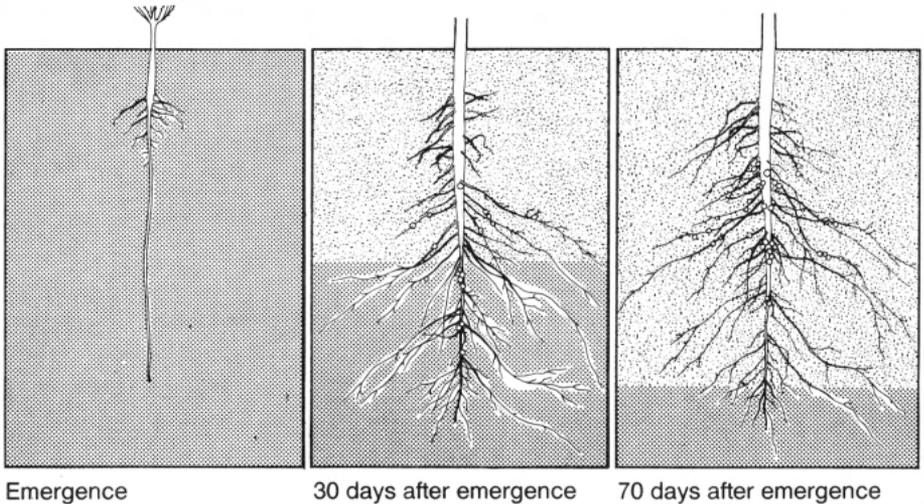


# Functions of the roots



- The roots transport nutrients and water to the rest of the plant.
- They support the shoot and its parts.
- In soybean, the roots also fix nitrogen.

# Root development



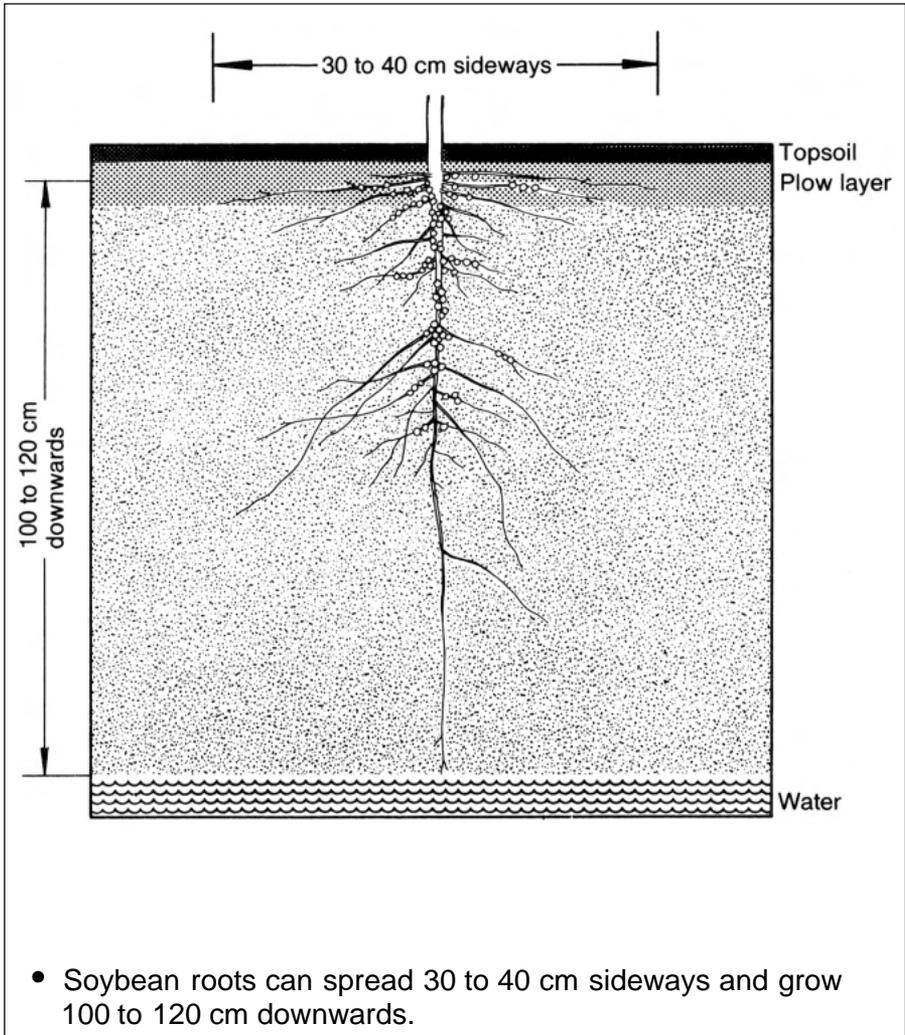
Emergence

30 days after emergence

70 days after emergence

- Roots develop much faster than the shoot.
- The side roots spread horizontally close to the soil surface for several weeks early in the season.
- As the soil moisture dries out, roots grow deep into the soil to absorb water and nutrients.

# Root distribution



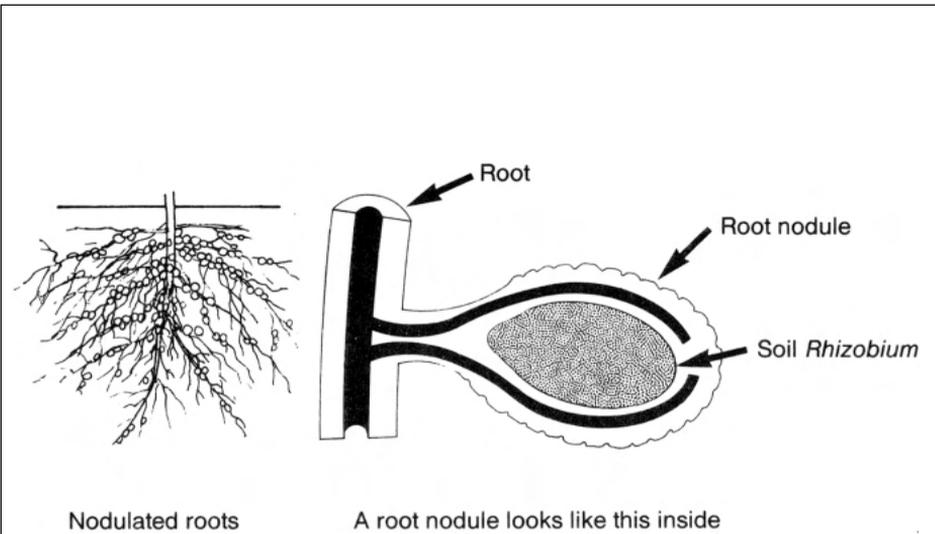


# Root nodules and nitrogen fixing

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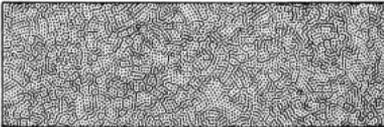
# Root nodules



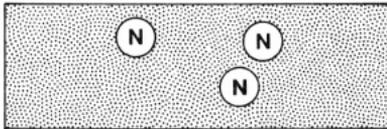
- Nodules are small lumps that form on soybean roots. Soil bacteria, known, as *Rhizobium japonicum*, live inside the nodules.
- The bacteria fix nitrogen from air into forms that the plant can use.
- Nitrogen fixing increases as the plant grows, reaching a peak when seed filling begins.

# Conditions affecting nodule growth and nitrogen fixing

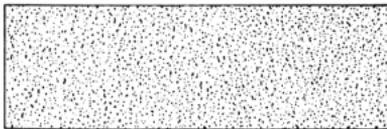
Good nodule growth and activity result when:



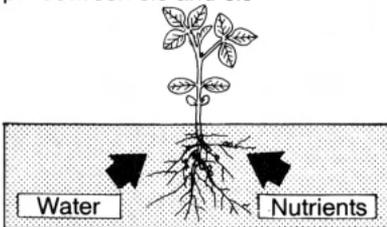
Soil contains *Rhizobium japonicum*



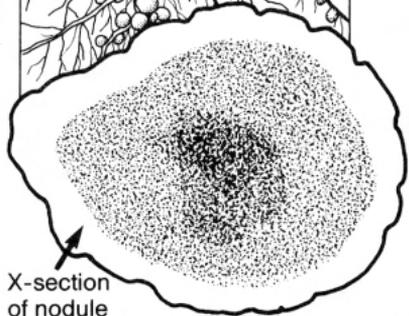
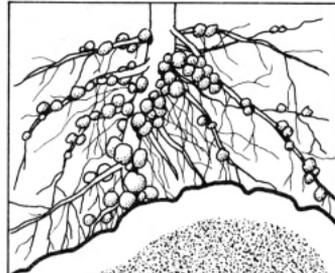
Soil nitrogen is low



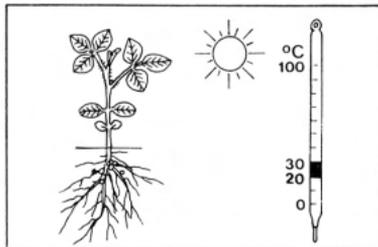
Soil is not too acid or alkaline  
pH between 5.5 and 6.5



Soil has enough water and nutrients especially phosphorus



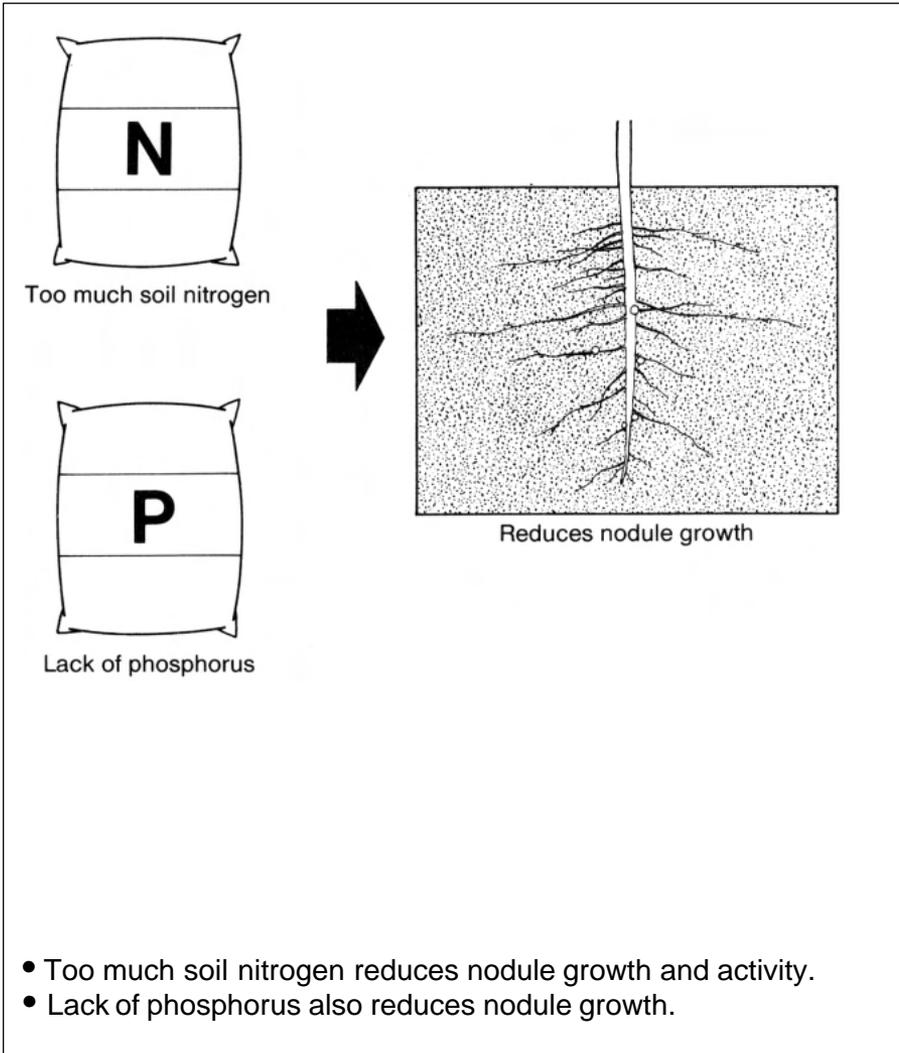
X-section of nodule



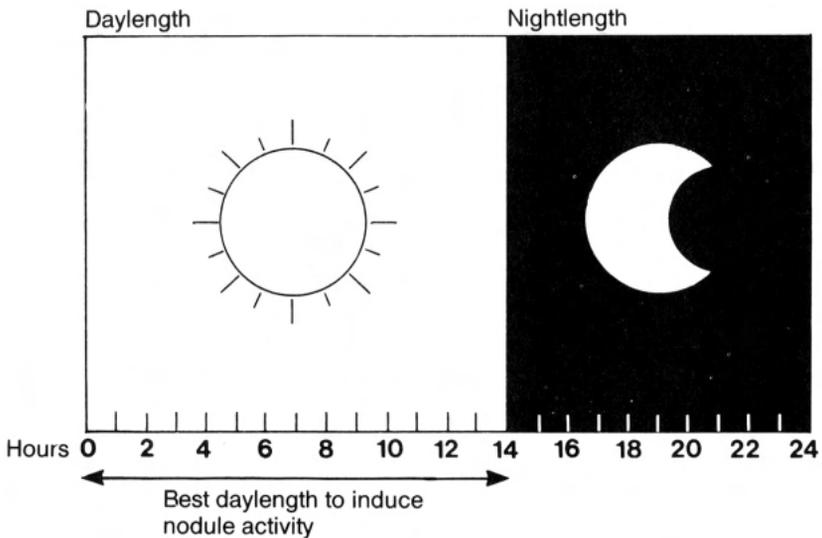
Plant gets enough sunlight and warmth temperature 20 to 30°C

- With good nodule growth and favorable soil and weather conditions, a soybean crop can fix up to 280 kg of nitrogen per hectare over the whole season.
- A healthy nodule is pink or red on the inside. White, brown, or green nodules mean that nitrogen is not being fixed.

# Conditions affecting nitrogen fixing — soil nitrogen and phosphorus

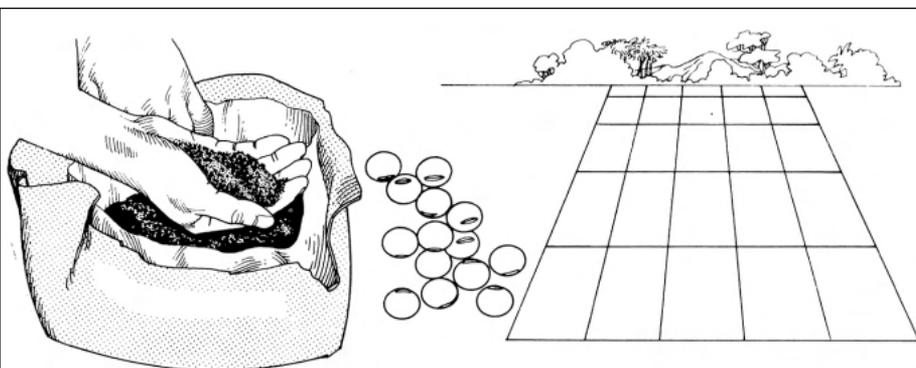


# Conditions affecting nitrogen fixing — temperature and daylength



- Warm days and cool nights increase nodule activity.
- Daylength should be about 10 to 14 hours.

# Conditions affecting nitrogen fixing — soil rhizobia



Treat seed with  
*Rhizobium japonicum* culture

1 pocket (400 g) culture is enough for  
half hectare (30 to 40 kg seed)

- Soybean needs the right kind of soil bacteria to grow root nodules.
- Seeds should be treated with *Rhizobium* culture before planting.



# Growing soybean



# Growing soybean — environment

Temperature and rainfall 71

Daylength 72

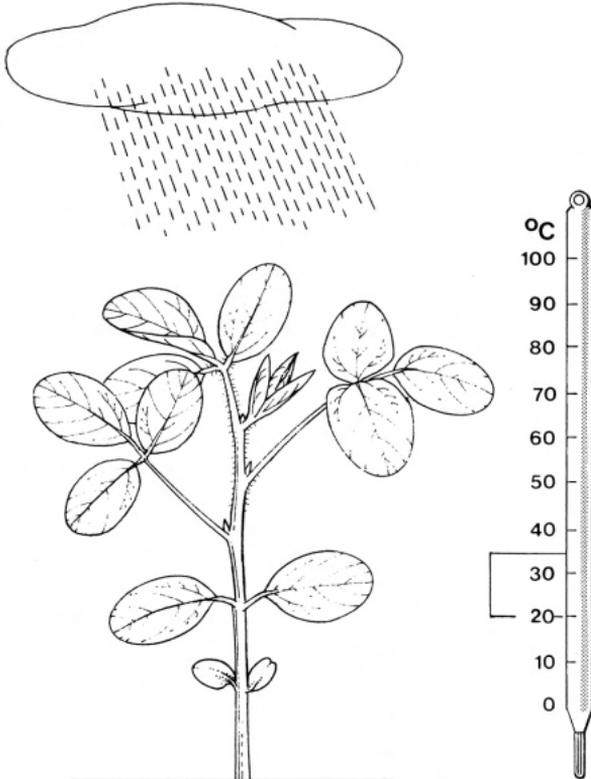
Light intensity 73

Soil 74

Soil pH 75



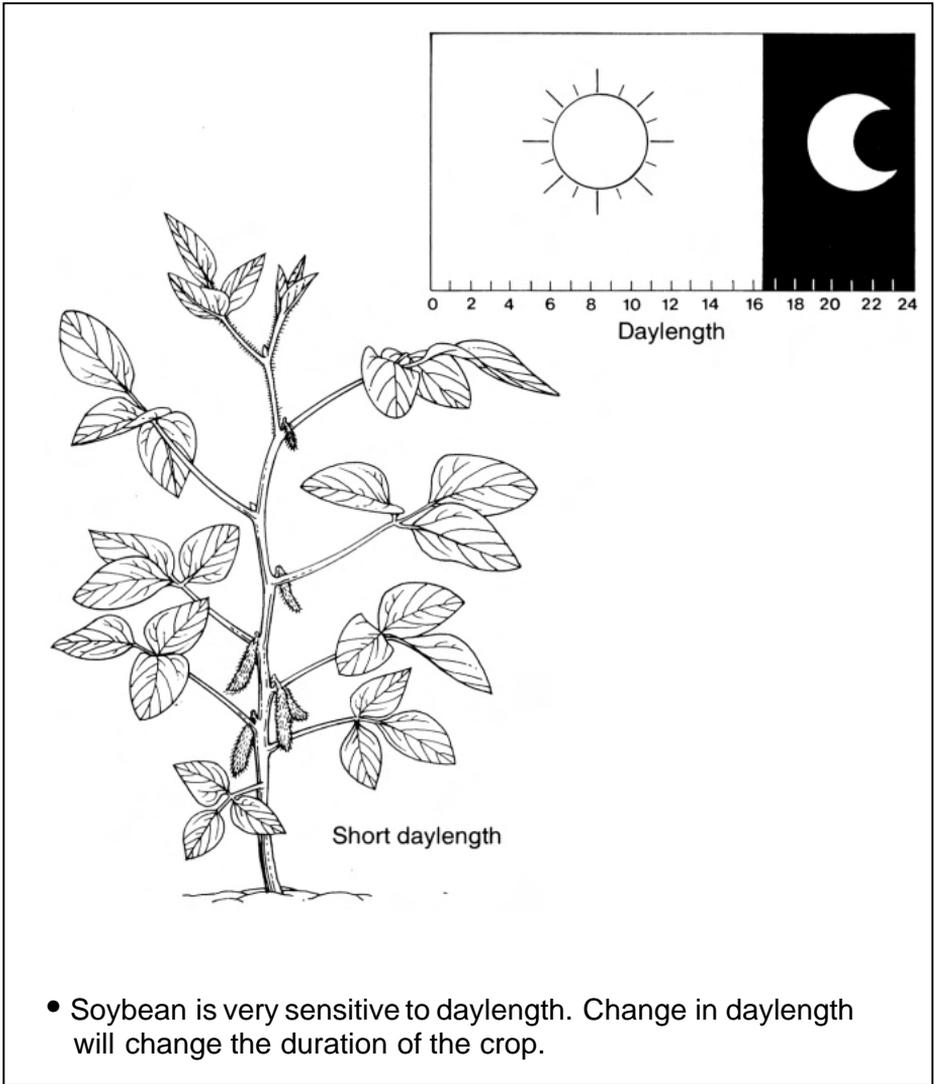
# Temperature and rainfall



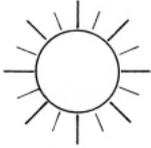
Soybean grows best at 20 to 35°C and 600 to 1500 mm rainfall

- Soybean can be grown throughout the tropics in intermediate to high rainfall zones.

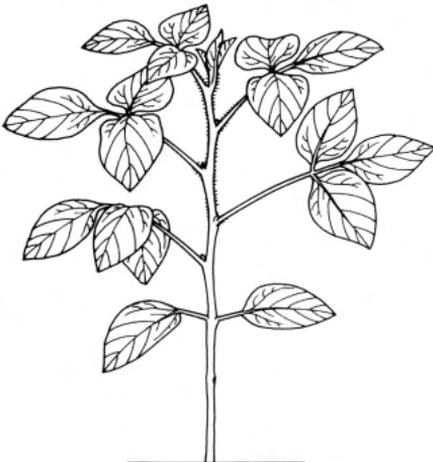
# Daylength



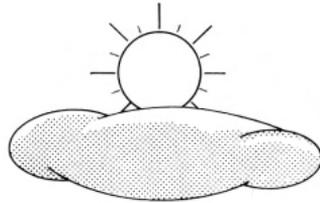
# Light intensity



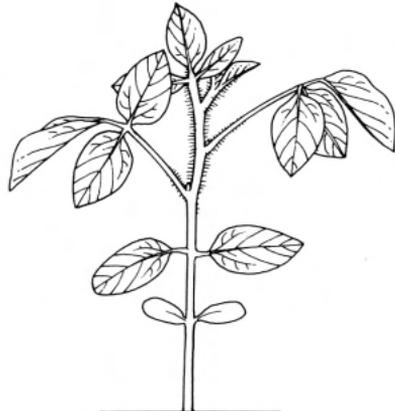
Sufficient light intensity



Normal growth



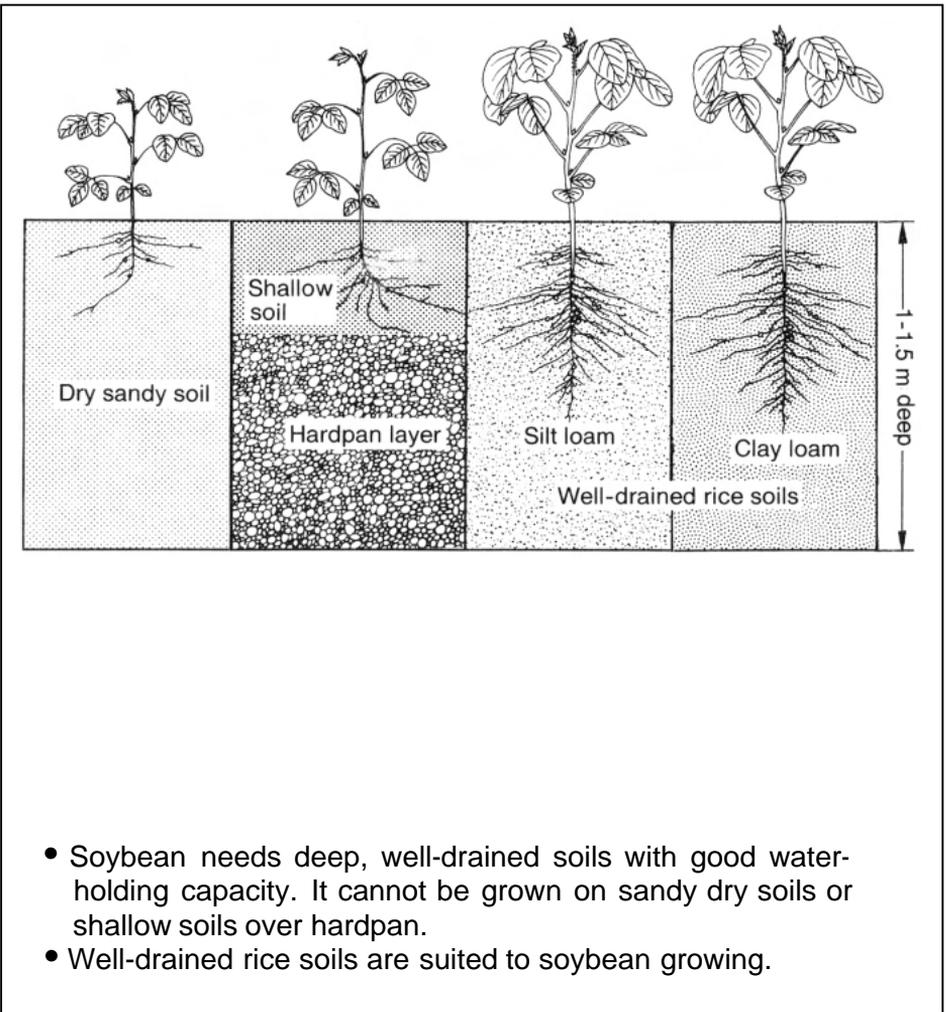
Reduced light intensity



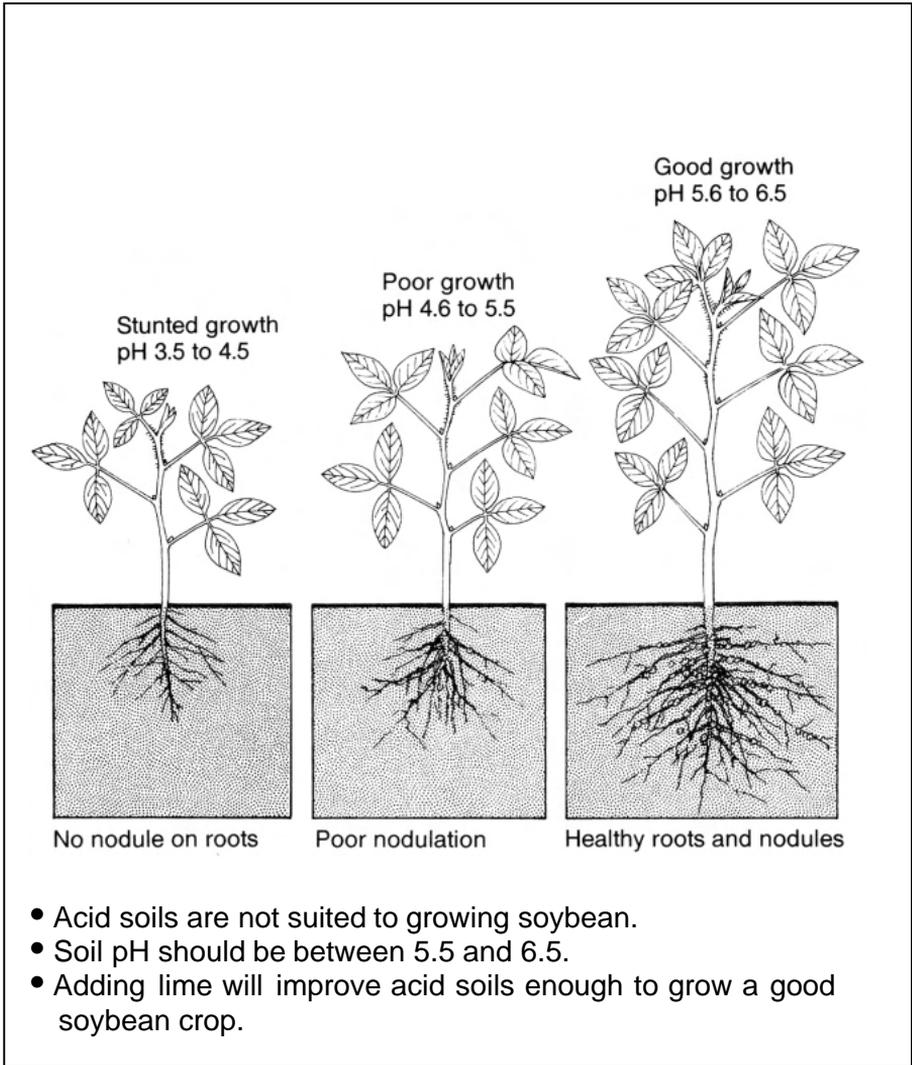
Poor growth

- Bright sunlight is needed for rapid leaf growth and healthy plant development.
- Soybean grows poorly under shade or reduced light.

# Soil



# Soil pH



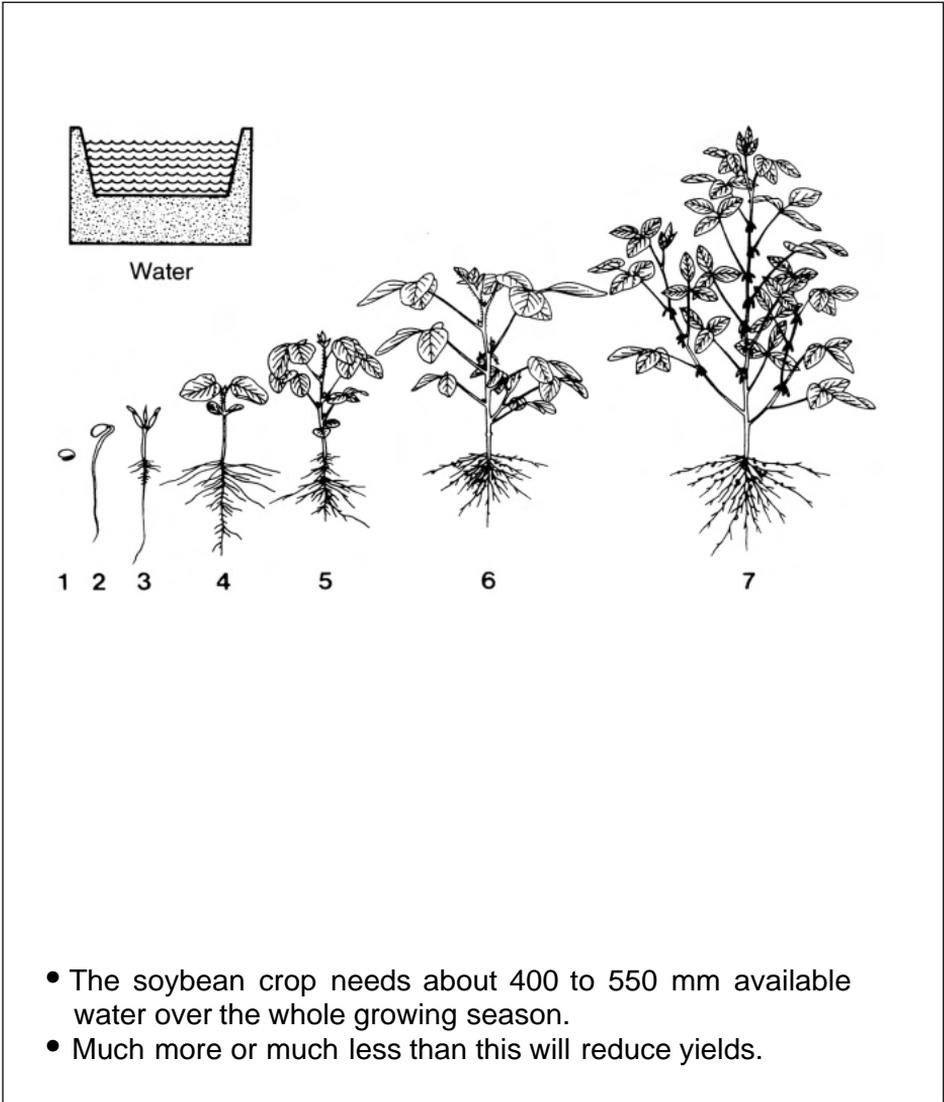


# Growing soybean — water

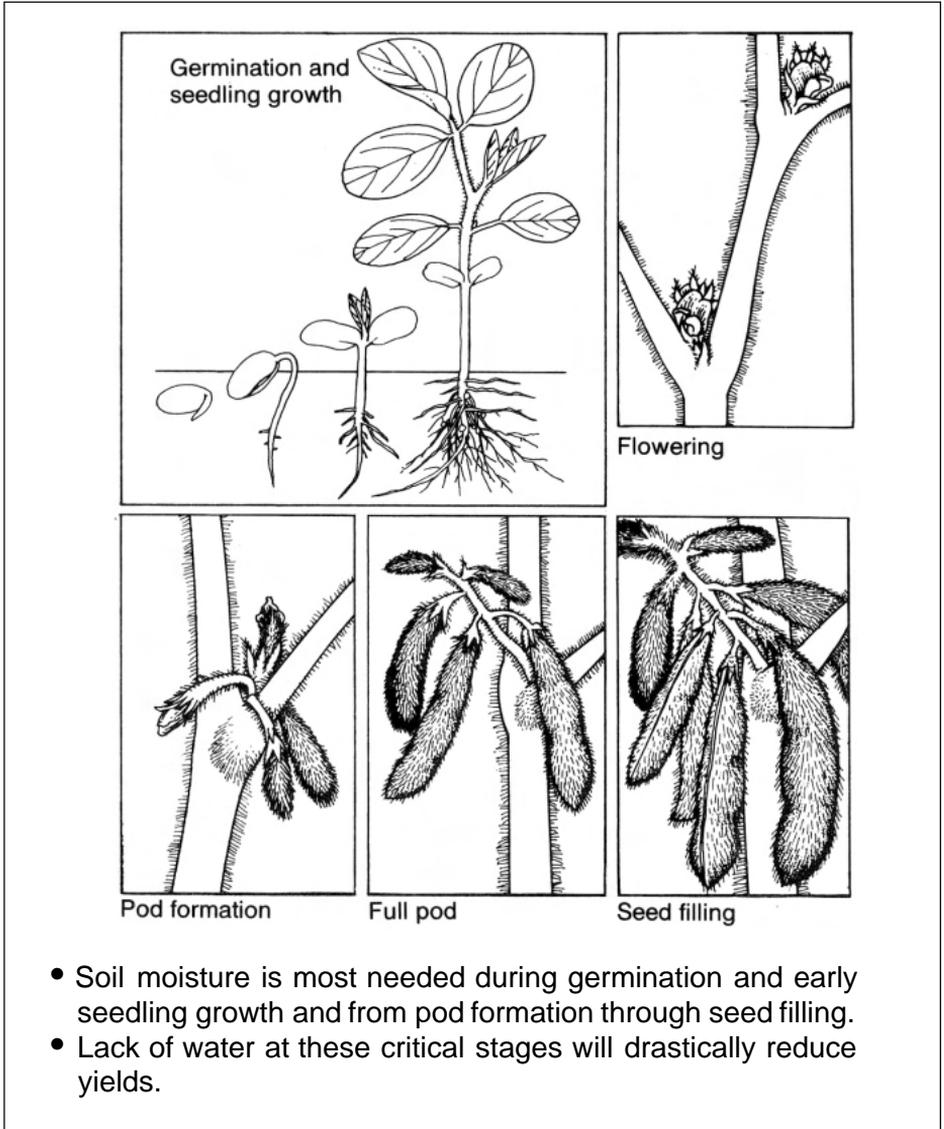
Water needs	<b>79</b>	
When water is most needed		<b>80</b>
How much water	<b>81</b>	
Irrigating soybean	<b>82</b>	



# Water needs

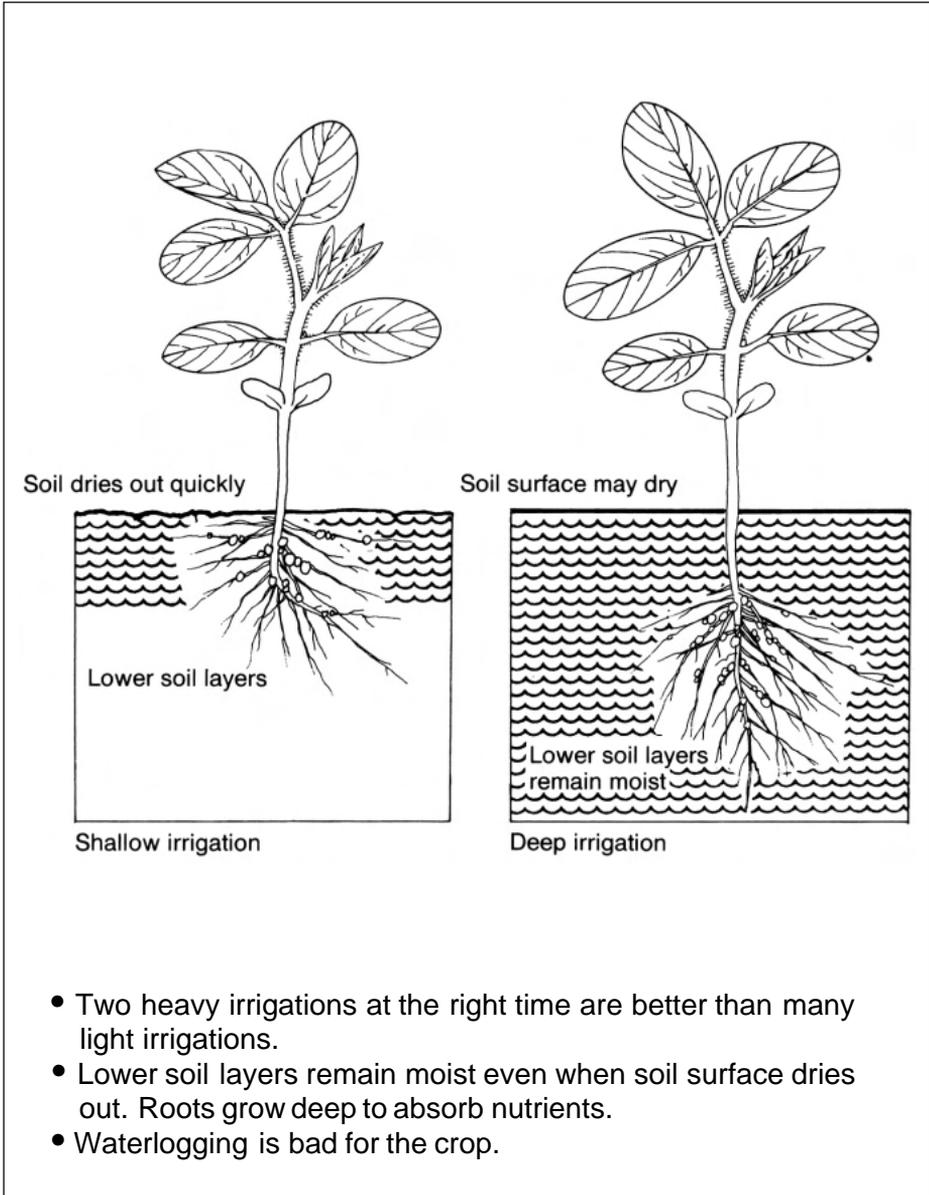


# When water is most needed



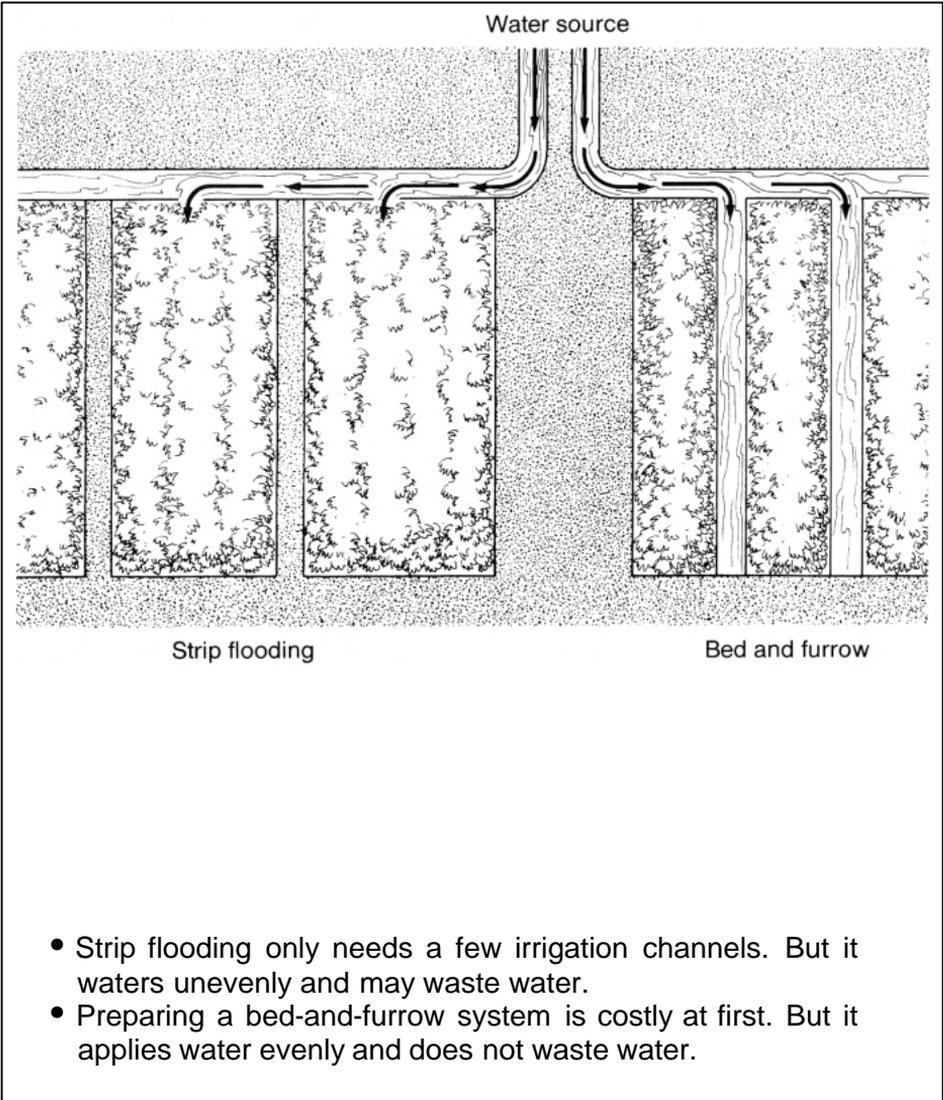
- Soil moisture is most needed during germination and early seedling growth and from pod formation through seed filling.
- Lack of water at these critical stages will drastically reduce yields.

# How much water



- Two heavy irrigations at the right time are better than many light irrigations.
- Lower soil layers remain moist even when soil surface dries out. Roots grow deep to absorb nutrients.
- Waterlogging is bad for the crop.

# Irrigating soybean



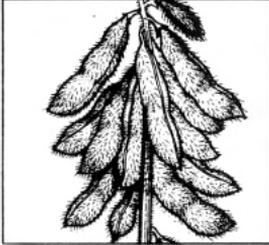
# Growing season — choosing the right variety

Choosing the right variety	<b>85</b>
The right variety — duration	<b>86</b>
The right variety — pest and disease resistance	<b>87</b>
The right variety — drought tolerance	<b>88</b>
The right variety — lodging resistance	<b>89</b>
The right variety — shattering resistance	<b>90</b>
The right variety — free nodulation	<b>91</b>

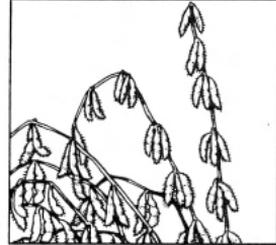


# Choosing the right variety

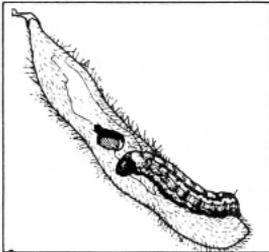
The right variety should have:



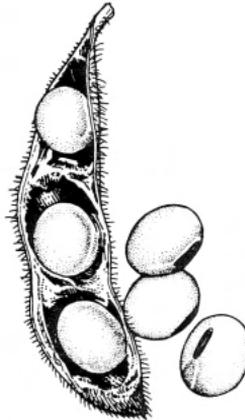
High yield



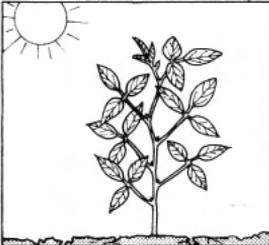
Lodging resistance



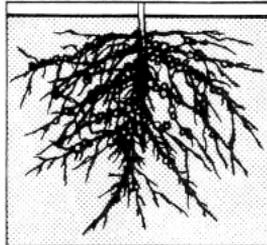
Insect pest tolerance



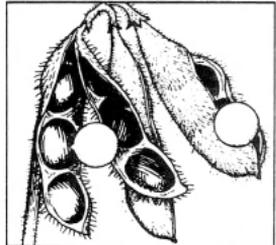
Disease tolerance



Drought tolerance



Good nodulation with local soil rhizobium



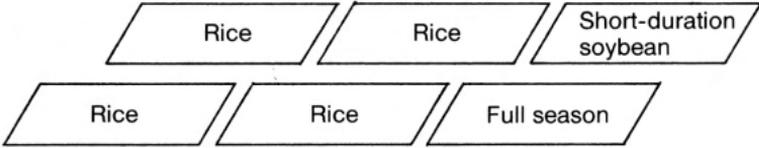
Shattering resistance

- Soybean yields depend on variety and growing conditions.
- Choose the variety to fit the cropping system and available water.
- Plant high-yielding varieties.

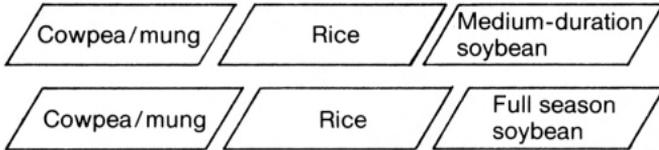
# The right variety — duration

Short duration — 75 to 84 days  
Medium duration — 85 to 94 days  
Full season — 95 to 110 days

## IRRIGATED



## RAINFED



- Full-season varieties usually yield more than short-duration ones.
- Short-duration varieties allow more than one crop to be grown in sequence.
- Intermediate varieties yield well under most growing conditions.

# The right variety — pest and disease resistance

The right soybean variety should be resistant to



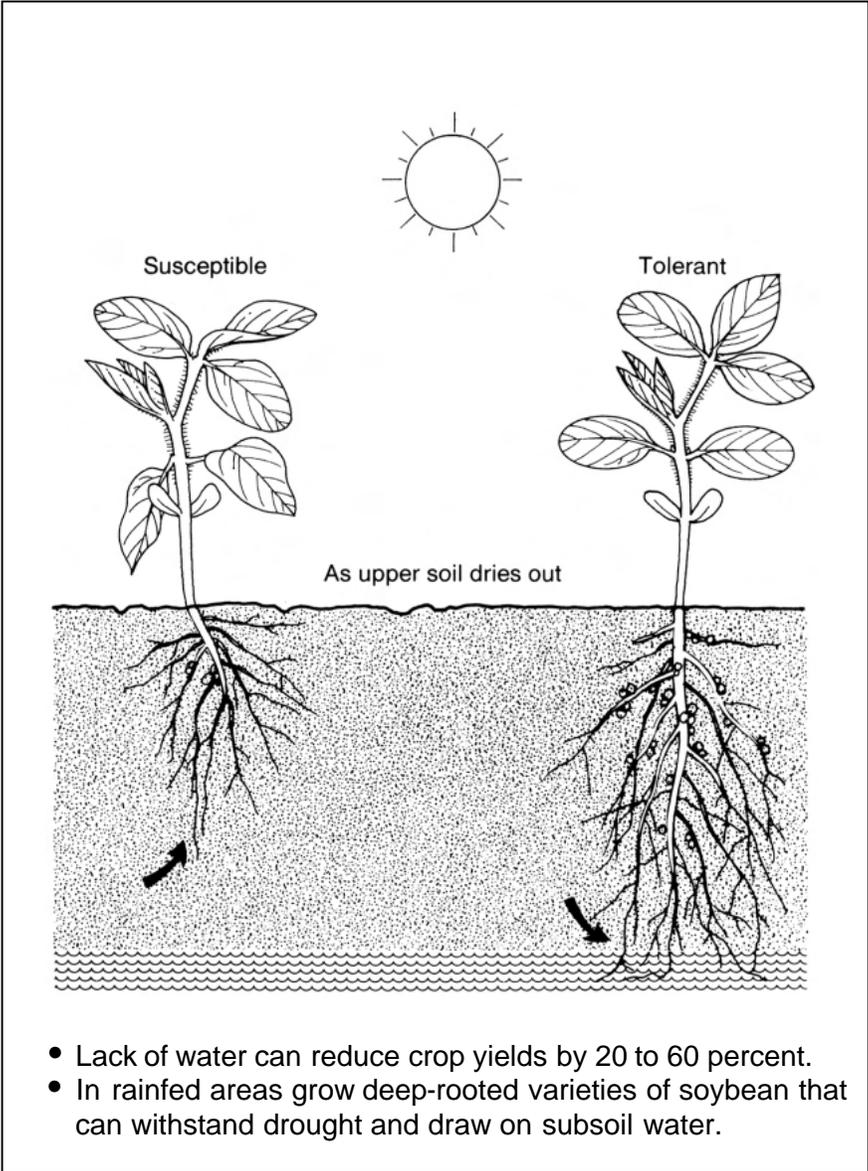
Pests



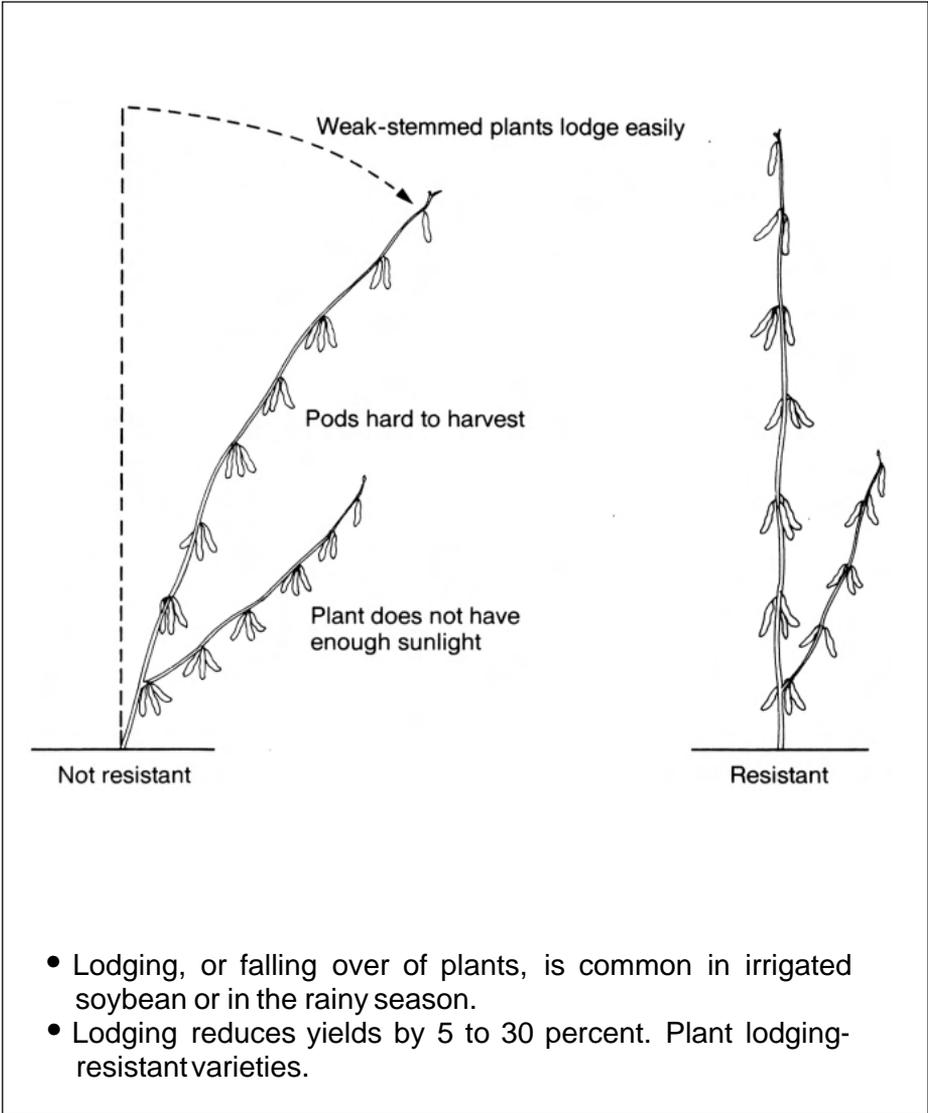
Diseases

- Many soybean varieties are resistant to pests and diseases. Choose the variety resistant to the most damaging pests and diseases in your area.

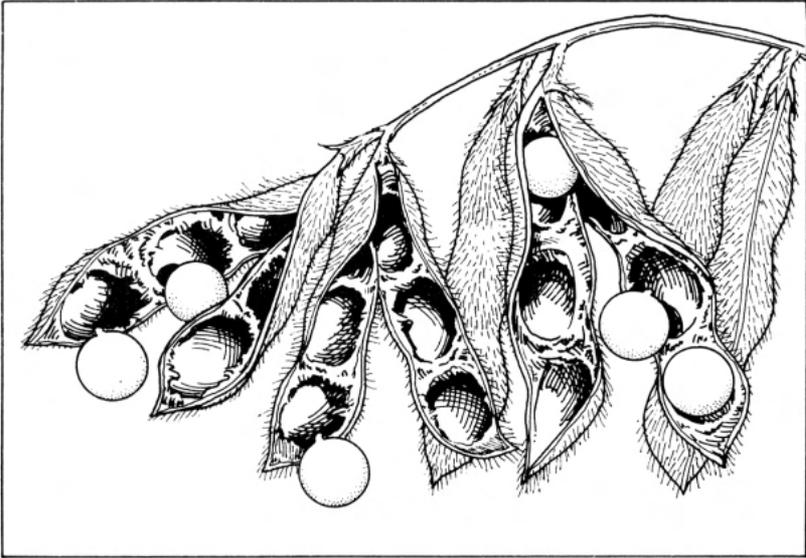
# The right variety — drought tolerance



# The right variety — lodging resistance



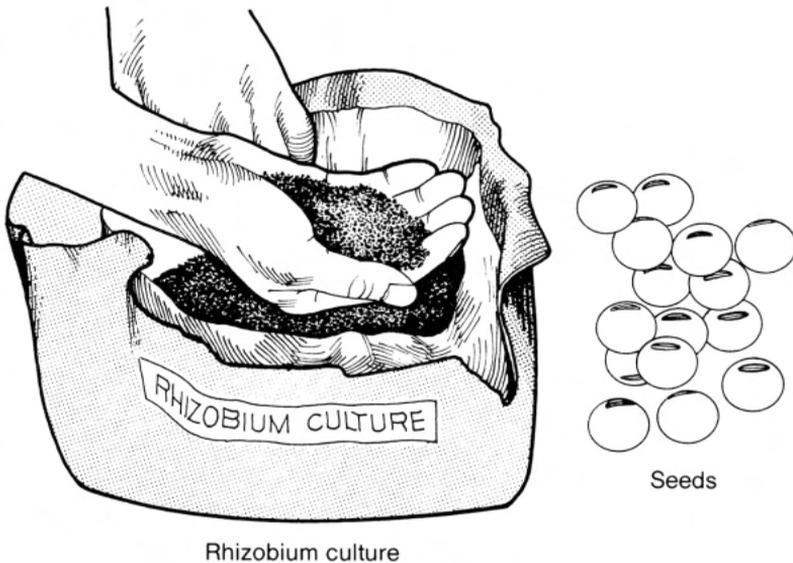
# The right variety — shattering resistance



Shattering may cause 5-10% yield loss

- Soybean pods break open easily, and seeds are lost, if harvest is delayed.
- Plant shatter-resistant varieties.

# The right variety — free nodulation



- Some soybean varieties can grow nodules with local soil rhizobia.
- In fields where soybean has not been grown for more than 5 years, plant free-nodulating varieties.
- Seed treatment with *Rhizobium* culture improves nodulation in all varieties.



# Tillage and planting

Preparing the land — high tillage **95**

Preparing the land — zero tillage **96**

Planting season and date **97**

Plant density **98**

Row spacing **99**

Planting method **100**

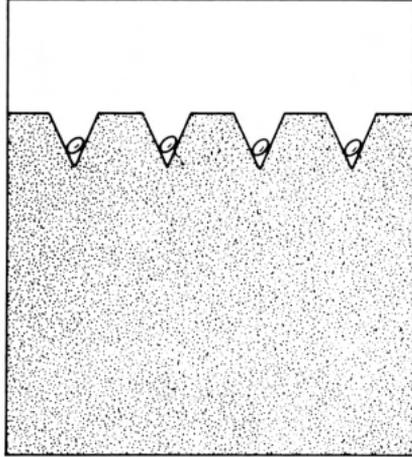
Planting depth **101**



# Preparing the land — high tillage



Deep plowing and two cross harrowings

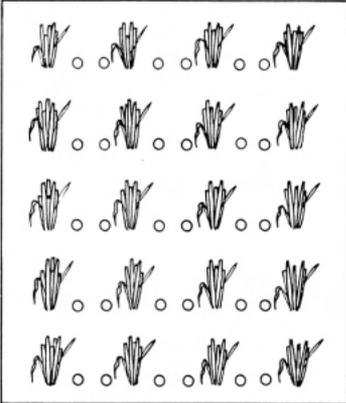


High tillage

- High tillage is common in irrigated areas where water is easily available. High tillage
  - airs the soil
  - helps seeds germinate and roots grow deep
  - controls weeds.
- But high tillage
  - is costly
  - delays planting
  - dries out the soil.

# Preparing the land — zero tillage

Zero tillage



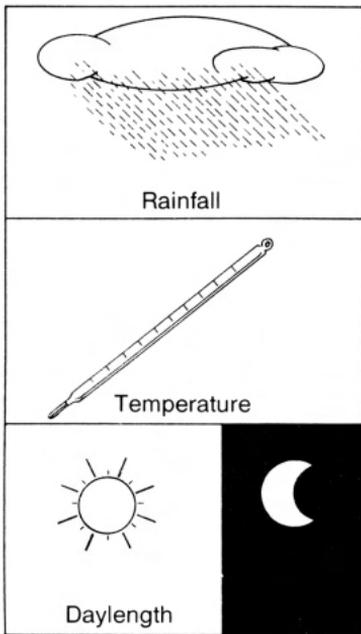
No plowing  
No harrowing



Soybean seed is planted in a furrow or dibbled at the base of rice stubble

- Zero tillage is common in rainfed areas, especially after lowland rice. Zero tillage
  - saves labor and costs
  - allows planting at once
  - makes full use of soil moisture.
- But zero tillage
  - does not air the soil
  - does not help roots grow deep
  - lets weeds grow.

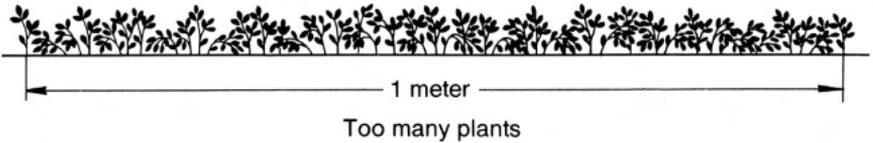
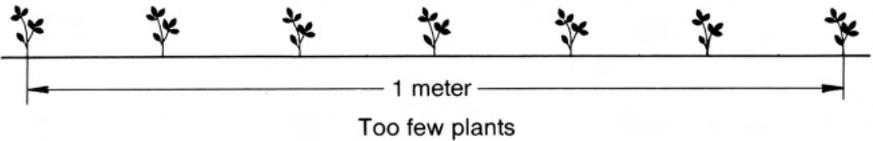
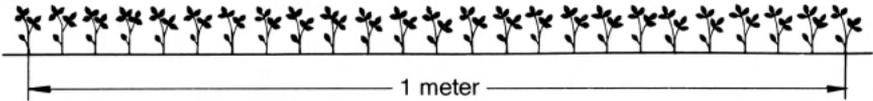
# Planting season and date



- The season for planting soybean depends on rainfall, temperature, and daylength.
- The best planting date differs with season and location. Short winter days usually lower seed yields.

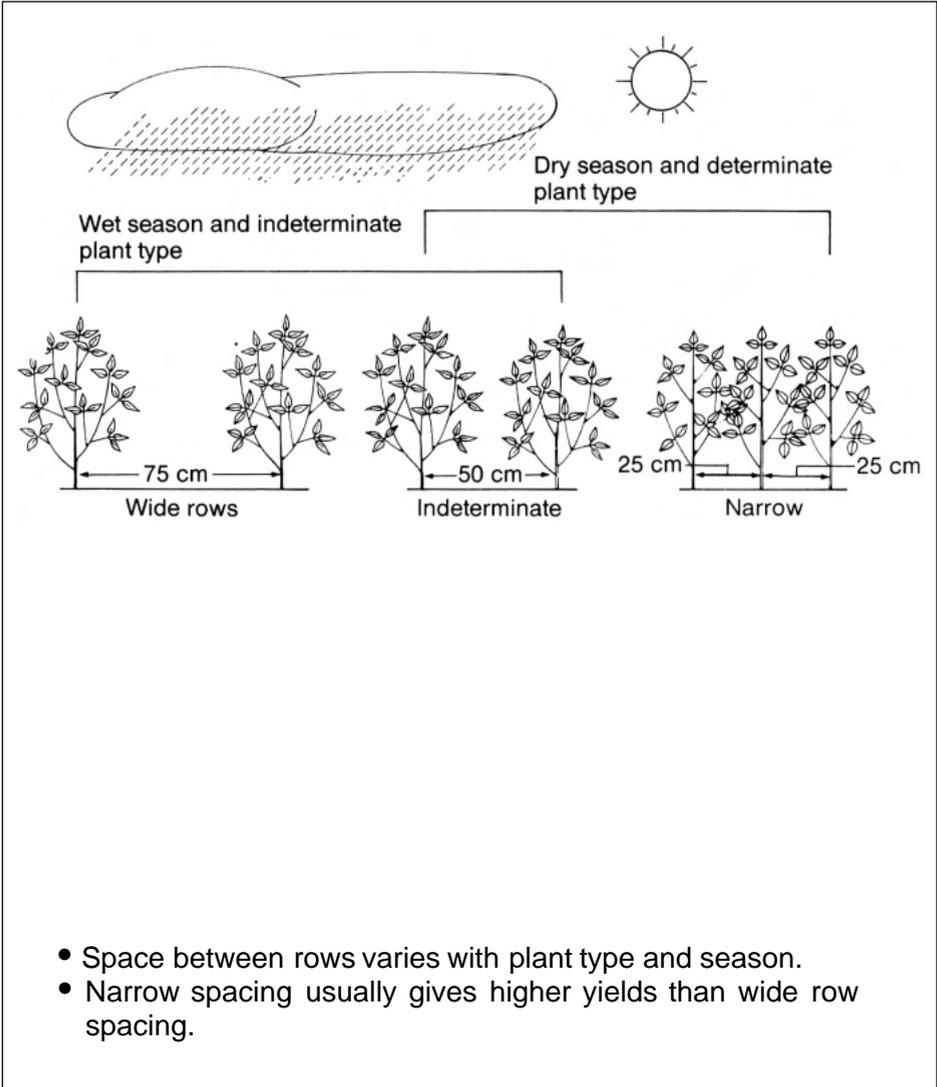
# Plant density

12 to 14 plants



- Best seed yields are obtained with 12 to 14 plants per meter row (planting 60 to 80 kg seed per hectare).
- Too dense a planting increases lodging.

# Row spacing



- Space between rows varies with plant type and season.
- Narrow spacing usually gives higher yields than wide row spacing.

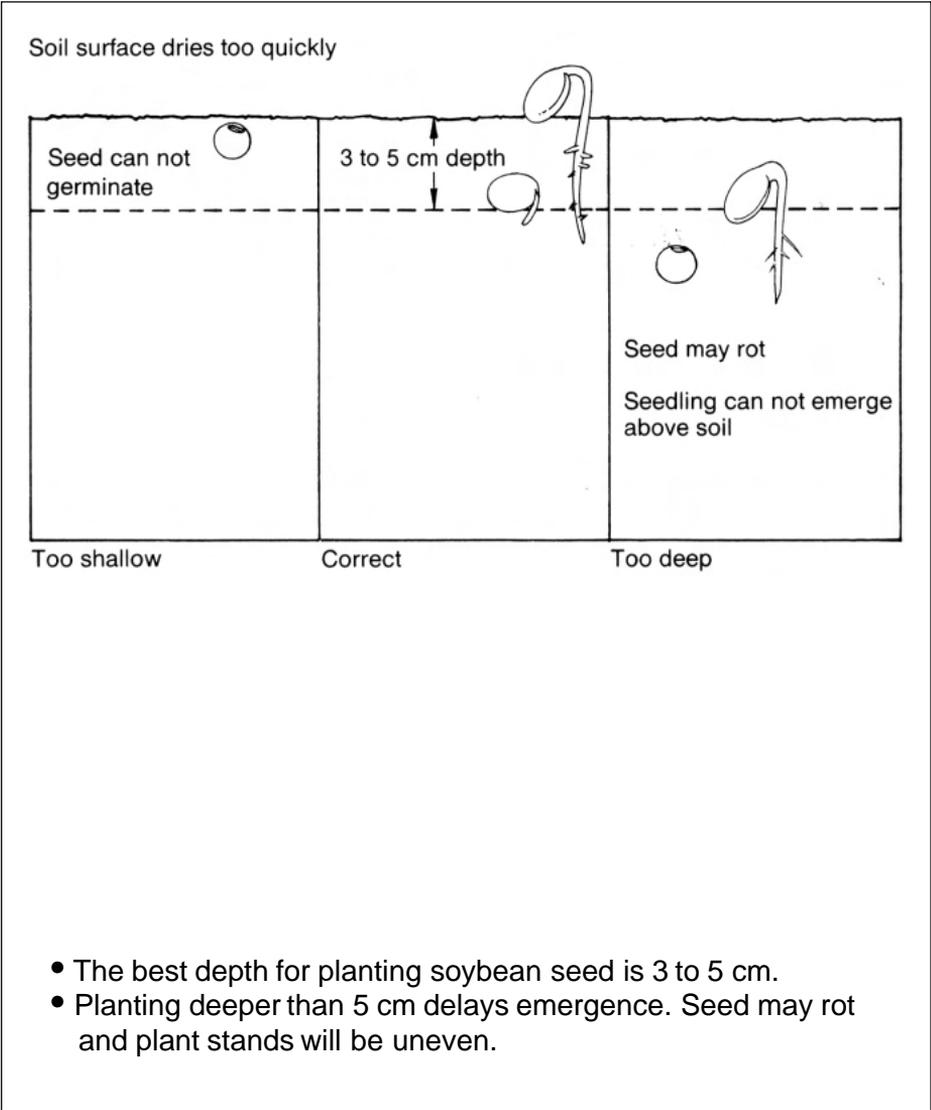
# Planting method



Dibble seed at the base of rice stubble  
after rice harvest

- Drill seed in rows by hand or animal-drawn seeder.
- Dibble seed at the base of rice stubble after rice harvest.

# Planting depth





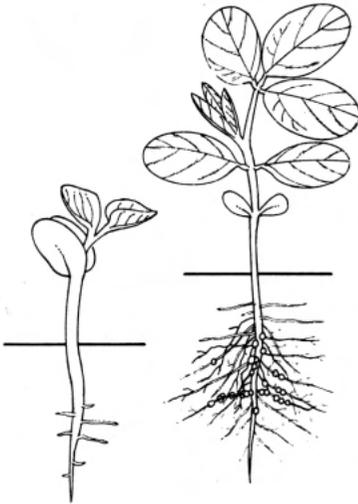
# Fertilizer and lime

Why apply fertilizer	<b>105</b>
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Fertilizer — nitrogen	<b>108</b>
Fertilizer — phosphorus	<b>109</b>
Fertilizer — potassium	<b>110</b>
Fertilizer — micronutrients	<b>111</b>
Lime	<b>112</b>

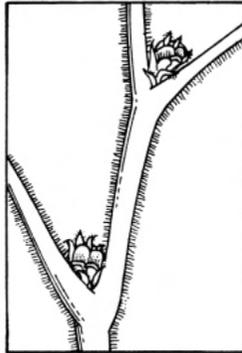


# Why apply fertilizer

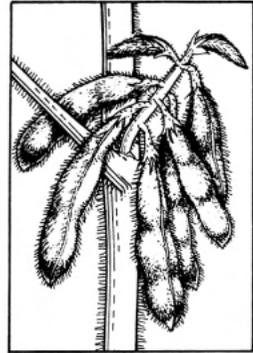
The plant needs nutrients to make its own food . . . .



— to grow



— to flower



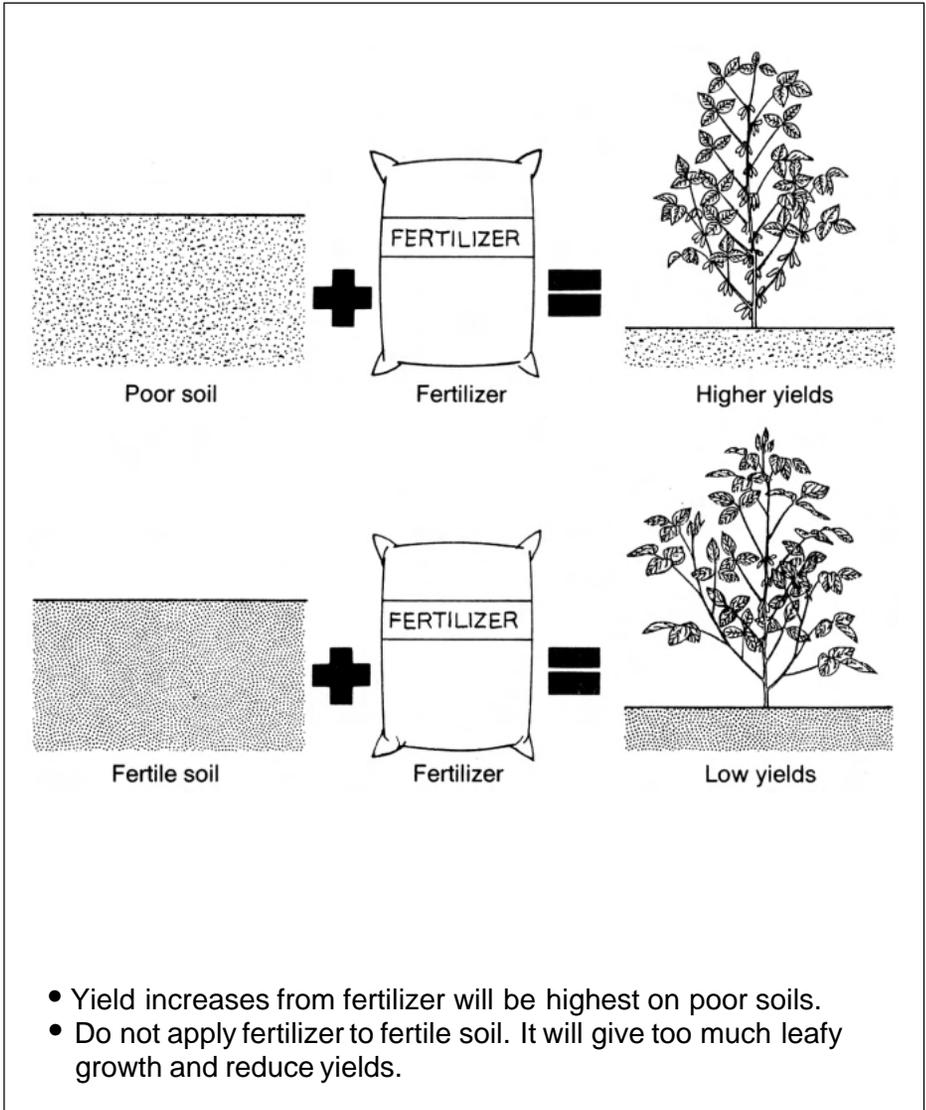
— to set seed

Nutrients that the soybean plant needs

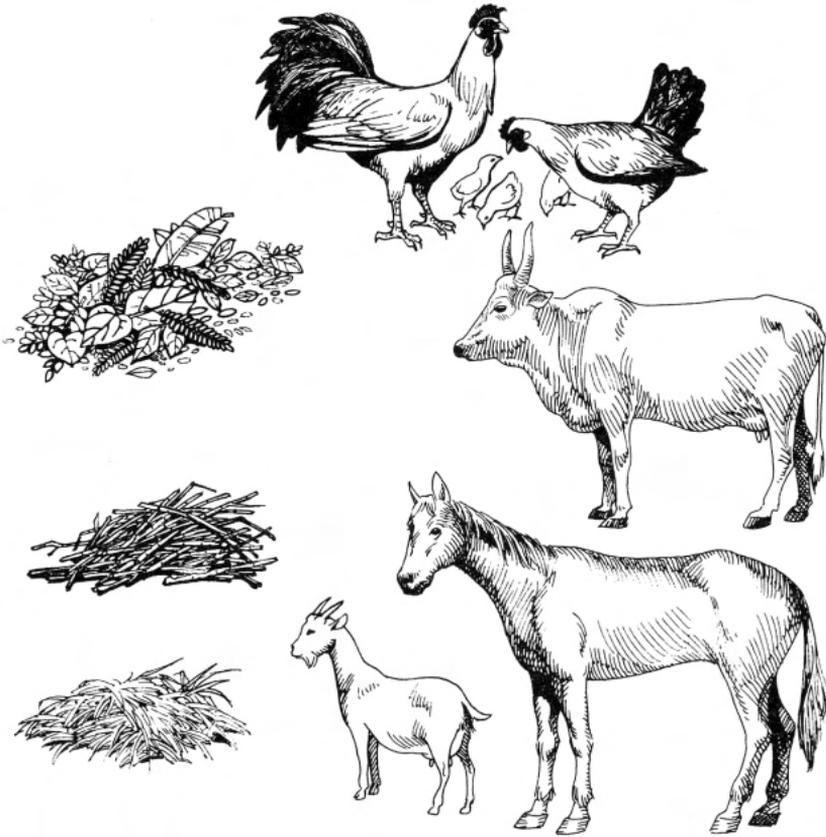
Nitrogen	Magnesium	Molybdenum	Zinc
Phosphorus	Sulfur	Boron	Manganese
Potassium	Calcium	Iron	

- A soybean plant needs many nutrients for healthy growth and high yields. Many of these are supplied by the soil.
- Where soils are poor, these nutrients must be supplied by adding fertilizer.

# Yield increases from fertilizer applied

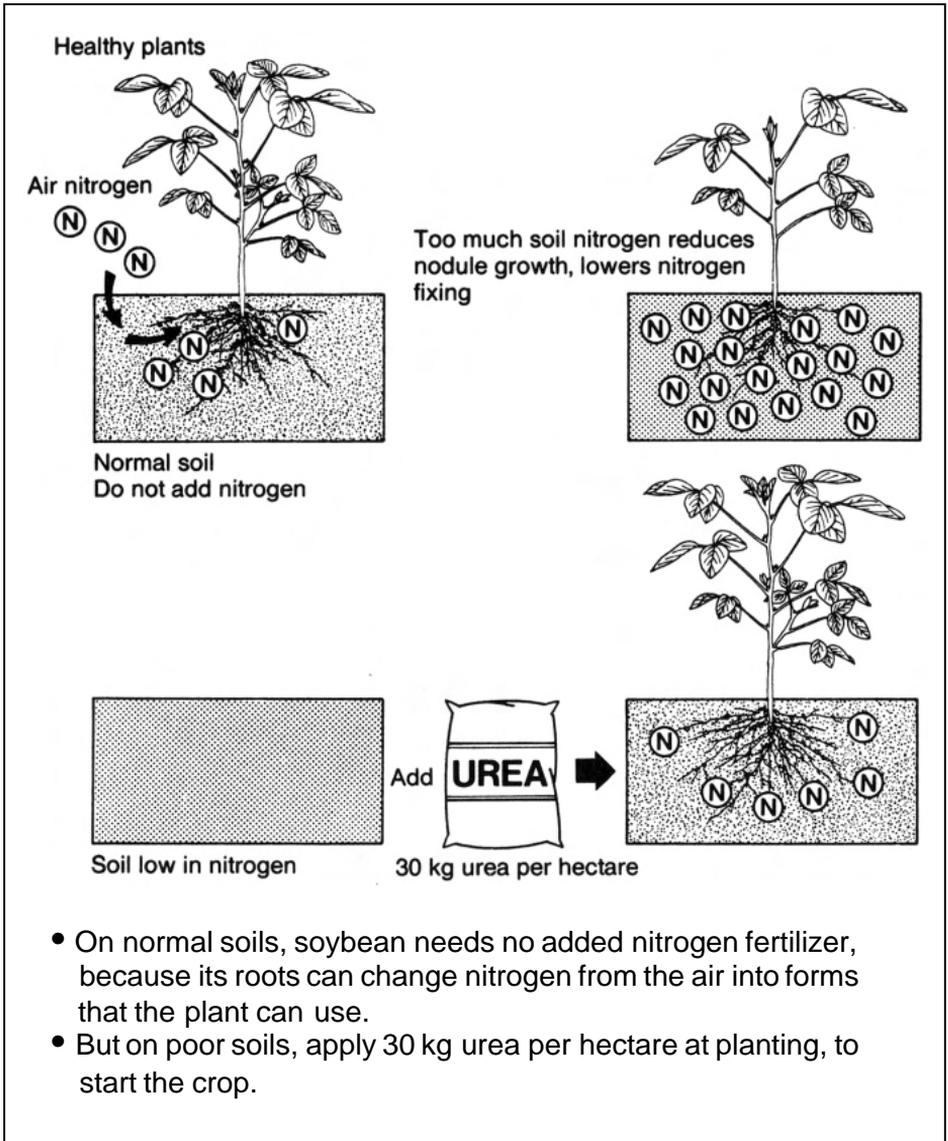


# Organic fertilizer



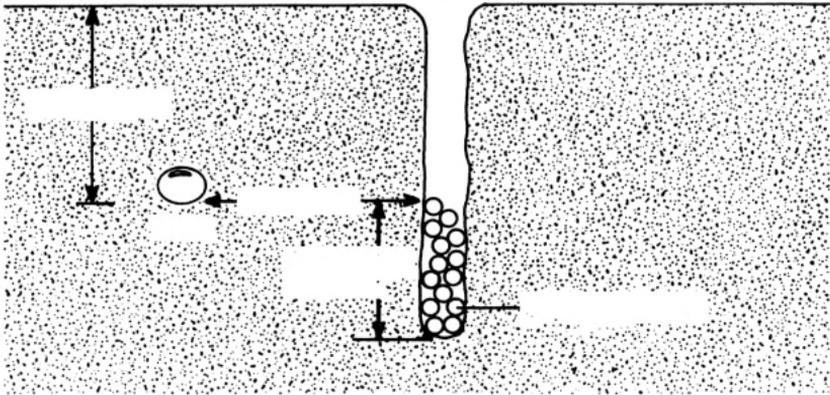
- Add organic fertilizer in any amount possible. Very large amounts are needed to improve seed yields significantly. But even small amounts will improve the soil structure and plant growth.

# Fertilizer — nitrogen



- On normal soils, soybean needs no added nitrogen fertilizer, because its roots can change nitrogen from the air into forms that the plant can use.
- But on poor soils, apply 30 kg urea per hectare at planting, to start the crop.

# Fertilizer — phosphorus



- Soybean needs phosphorus for root and nodule growth and for flowering.
- If soil is low in phosphorus, add 180 kg per hectare single superphosphate at planting time.

# Fertilizer — potassium



Soil low in potassium

Add

**K**

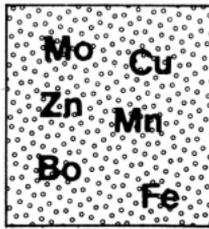
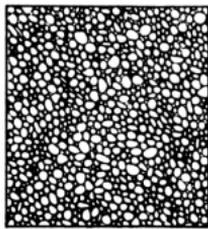
50 to 60 kg potash per hectare at planting

Seed

Potash

- Most soils have enough potassium for the soybean crop.
- Where soil tests low in potassium, 50 to 60 kg potash per hectare should be applied at planting.

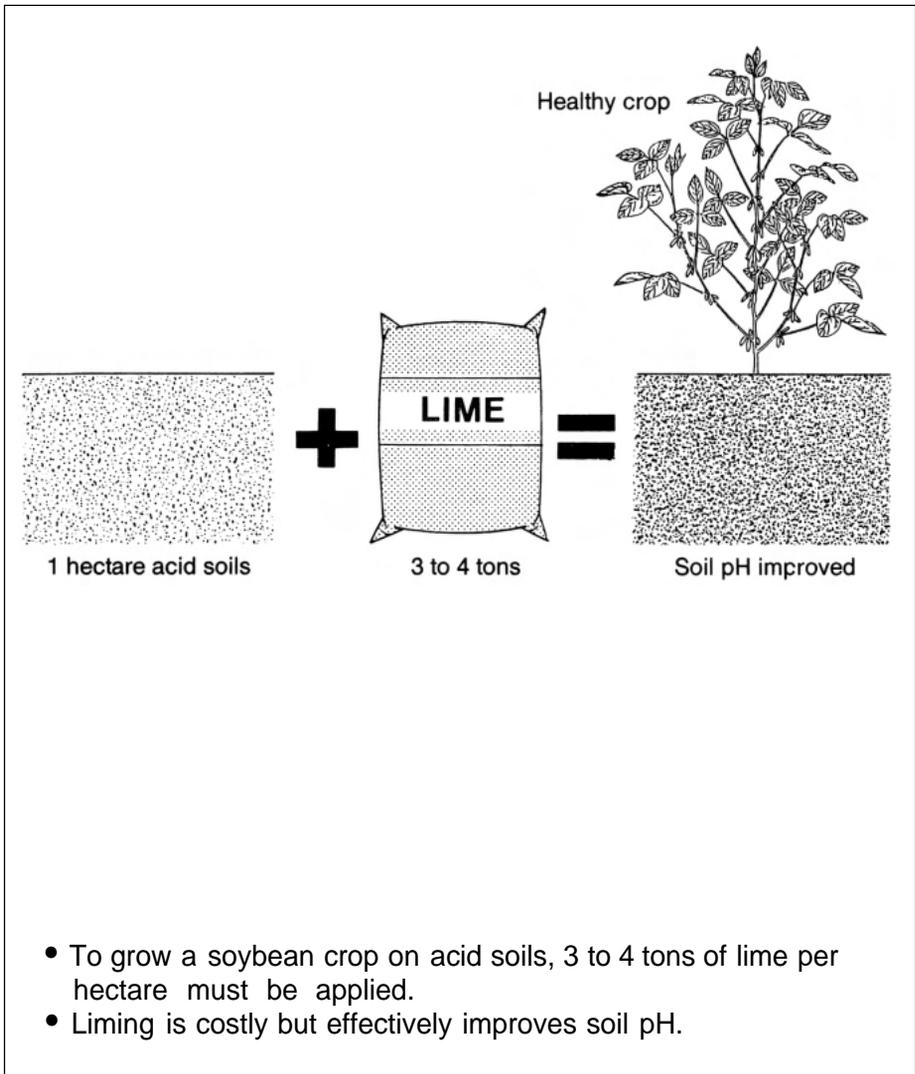
# Fertilizer — micronutrients



Good crop yield

- Micronutrients are needed only in very small amounts, and most soils contain enough.
- A micronutrient should be applied only where soil tests show a lack of it.

# Lime

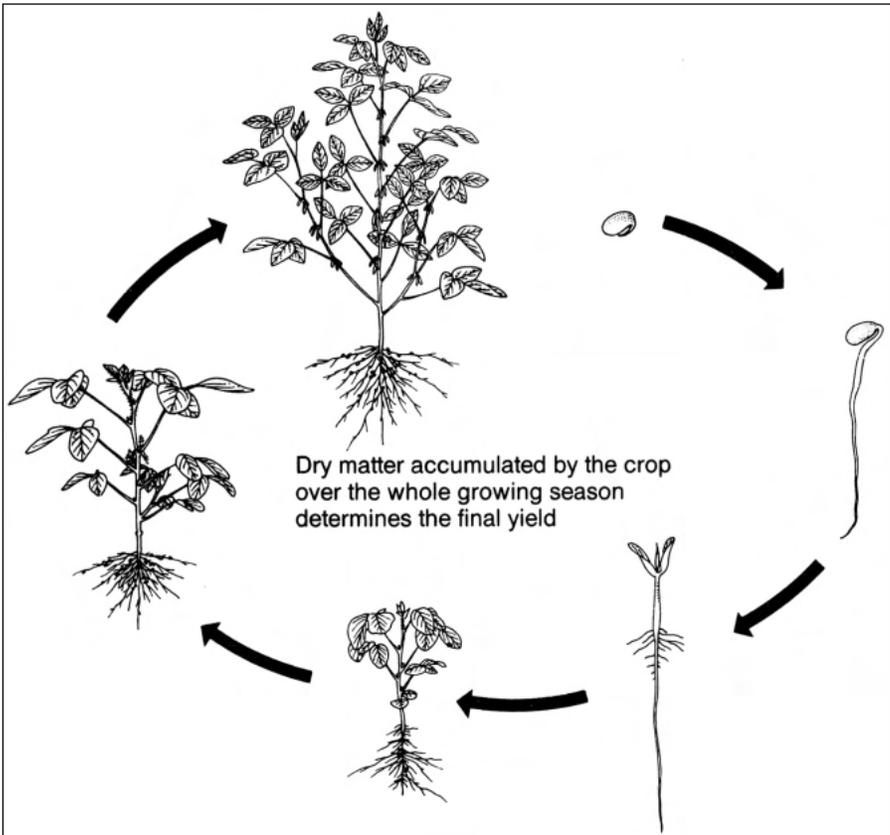


# Growing conditions and dry matter production

Dry matter production	<b>115</b>
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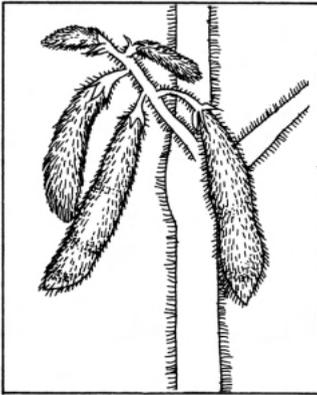


# Dry matter production



- The dry matter produced by a plant is the fresh plant weight minus water.
- The dry matter accumulated by the crop over the whole growing season determines the final yield.
- Growing conditions at each stage affect dry matter accumulated.

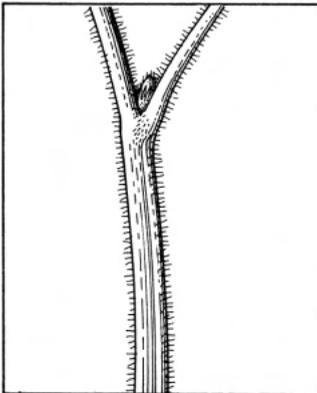
# Dry matter distribution



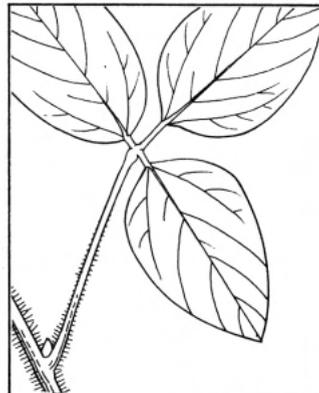
Pod



Root/nodule



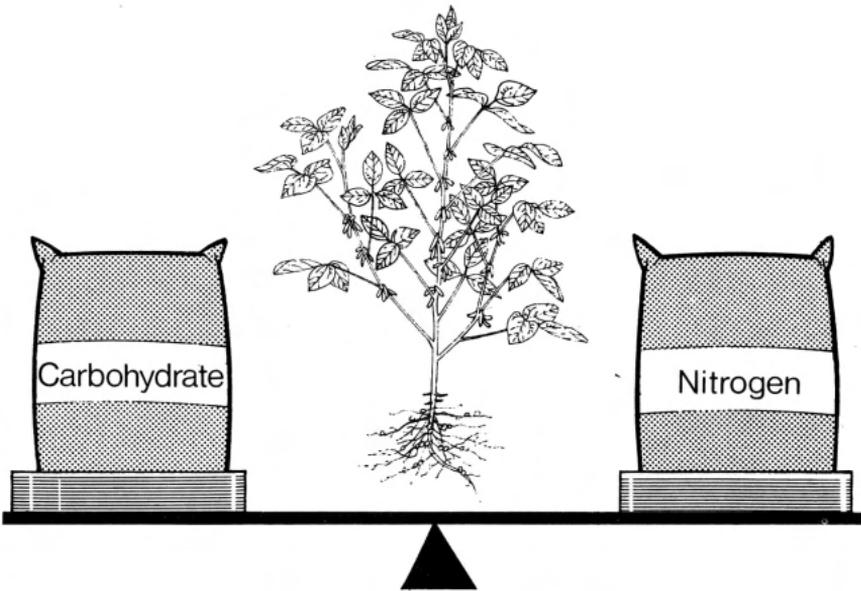
Stem



Leaves/petioles

- High seed yield depends on proper distribution of dry matter to roots, stem, leaves, and pods.

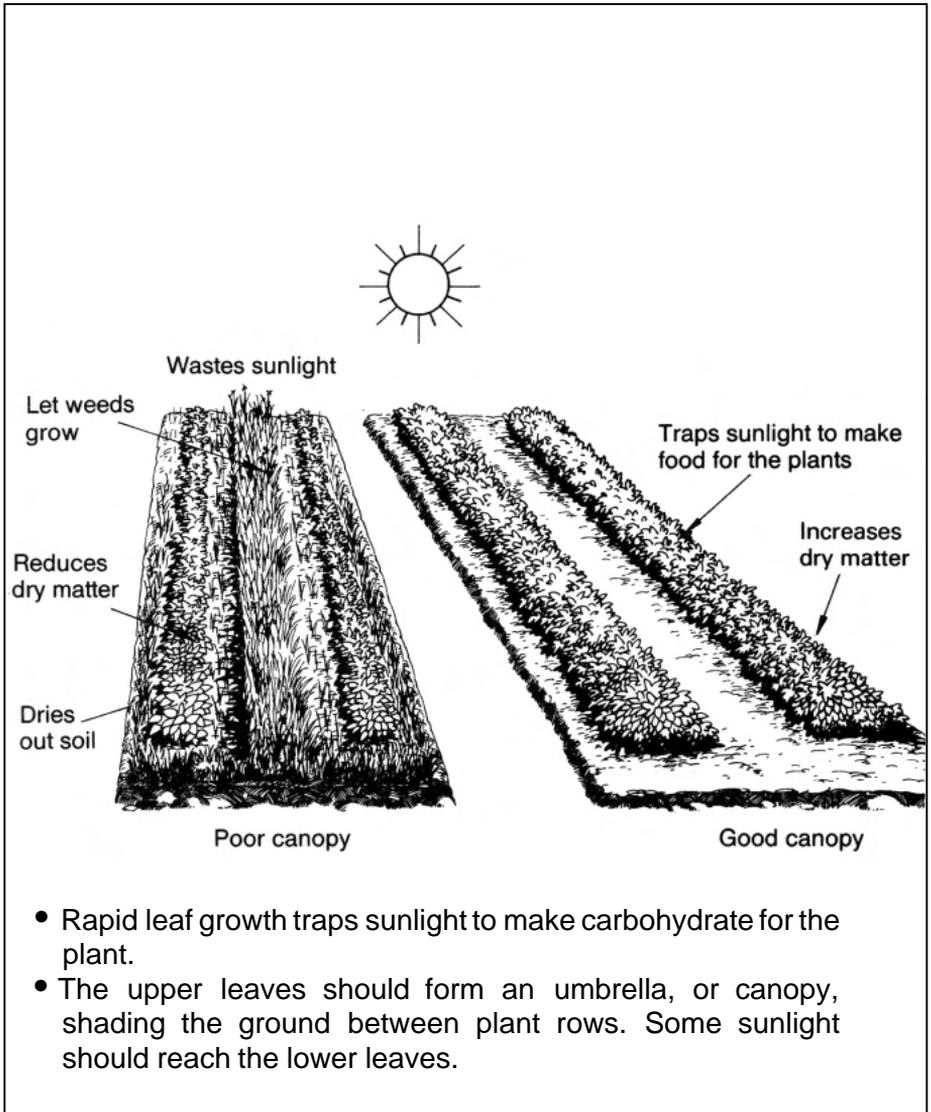
# Factors affecting dry matter production



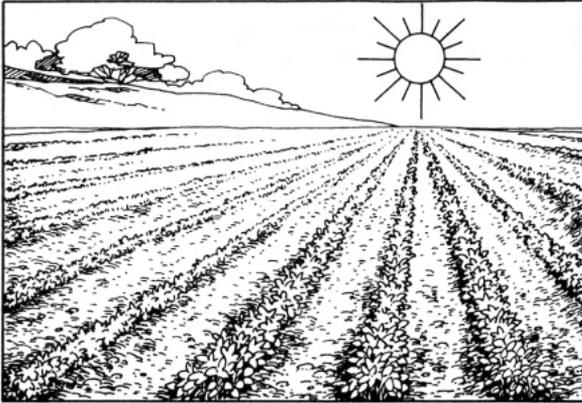
A balance of carbohydrate and nitrogen

- For best dry matter production, there should be a balance between the carbohydrate made by the leaves and the nitrogen fixed by the roots.

# Factors affecting dry matter production— leaf growth



# Factors affecting dry matter production — sunlight



Light increases dry matter production

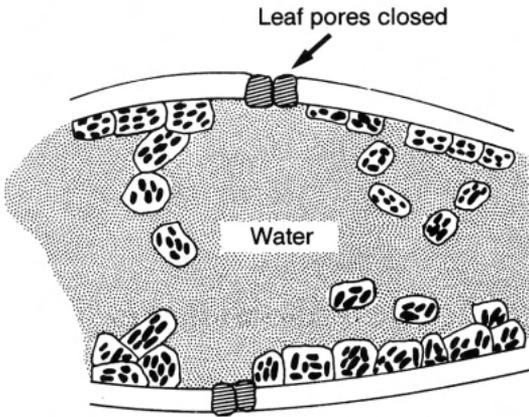


Shade reduces dry matter production

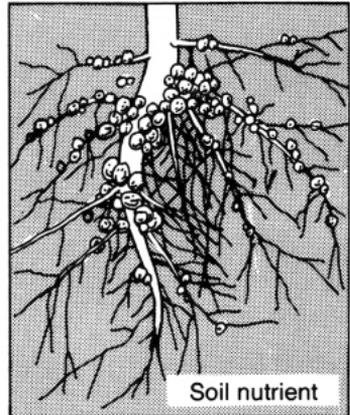
- Bright sunlight increases dry matter produced.
- When soybean is grown in the shade, dry matter is reduced as shade increases.

# Factors affecting dry matter production — water

Cross section of a highly magnified leaf



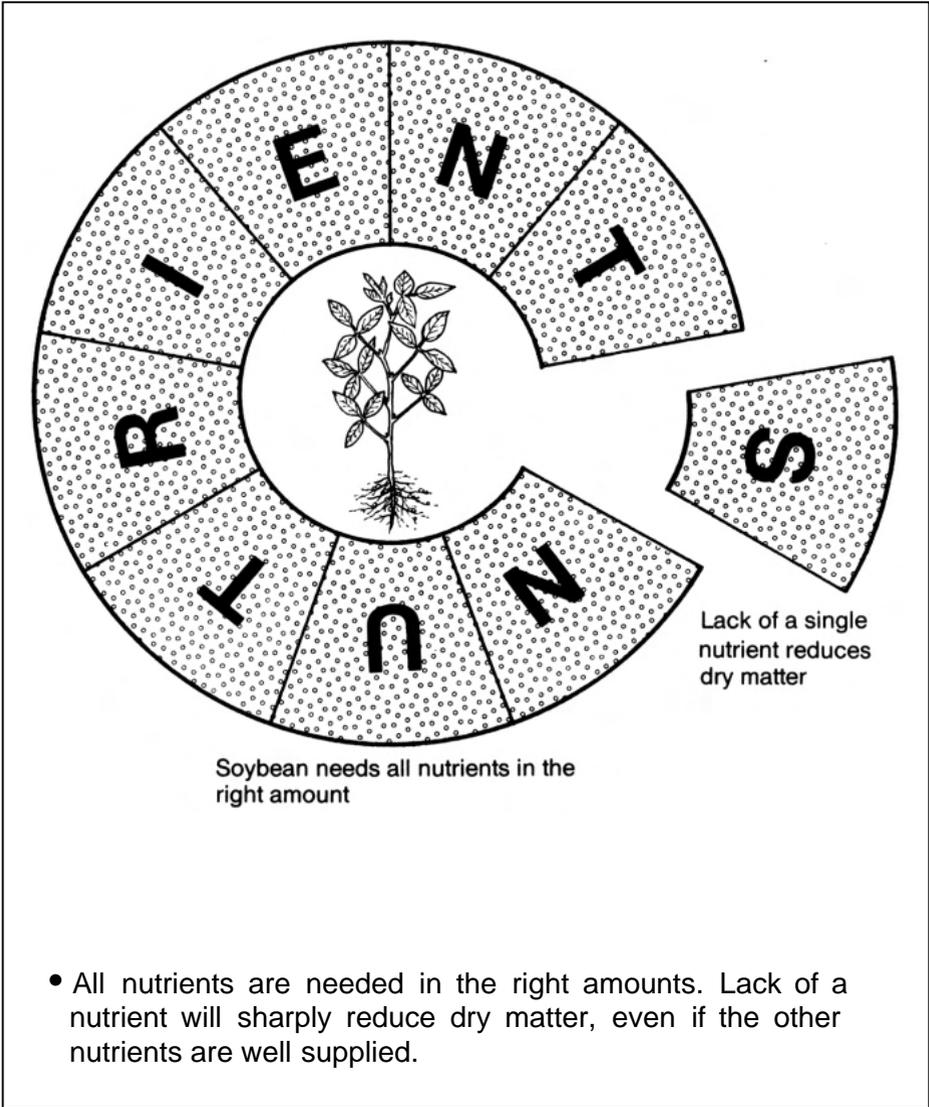
With little water, leaf pores close, reducing food made by leaves



With too much water, roots can not absorb soil nutrients

- The maximum dry matter is produced when the soil contains the right amount of moisture.
- Soybean should be grown on deep, well-drained soils.

# Factors affecting dry matter production — nutrients





# Harvesting and storing soybean

Harvesting	<b>125</b>
Threshing	<b>126</b>
Storage	<b>127</b>



# Harvesting

Harvest within a week after 95% pods have turned yellow



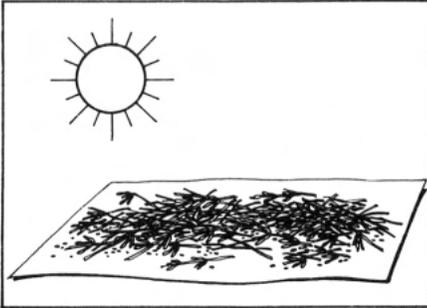
Machine harvest



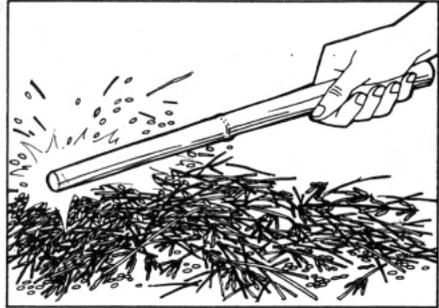
Hand picked

- Harvesting at the right time is critical to soybean seed quality and yield.
- When harvest is delayed soybean pods shatter, causing seed loss.
- Rain after pods have ripened will spoil seed quality.

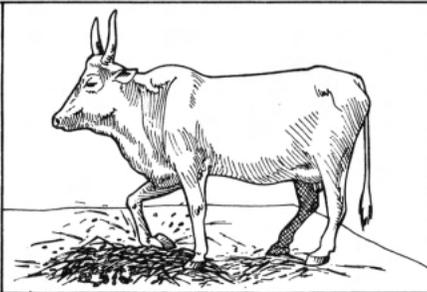
# Threshing



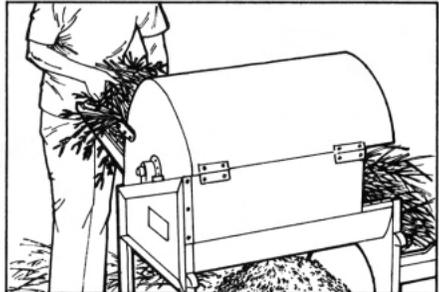
Sun or machine dried pods with less than 12% moisture



Beaten with a stick



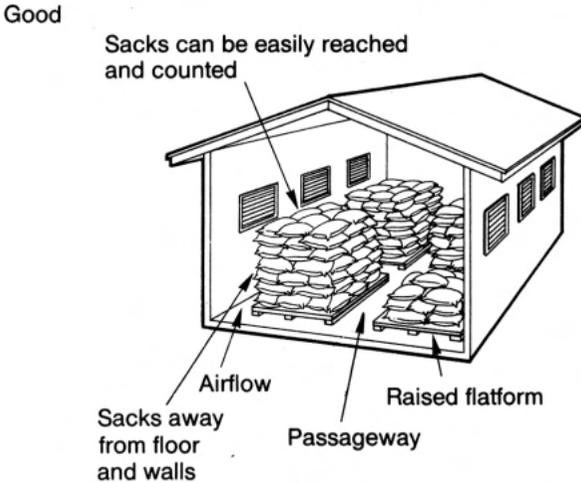
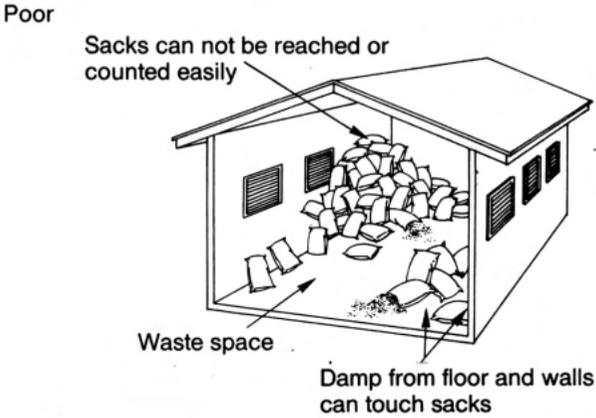
Trampled by cattle



Threshed by machine

- Harvested pods should be well dried before threshing.
- Hand threshing is usually done by beating with a stick.
- For large-scale production, soybean can be machine-threshed.

# Storage



- Seed for storage should be dry, with no more than 12% moisture.
- The storage shed should be cool and dry.



# **Increasing yields and profits**

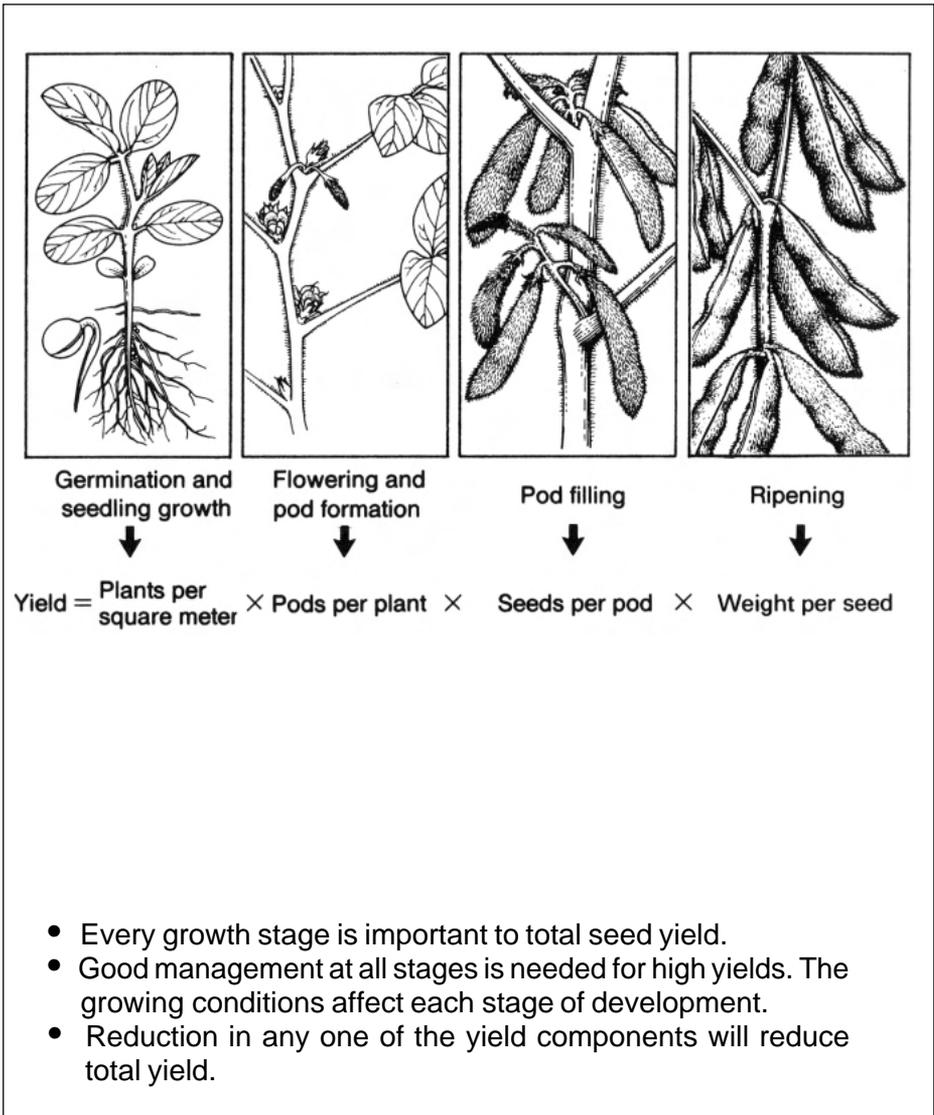


# Increasing yields and profits — yield components

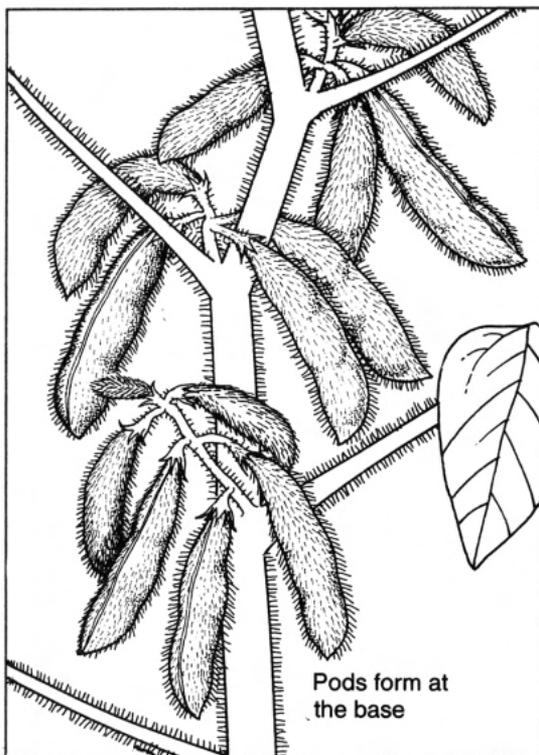
Yield components	<b>133</b>
Yield components — pods per plant	<b>134</b>
Yield components — seeds per pod	<b>135</b>
Yield components — seed weight	<b>136</b>



# Yield components



# Yield components — pods per plant



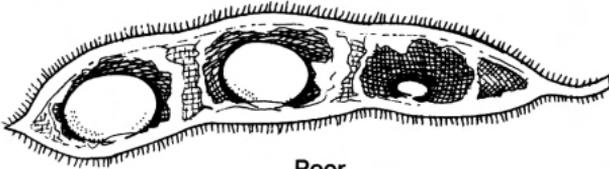
- The number of pods per plant is the most important yield component.
- About 40 percent of the flowers on a plant form pods. These can produce a good seed yield under favorable growing conditions.

# Yield components — seeds per pod



Good

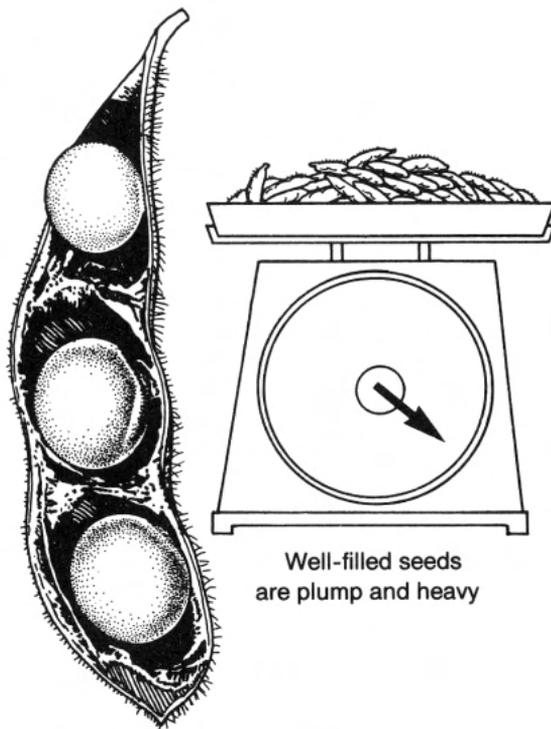
Well-filled pods have no empty seeds



Poor

- The number of seeds per pod is determined at flowering, when the male pollen cell fertilizes the egg in the ovary.

# Yield components — seed weight



- Maximum seed size and weight depend on soybean variety.
- The weight of a seed is determined during seed filling.
- Drought or lack of nutrients at this stage will reduce the rate and length of time of seed filling.

# Increasing yields and profits — production factors

Production factors	<b>139</b>
Planting improved varieties	<b>140</b>
Making the most of soil moisture	<b>141</b>
Using irrigation	<b>142</b>
Using fertilizer	<b>143</b>
Controlling pests and diseases	<b>144</b>



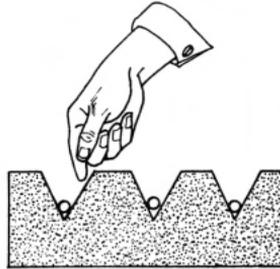
# Production factors



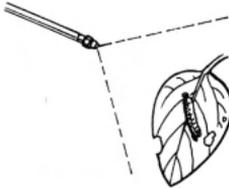
Harvesting time



Variety



Planting time



Pest control

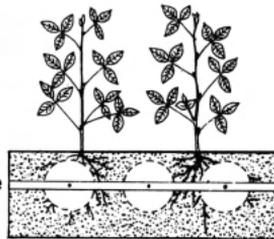


Seeding rate



Fertilizer

Water table

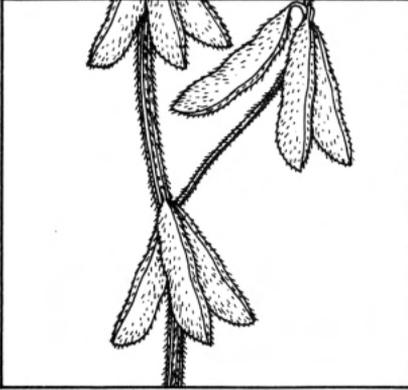


Water

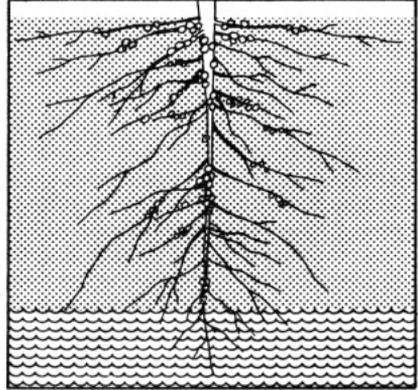
- Yields and profits from soybean can be high with the right combination of production factors.
- The right combination depends on soybean variety, and on season, location, and growing conditions.

# Planting improved varieties

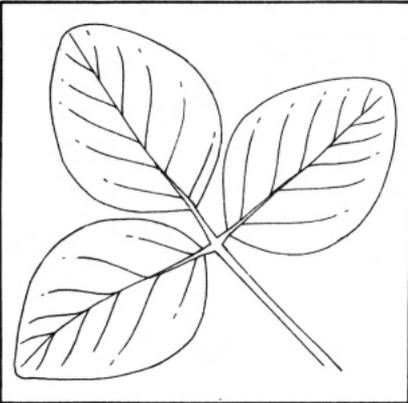
Plant varieties resistant to pests and diseases



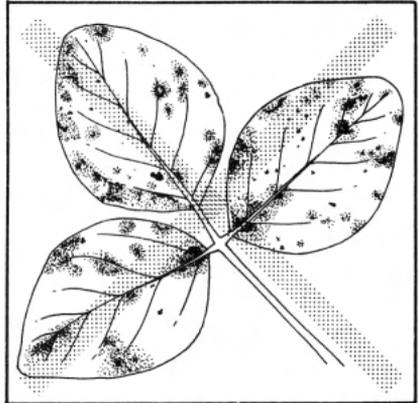
Plant high yielding varieties



Plant deep-rooted varieties that can reach subsoil water



Resistant

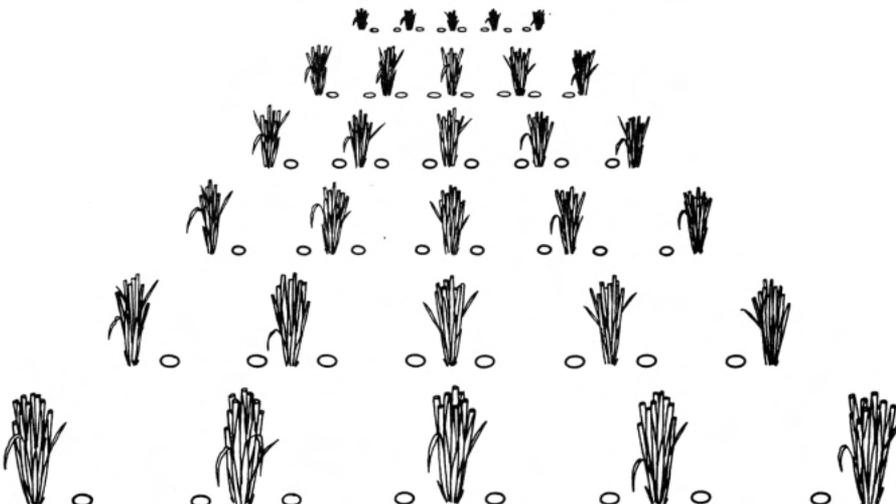


Susceptible

- Improved varieties give higher yields than traditional ones.
- Plant high-yielding varieties that are resistant to insects and diseases.

# Making the most of soil moisture

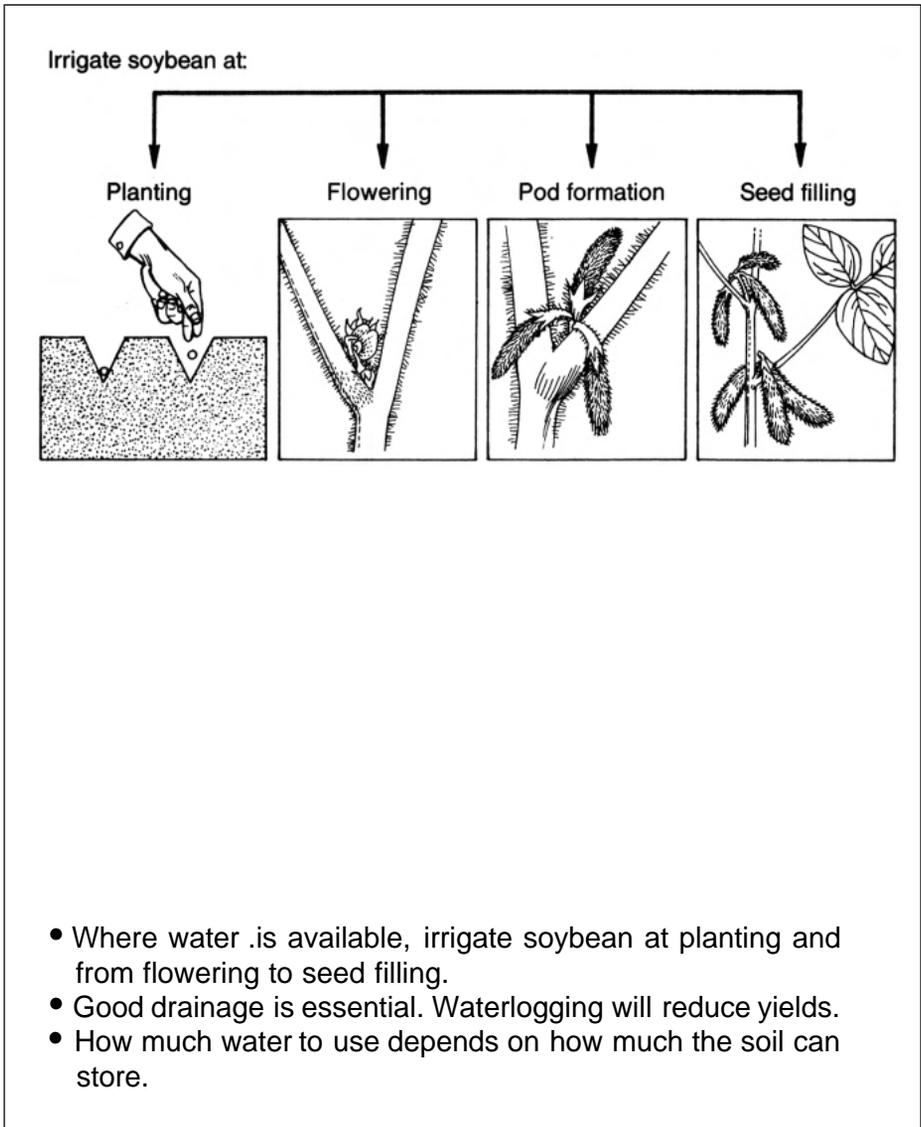
Use zero tillage and narrow rows



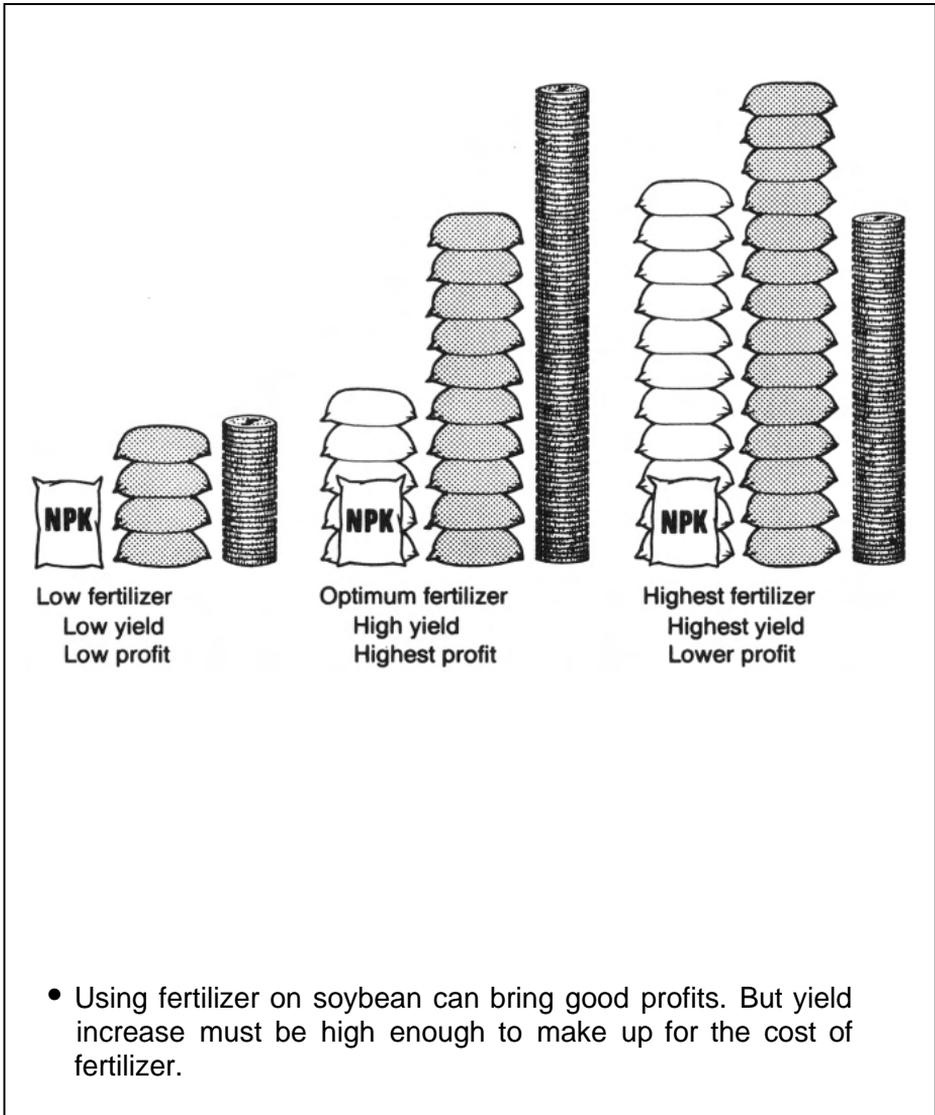
The diagram illustrates a planting layout for crops using zero tillage and narrow rows. It shows a grid of plants in narrow rows, with the text "Use zero tillage and narrow rows" above it. The plants are arranged in a pattern that suggests a high density of plants per row, with the rows themselves being narrow. The plants are shown in various stages of growth, from small seedlings to larger, more developed plants. The layout is designed to maximize the use of soil moisture by minimizing the distance between plants and reducing the amount of soil that is tilled.

- In rainfed crops, making the most of soil moisture is the key to high yields.
- Plant soybean at once after the rice harvest. Or plant as a relay crop in standing rice 10 days before harvest.

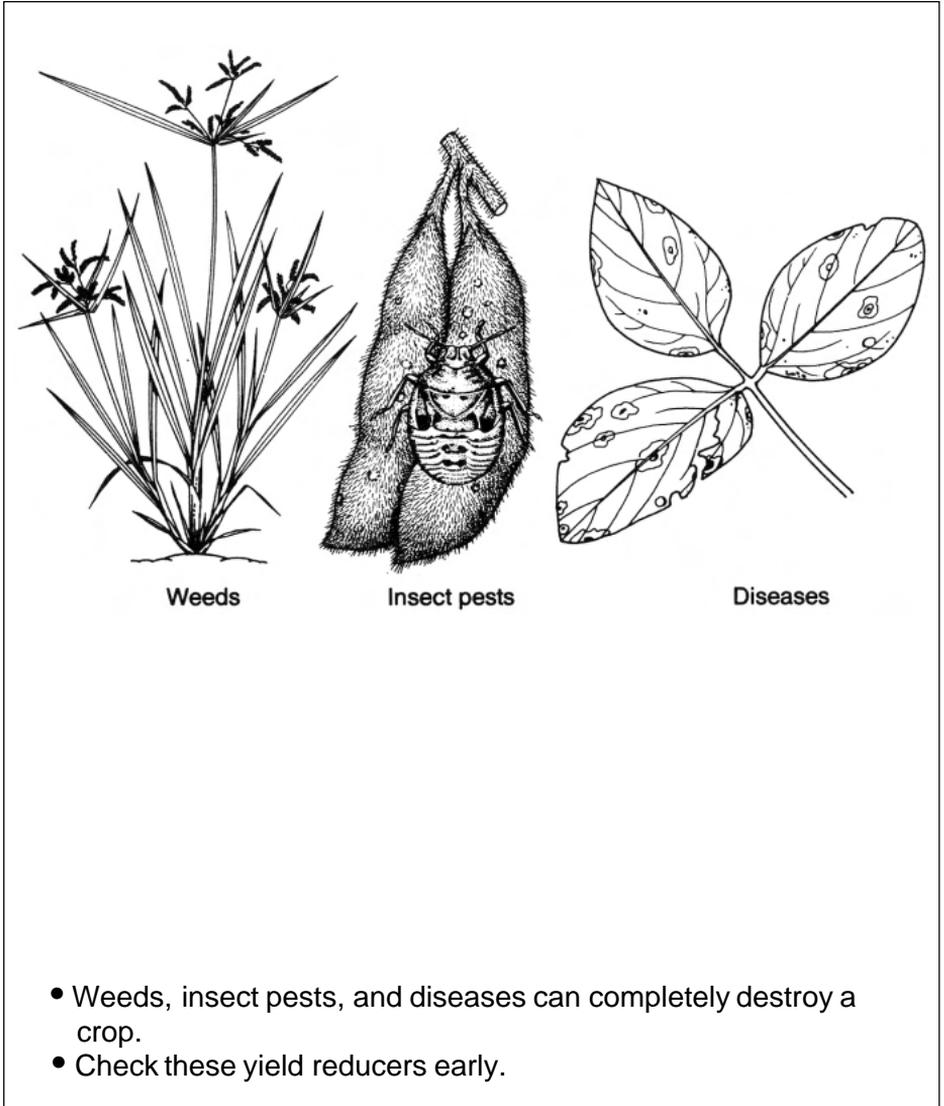
# Using irrigation



# Using fertilizer



# Controlling pests and diseases

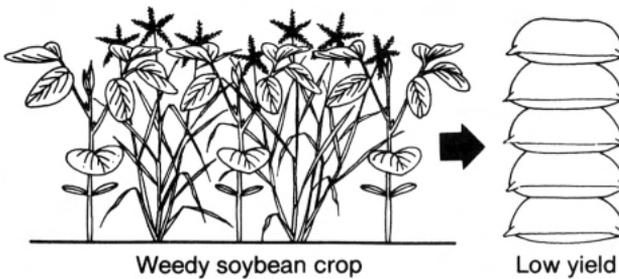
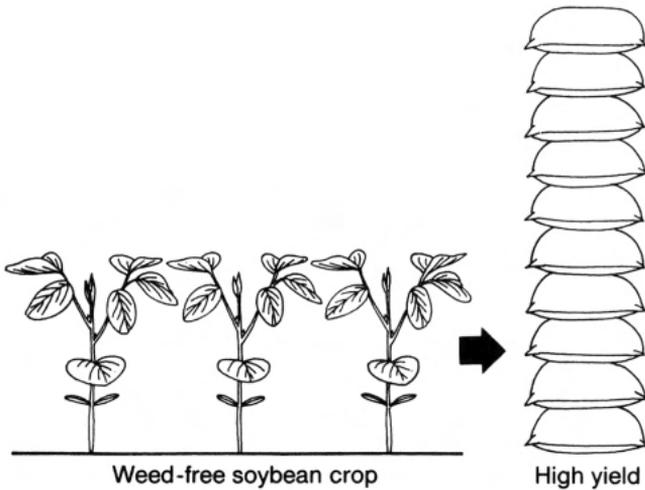


# Yield reducers — weeds

Yield loss from weeds	<b>147</b>
Weeds compete with soybean	<b>148</b>
Weeds affect seedling growth	<b>149</b>
Controlling weeds — by handweeding	<b>150</b>
Using cultural practices	<b>151</b>
By intercultivation	<b>152</b>
Using herbicides	<b>153</b>
Common soybean weeds	<b>154</b>
Grasses	<b>155</b>
Grasses	<b>156</b>
Sedges	<b>157</b>
Sedges	<b>158</b>
Broadleaf weeds	<b>159</b>
Broadleaf weeds	<b>160</b>
Broadleaf weeds	<b>161</b>

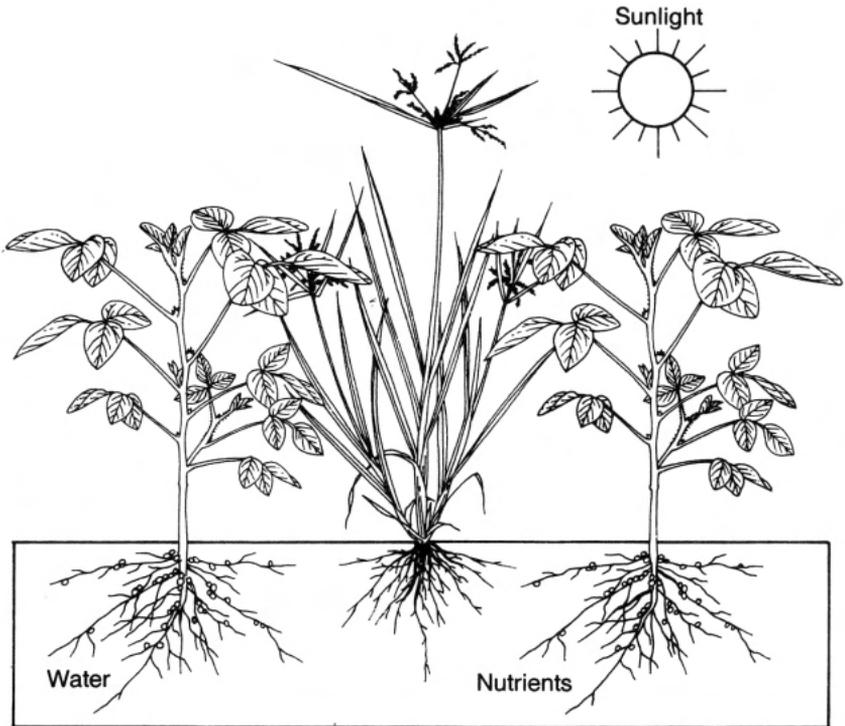


# Yield loss from weeds



- Weeds reduce yields in all seasons – more in the wet season than in the dry season.

# Weeds compete with soybean



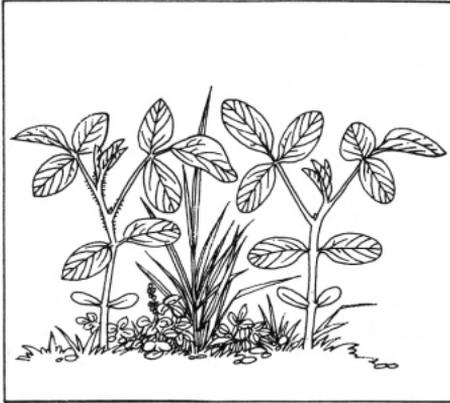
- Weeds compete with the soybean plant for sunlight, nutrients, and water.

# Weeds affect seedling growth

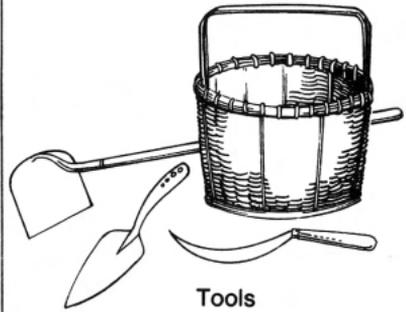


- Weeds do the most damage in the first 5 weeks after soybean is planted.

# Controlling weeds — by handweeding



First handweeding



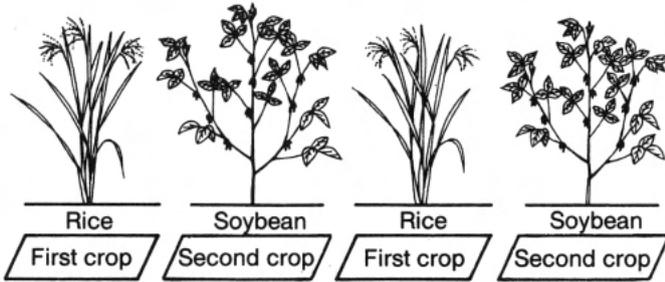
Tools



Second handweeding

- Weeds can be controlled by handweeding.
- Two handweeding are needed — one 2 weeks after planting and one at flowering.

# Using cultural practices



Tillage

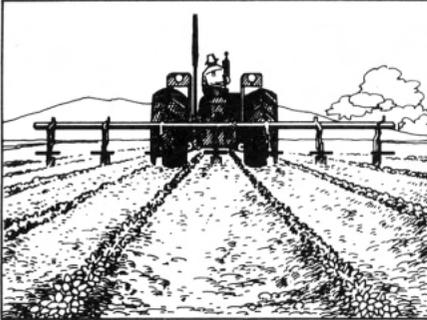


Early planting

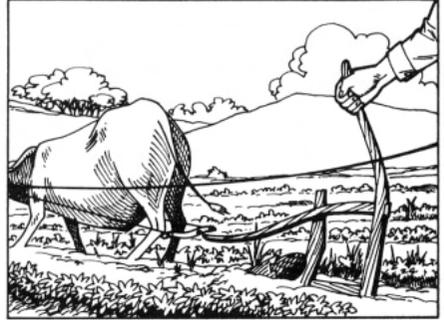


- Crop rotation, tillage, and early planting reduce weeds.

# By intercultivation



Tractor



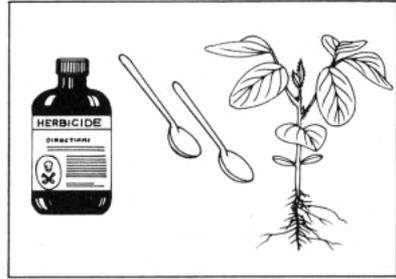
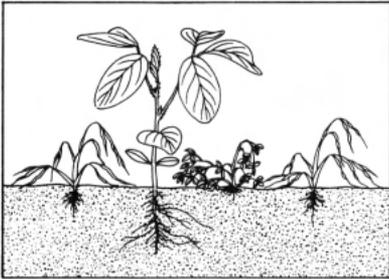
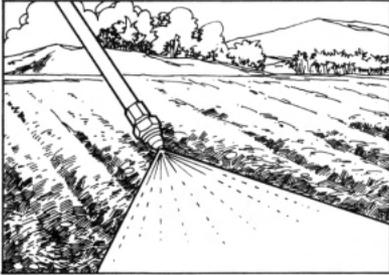
Animal-drawn



Hand

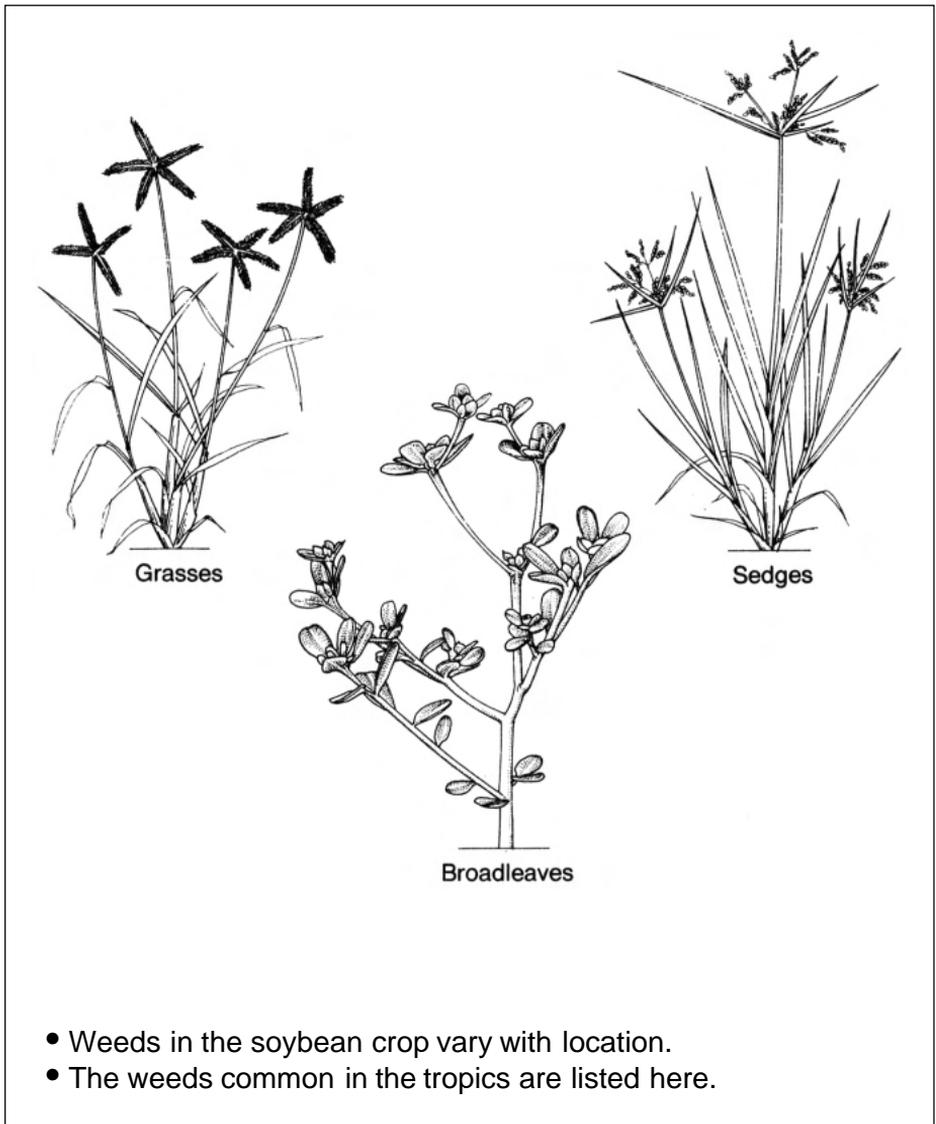
- Weeds can be controlled by intercultivation using a hand hoe or animal-drawn tools.
- For large-scale production, a tractor should be used.

# Using herbicides



- Weeds can be controlled with chemical herbicides that kill the weeds but let soybean grow.
- Herbicides can be applied at planting to keep weeds from growing.

# Common soybean weeds



# Grasses



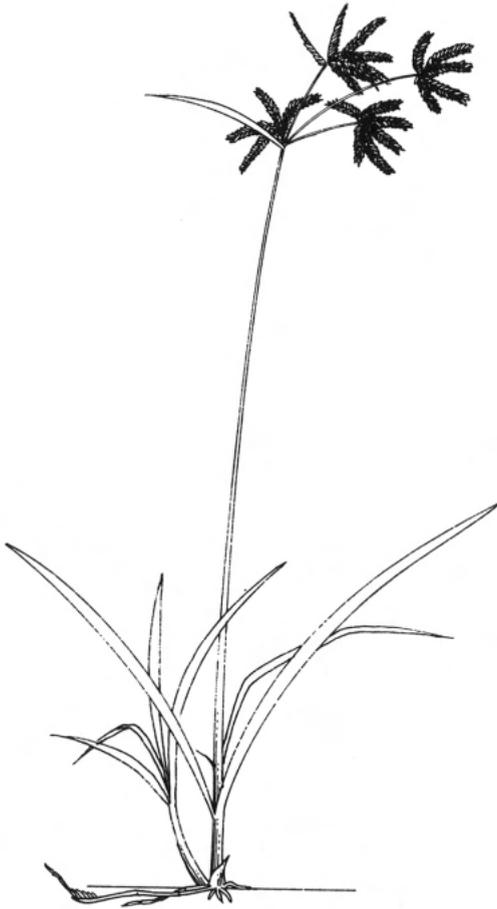
- Scientific name: *Echinochloa colona*

# Grasses



- Scientific name: *Dactyloctenium aegyptium*

# Sedges



- Scientific name: *Cyperus rotundus*

# Sedges



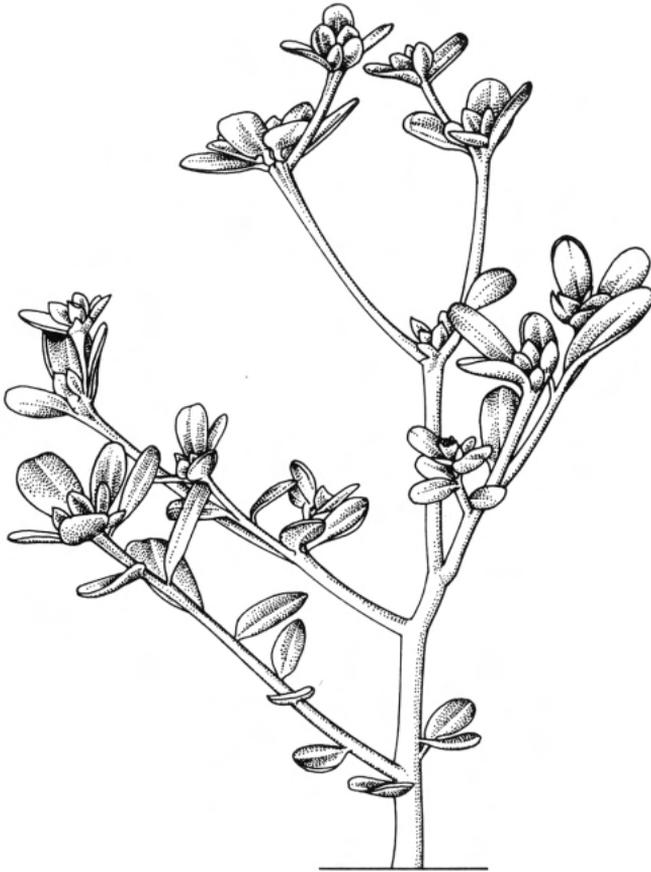
- Scientific name: *Cyperus iria*

# Broadleaf weeds



- Scientific name: *Amaranthus spinosus*  
Common name: Spiny amaranth

# Broadleaf weeds



- Scientific name: *Portulaca oleracea*

# Broadleaf weeds



- Scientific name: *Mimosa pudica* L.  
Common name: Touch-me-not

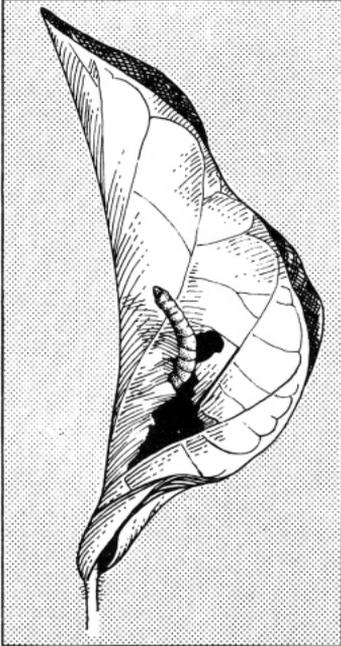


# Yield reducers — insect pests

Yield loss to insect pests	<b>165</b>
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Using insecticides	<b>168</b>
Combining pest control methods	<b>169</b>
Common insect pests of soybean in the tropics — at seedling stage	<b>170</b>
At preflowering stage	<b>171</b>
At preflowering stage	<b>172</b>
Pretlowering to pod formation	<b>173</b>
At pod development stage	<b>174</b>
At pod development stage	<b>175</b>



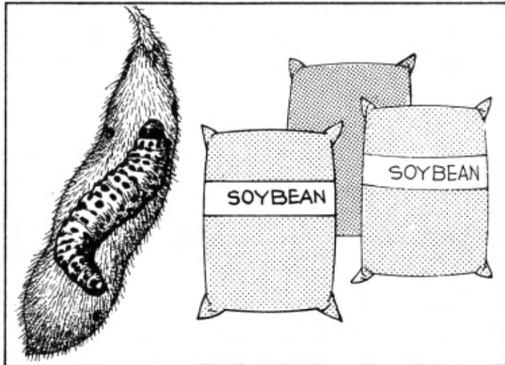
# Yield loss to insect pests



Leafminers and leaffolders reduce yields



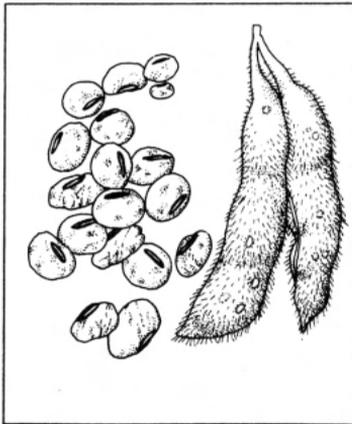
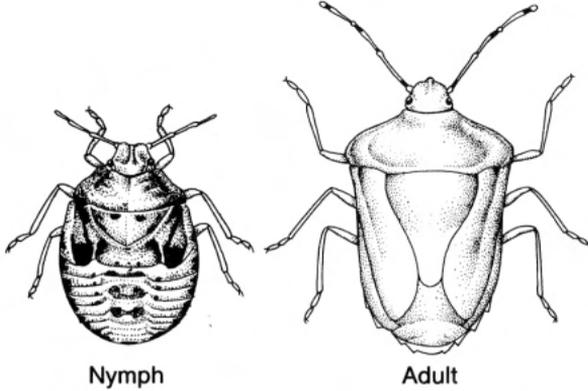
Beanflies stunt or kill seedlings



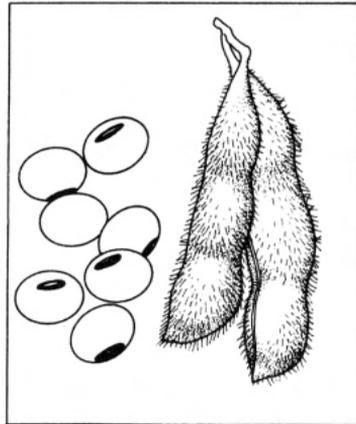
Podborers can cause as much as 80% yield loss

- Insect pests attack soybean at all stages of growth, from emergence to pod ripening.
- The most damaging pests vary with location and season.
- Yield loss depends on the growth stage at which the crop is attacked.

# Controlling pests — planting resistant varieties



Damaged seeds



Resistant variety

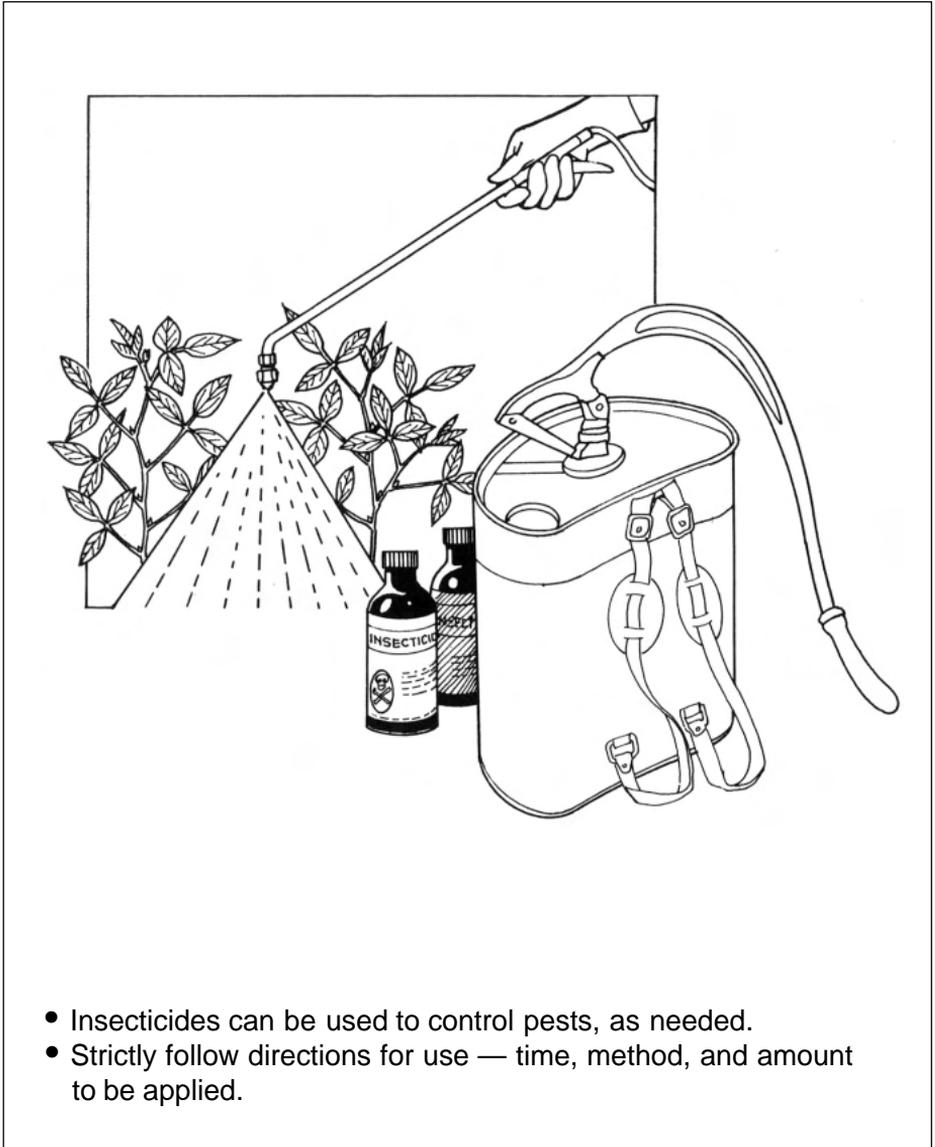
- Some soybean varieties are resistant to one or more insect pests.
- Planting resistant varieties is a low-cost way of controlling insect damage.

# Using cultural practices

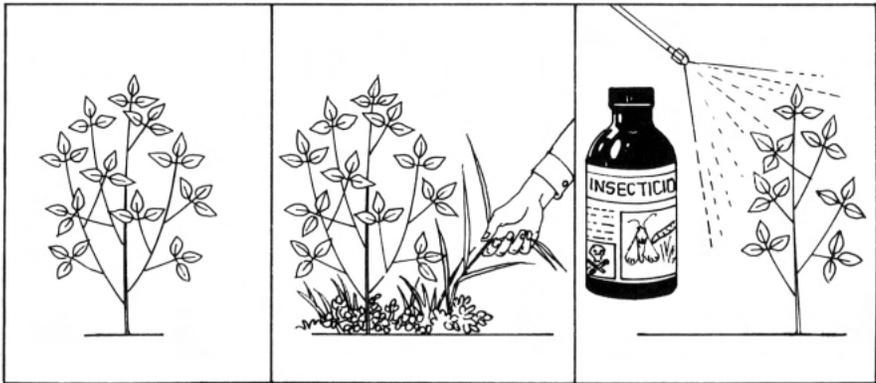


- Some insects can be controlled by cultural practices.

# Using insecticides



# Combining pest control methods



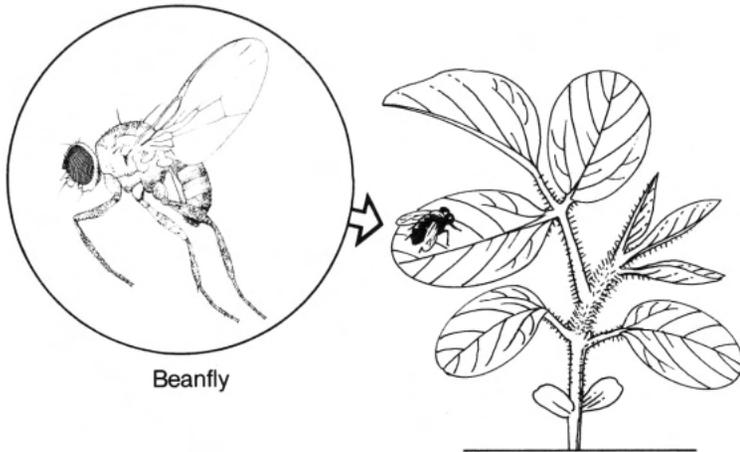
Plant resistant varieties

Cultural practices

Apply insecticides

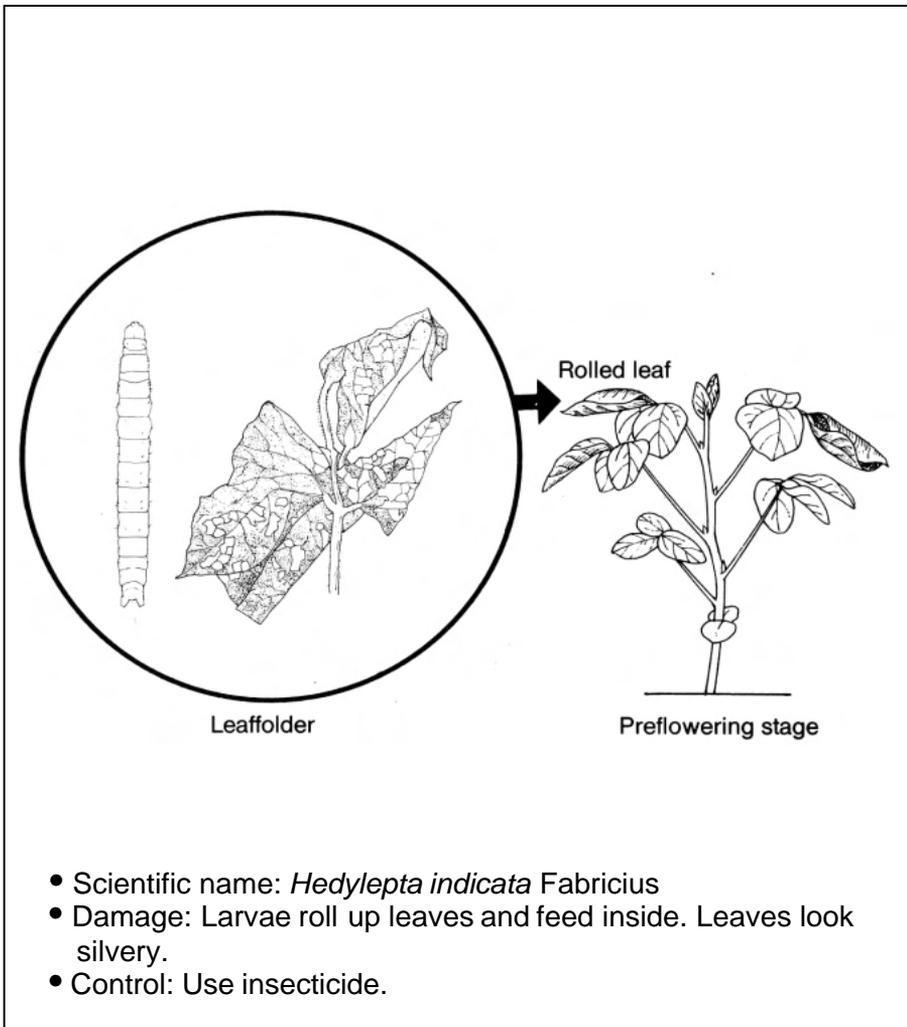
- Several pest control methods can be combined:
  - planting resistant varieties
  - using proper cultural practices
  - applying the right insecticide at the right time.

# Common insect pests of soybean in the tropics — at seedling stage

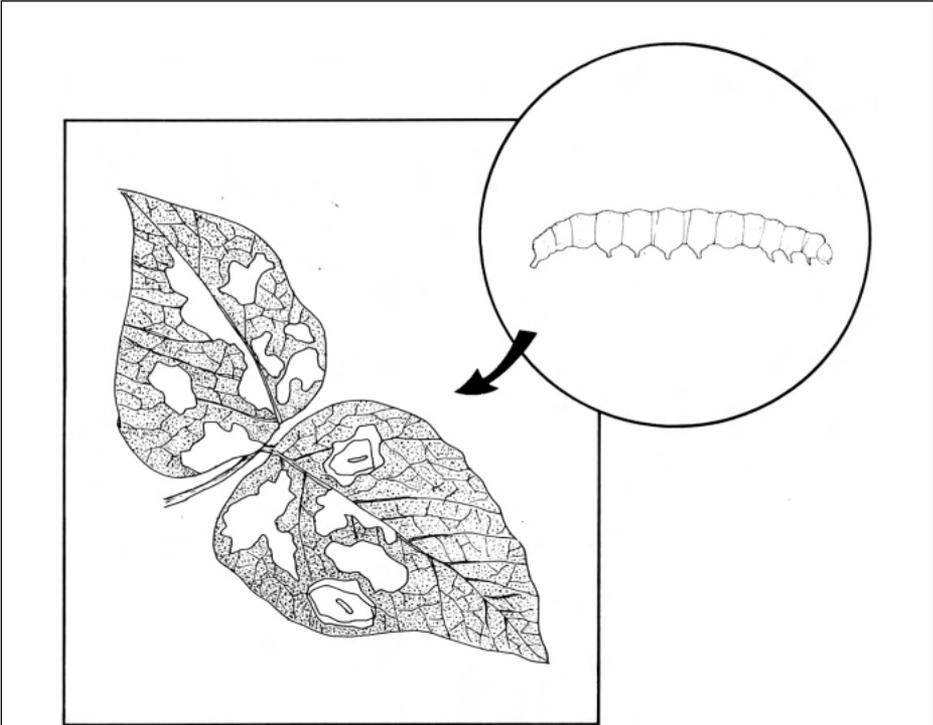


- Scientific name: *Melanagromyza sojae* (Zehntner)  
*Ophiomyia phaseoli* (Tryon)
- Damage: Adults lay eggs on soybean leaves. Larvae tunnel through petioles and main stem. Seedlings are stunted or killed.
- Control: Use insecticide.

# At preflowering stage



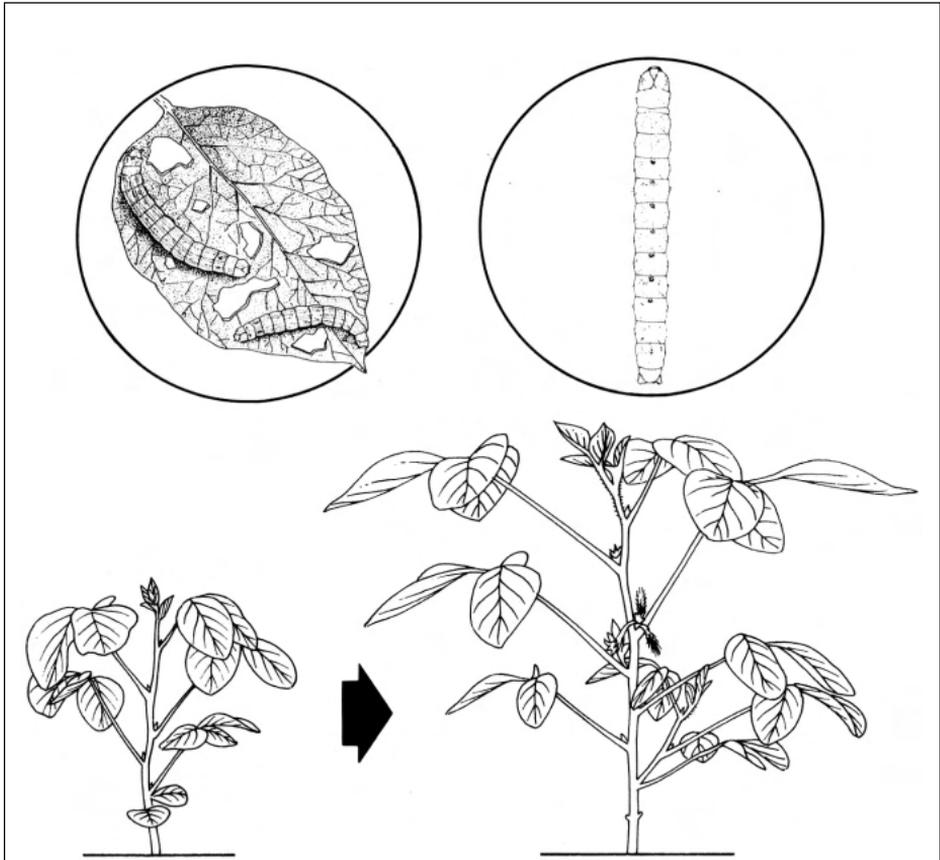
# At preflowering stage



Leafminer

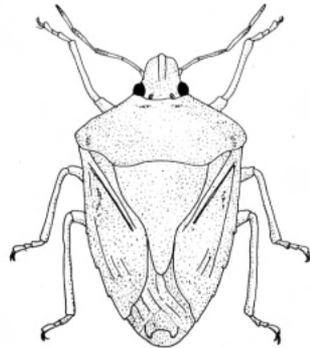
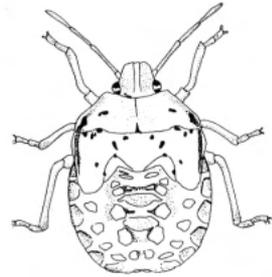
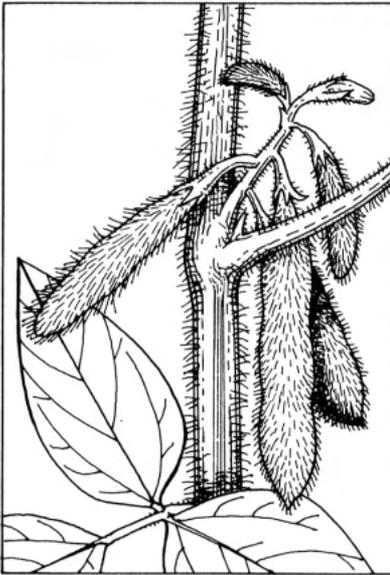
- Scientific name: *Aproaerema modicella* Deventer
- Damage: The reddish caterpillars mine green portion of leaves; only a thin, silvery membrane is left. Leaves may drop off.
- Control: Use insecticide.

# Preflowering to pod formation



- Scientific name:
  1. *Spodoptera litura* (Fabricius)
  2. *Heliothis armigera* (Hubner)
- Damage: Caterpillars feed on plant leaves and stems.
- Control: Use insecticide.

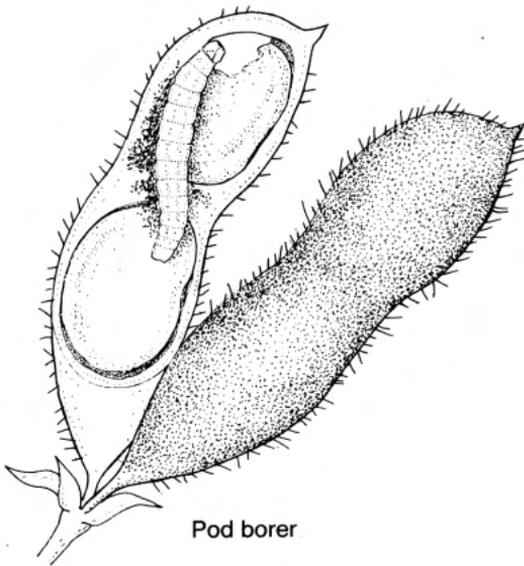
# At pod development stage



Green soldier bug

- Scientific name: *Nezara viridula* (Linnaeus)
- Damage: Young (nymphs) and adult stinkbugs suck juices out of pods and seeds.
- Control: Use insecticide.

# At pod development stage



- Scientific name:
  1. *Etiella zinckenella* (Treitschke)
  2. *Maruca testulalis* (Geyer)
- Damage: Larvae bore on young pods, feed on developing seeds and cause heavy yield loss.
- Control: Use insecticide.

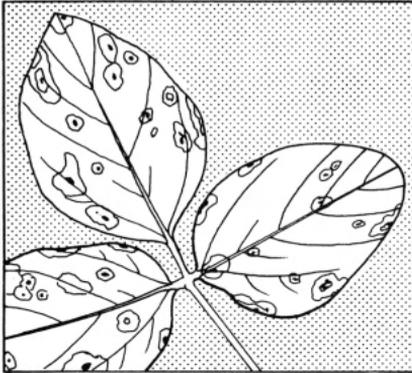


# Yield reducers — diseases

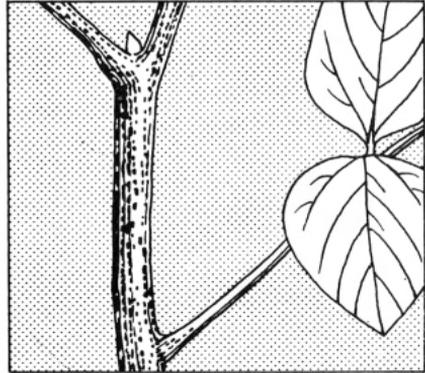
Yield loss to diseases	<b>179</b>
Controlling diseases — planting resistant varieties	<b>180</b>
Using cultural practices	<b>181</b>
Using chemicals	<b>182</b>
Soybean diseases common in the tropics —	
Pythium seedling rot	<b>183</b>
Fusarium root rot	<b>184</b>
Rhizoctonia root rot	<b>185</b>
Phytophthora root rot	<b>186</b>
Charcoal rot	<b>187</b>
Anthracnose	<b>188</b>
Soybean rust	<b>189</b>
Purple seed stain	<b>190</b>
Bacterial pustule	<b>191</b>
Soybean mosaic	<b>192</b>
Bud blight	<b>193</b>



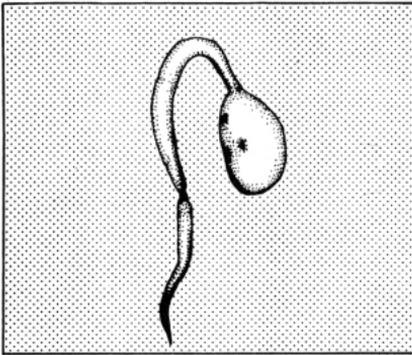
# Yield loss to diseases



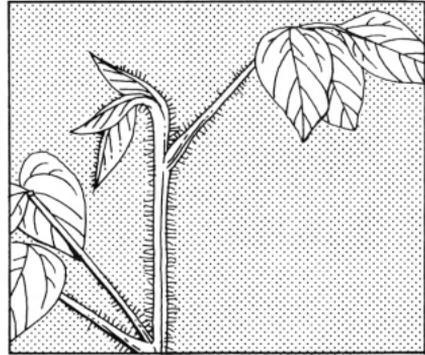
Leaf diseases



Stem diseases



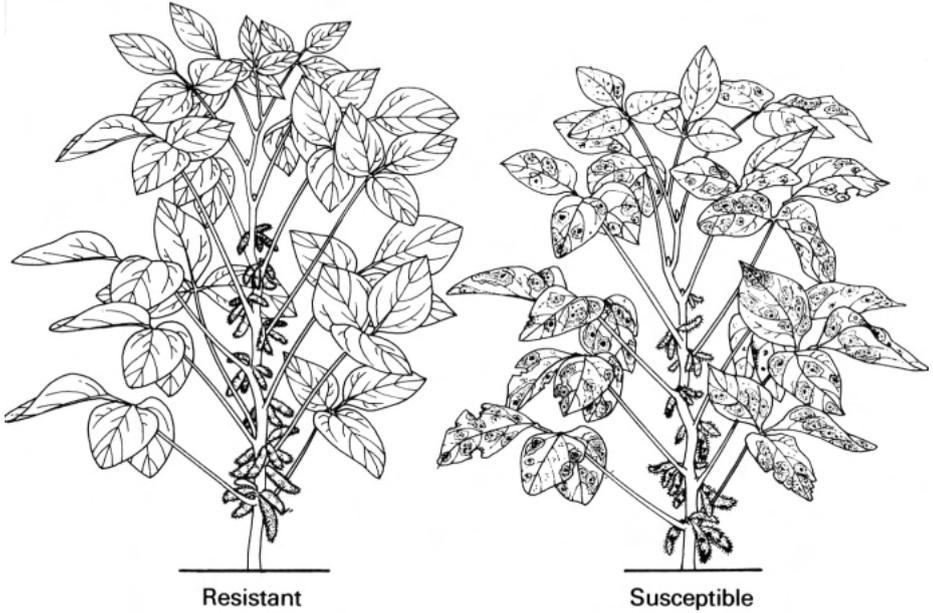
Seedling rot



Bud blight

- Many diseases attack soybean and can severely reduce yields.
- Diseases and their severity vary with location and season. The ones common in the tropics are listed here.

# Controlling diseases — planting resistant varieties



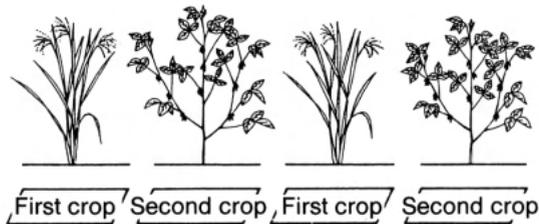
- Some soybean varieties are resistant to one or more diseases.
- Planting resistant varieties is a low-cost way of preventing disease.

# Using cultural practices

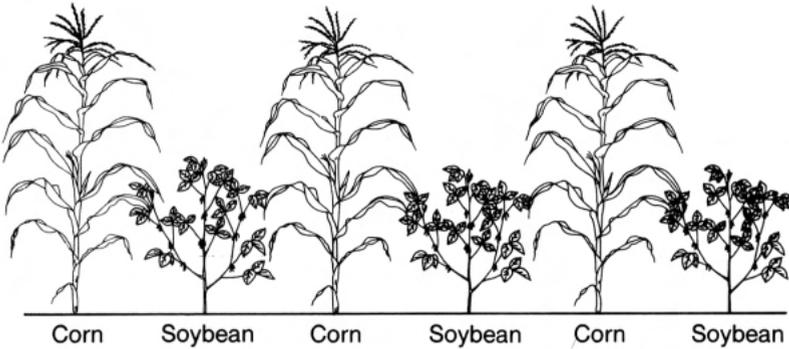
Deep plowing



Crop rotation

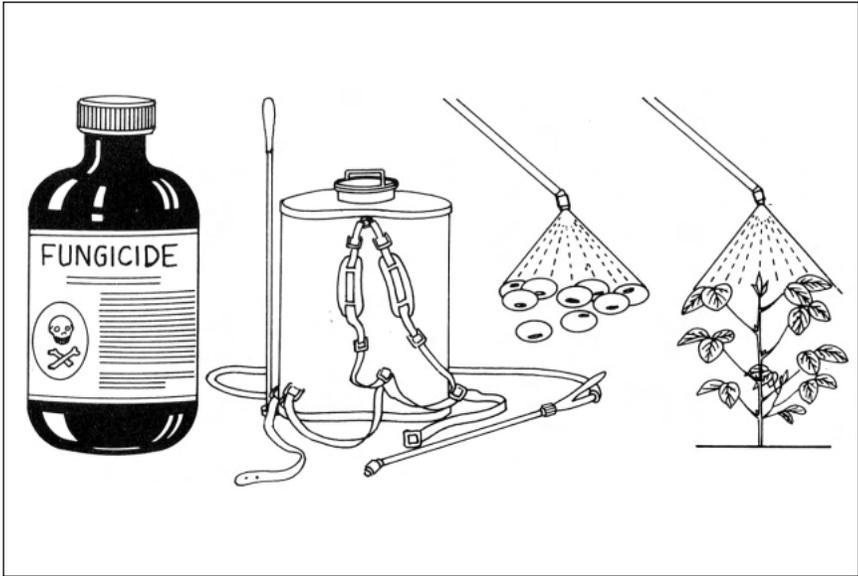


Intercropping



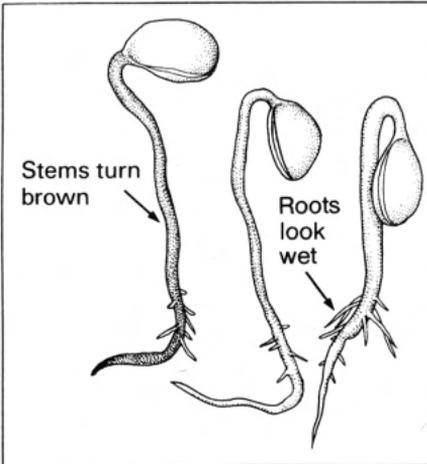
- Use cultural practices such as deep plowing, crop rotation, and intercropping to control diseases.
- Destroy crop residue that may shelter and spread disease.

# Using chemicals

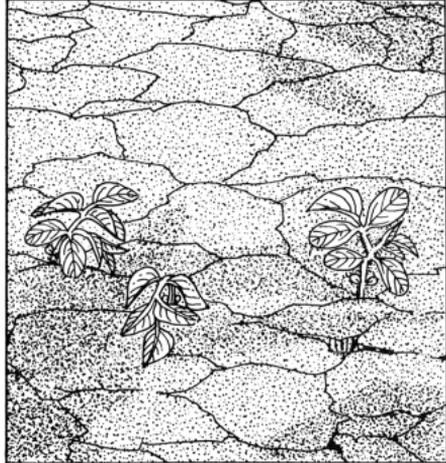


- Chemicals effectively control some diseases.
- Fungicides are especially useful in checking fungal diseases that attack seedlings and leaves.

# Soybean diseases common in the tropics — Pythium seedling rot



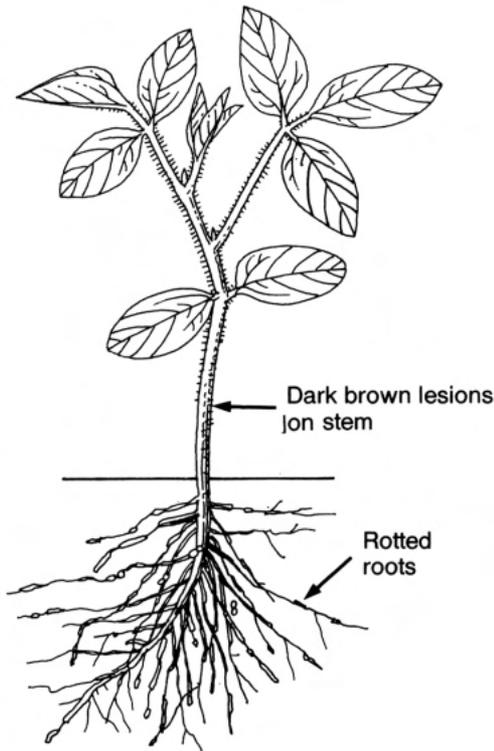
Caused by two kinds of soil fungus



Crop stand destroyed

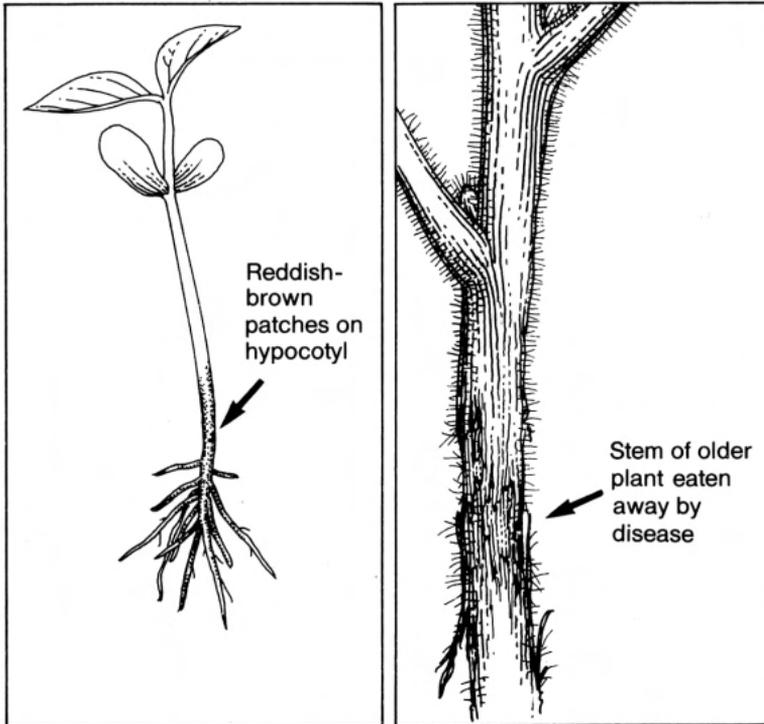
- Scientific name: *Pythium ultimum* and *Pythium debaryanum*
- Symptoms: Roots look wet. Seedling turns brown.
- Control: Plant good quality, fresh seed. Treat seed with fungicide before planting.

# Fusarium root rot



- Scientific name: *Fusarium oxysporum*
- Symptoms: Attacks in wet weather — heavy rain or flooded conditions. Seedling roots rot away; stems develop dark brown patches.
- Control: Plant good quality seed, treated with fungicide.

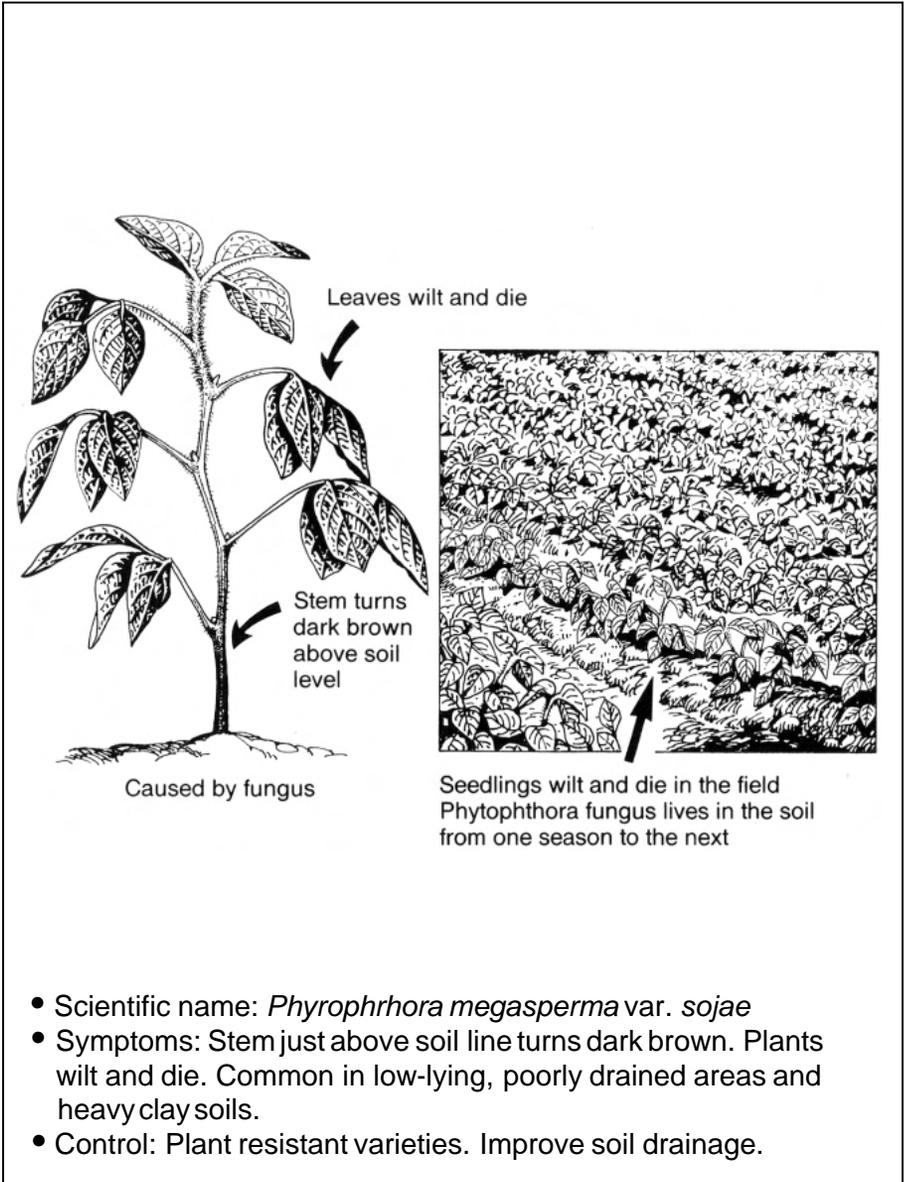
# Rhizoctonia root rot



Caused by common soil fungus  
Fungicide is not very useful against this disease

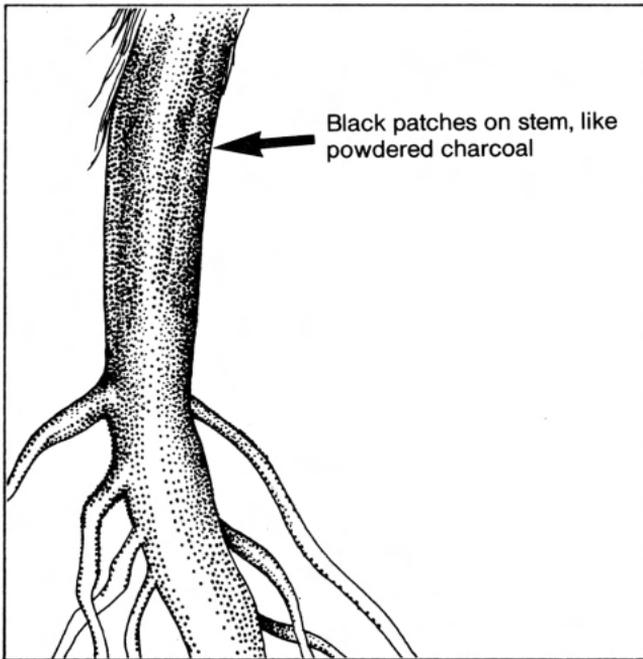
- Scientific name: *Rhizoctonia solani*
- Symptoms: Brown or reddish brown patches on lower stem and seedling hypocotyl.
- Control: Ridge soil around base of plants to reduce damage.

# Phytophthora root rot



- Scientific name: *Phytophthora megasperma* var. *sojae*
- Symptoms: Stem just above soil line turns dark brown. Plants wilt and die. Common in low-lying, poorly drained areas and heavy clay soils.
- Control: Plant resistant varieties. Improve soil drainage.

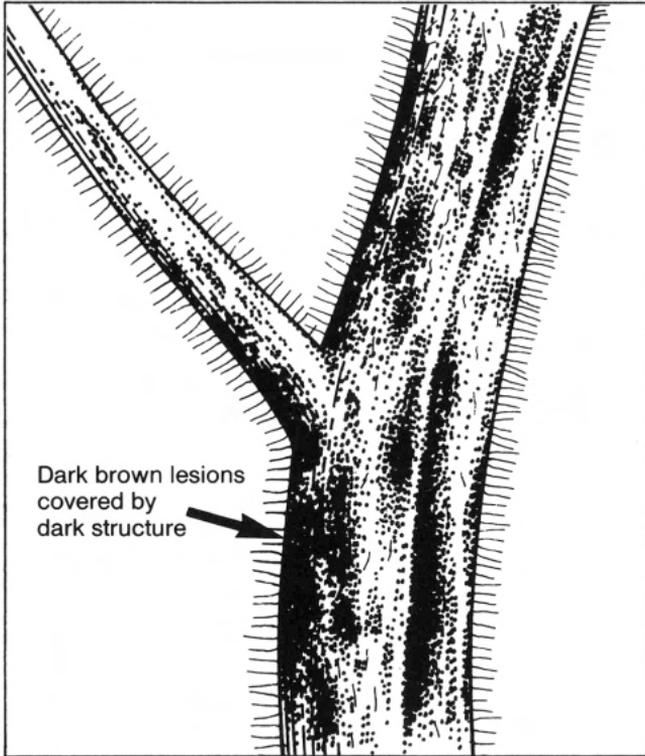
# Charcoal rot



Caused by fungus that lives  
in dry soil

- Scientific name: *Macrophomina phaseolina*
- Symptoms: Lower stem shows black patches like powdered charcoal. Common in hot, dry weather and dry soil.
- Control: Crop rotation. Do not grow soybean in the same field in successive years.

# Anthracnose

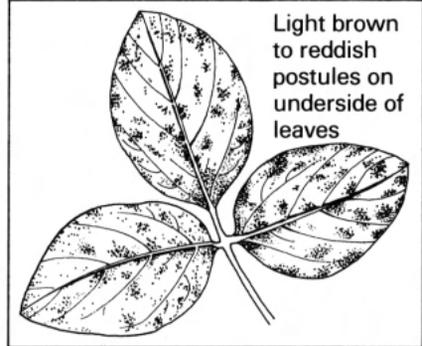


- Scientific names: *Colletotrichum dermatium* var *truncata* and *Glomerella glycines*
- Symptoms: Anthracnose infects young seedlings and older plants. Dark brown patches appear on stem.
- Control: Crop rotation. Plant good quality, disease-free seed, treated with fungicide.

# Soybean rust

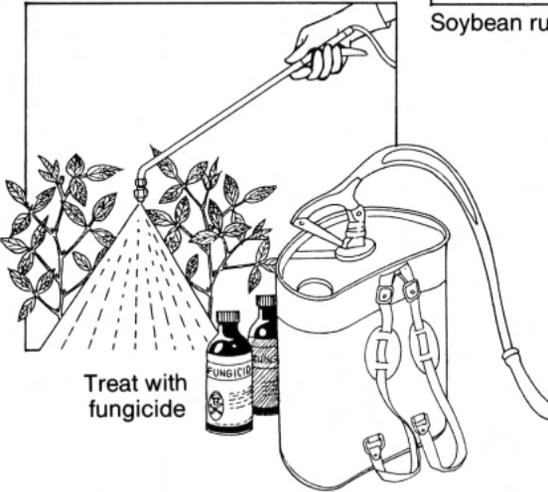


Rust can reduce yields  
30-90%



Light brown  
to reddish  
pustules on  
underside of  
leaves

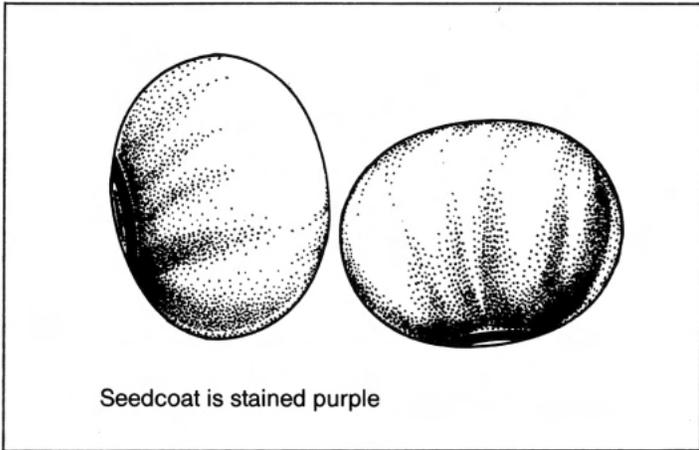
Soybean rust



Treat with  
fungicide

- Scientific name: *Phakopsora pachyrhizi*
- Symptoms: Light brown to reddish pustules on undersides of leaves. Leaves may drop off.
- Control: Use tolerant varieties that will yield even with rust attack. Treat with fungicide. No variety has been found to be free from this disease.

# Purple seed stain



- Scientific name: *Cercospora kikuchii*
- Symptoms: Pale to dark purple staining of the seed. Infected seeds can produce diseased seedlings. Spreads to stem and leaves.
- Control: Treat seed with fungicide before planting.

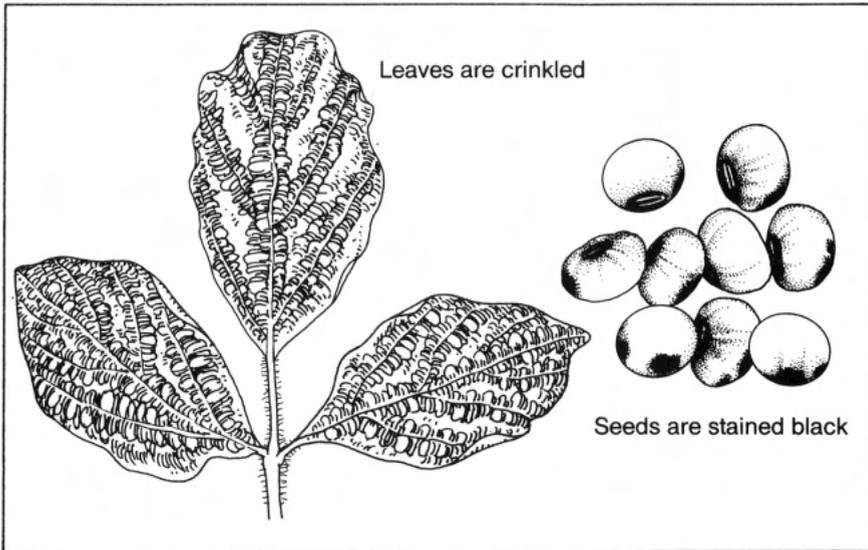
# Bacterial pustule



Brown spots with yellow edges on undersurface of leaf

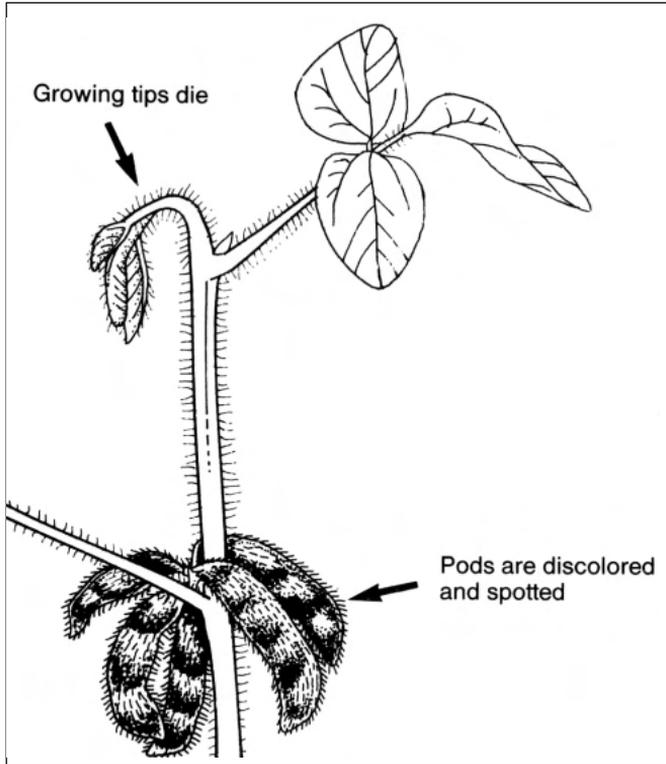
- Scientific name: *Xanthomonas phaseoli* var *sojensis*
- Symptoms: Spots with brown center and yellow outer ring on under surface of leaf. Common in warm, wet weather.
- Control: Follow crop rotation. Plant resistant varieties.

# Soybean mosaic



- Caused by soybean mosaic virus, which is seed-borne or carried by aphids from infected to healthy plants.
- Symptoms: Crinkled leaves, black-stained seeds.
- Control: Plant resistant varieties. Pull out and destroy infected plants from field. Plant new crops in disease-free fields.

# Bud blight



- Caused by tobacco ringspot virus.
- Symptoms: The top bud and shoot turn brown. Plant is stunted and remains green after normal plants have matured.
- Control: Pull infected plants from seed production fields. Do not plant soybean next to another legume crop.



# **Soybean in other cropping systems**

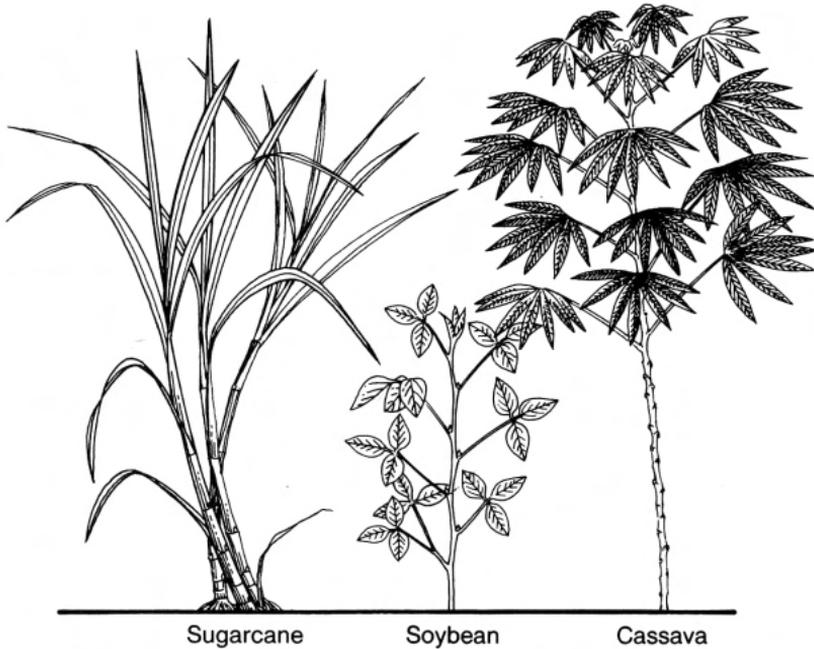


# Soybean in other cropping systems — sequence cropping

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Soybean before sorghum	<b>201</b>
Soybean before cotton	<b>202</b>
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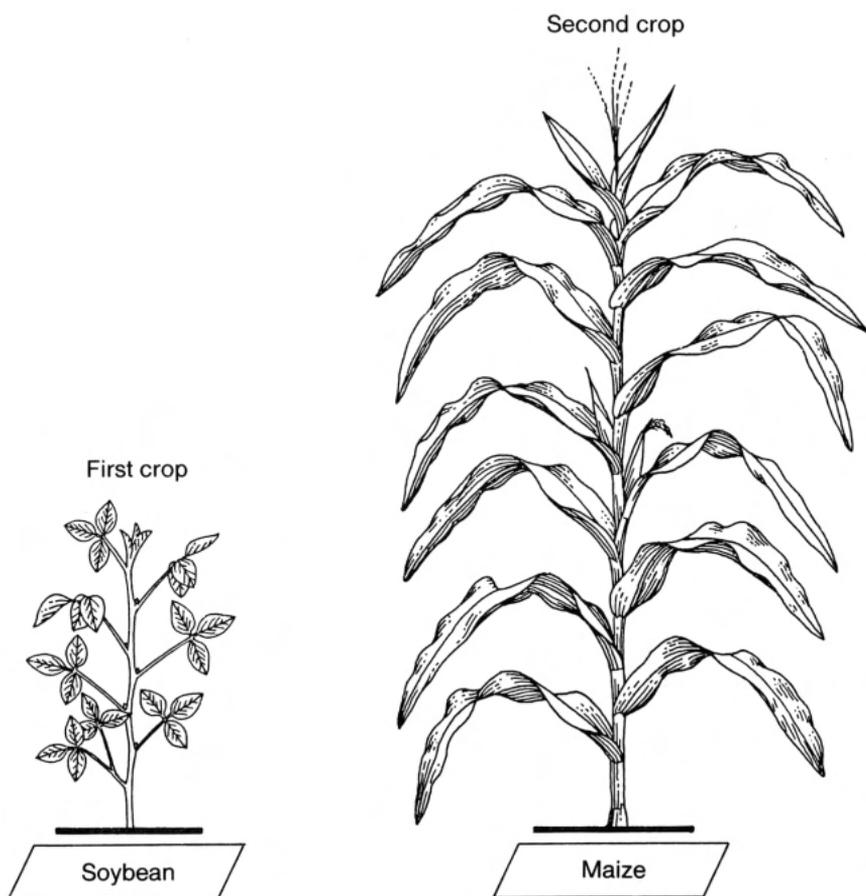


# Soybean in other cropping systems



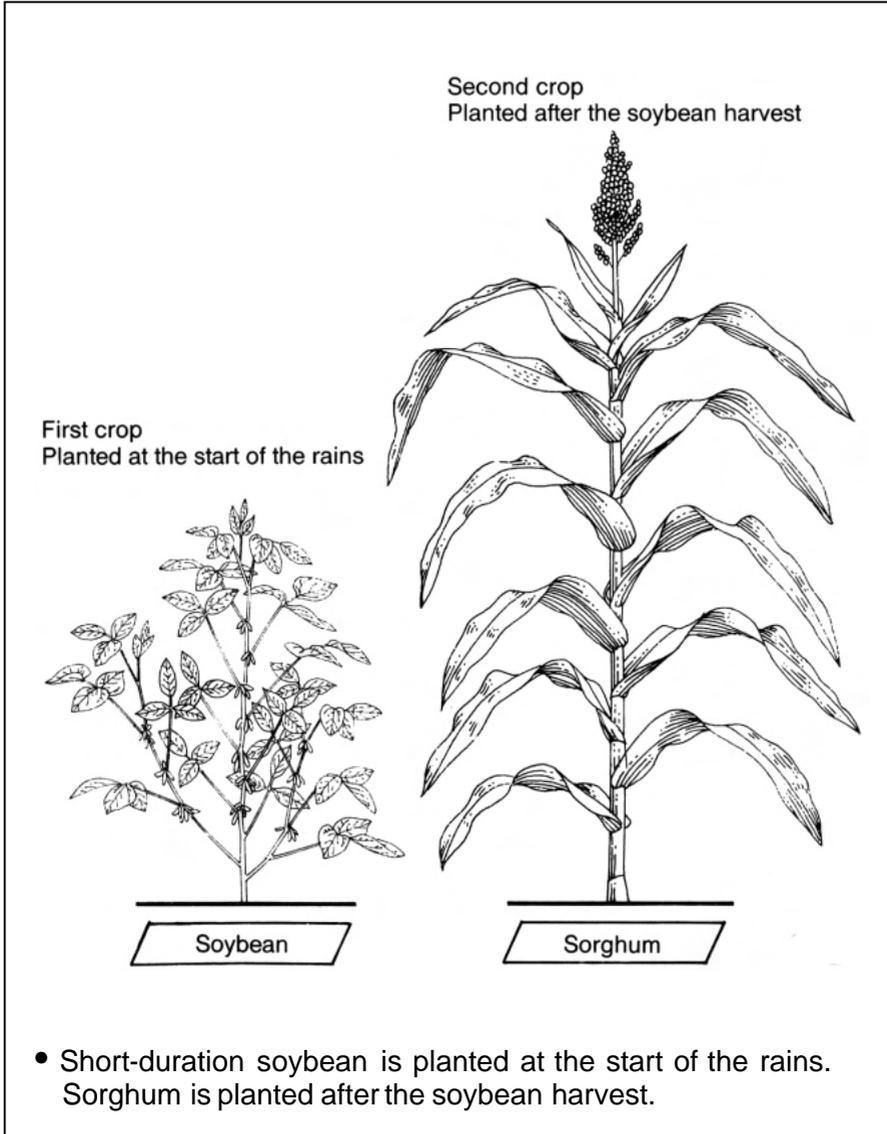
- Soybean can also be grown with crops other than rice—with other cereals, sugarcane, cotton, or cassava.
- Short-duration varieties are especially suited to sequence cropping in upland areas.
- Soybean can be intercropped, strip-cropped, or grown in the spaces between plantation crops.

# Sequence cropping — soybean before maize



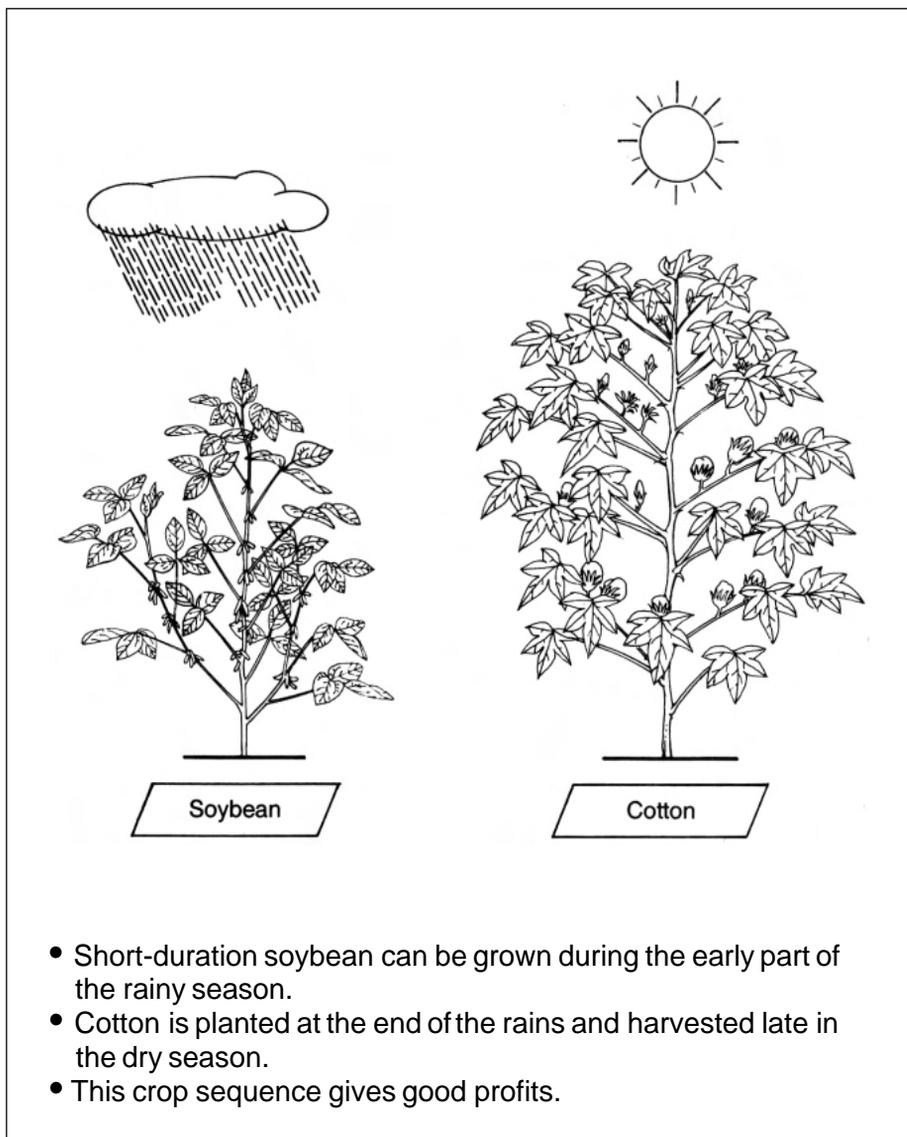
- Short-duration soybean is planted at the start of the rains in May. Maize is planted after the soybean harvest.
- The soybean-maize sequence is a more sustainable cropping system than continuous cereal cropping.

# Soybean before sorghum

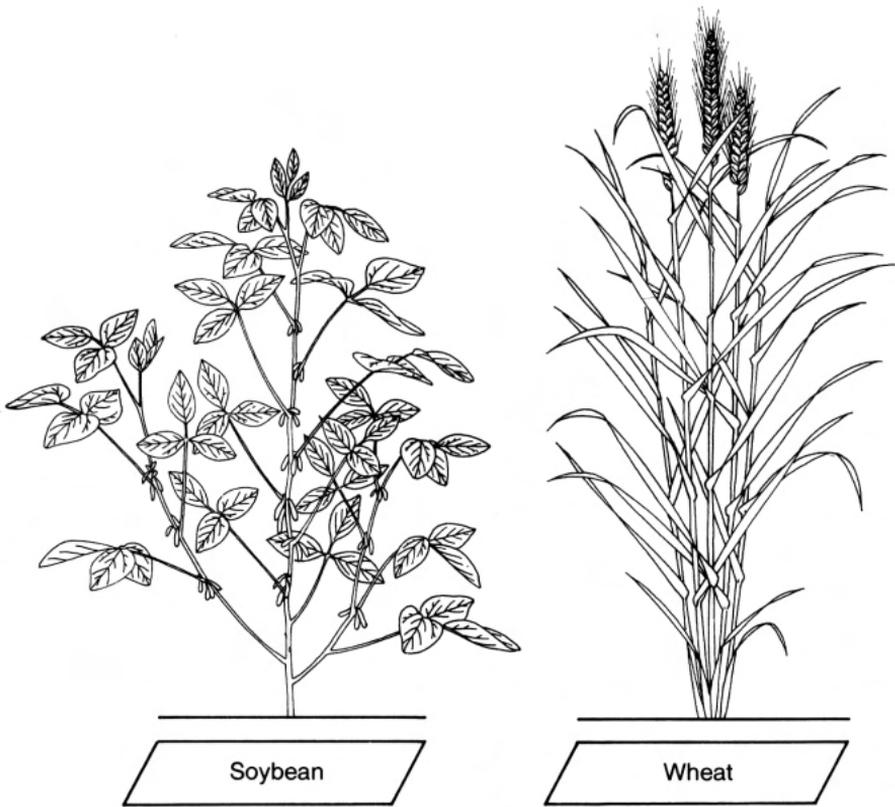


- Short-duration soybean is planted at the start of the rains. Sorghum is planted after the soybean harvest.

# Soybean before cotton



# Soybean before wheat



- In the cooler tropics where winter wheat can be grown, soybean can be planted as a first crop during the rainy season.
- Wheat is planted in November, and harvested in March-April.

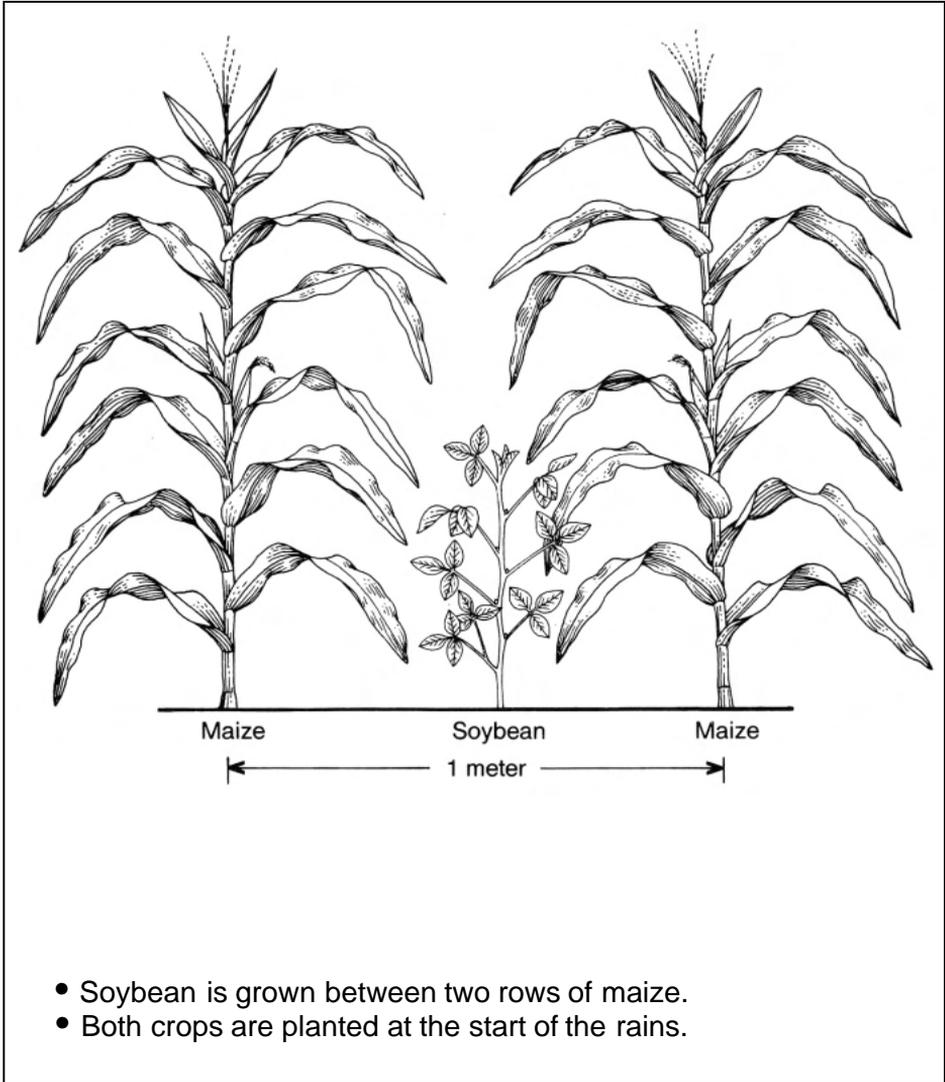


# Soybean in other cropping systems — intercropping

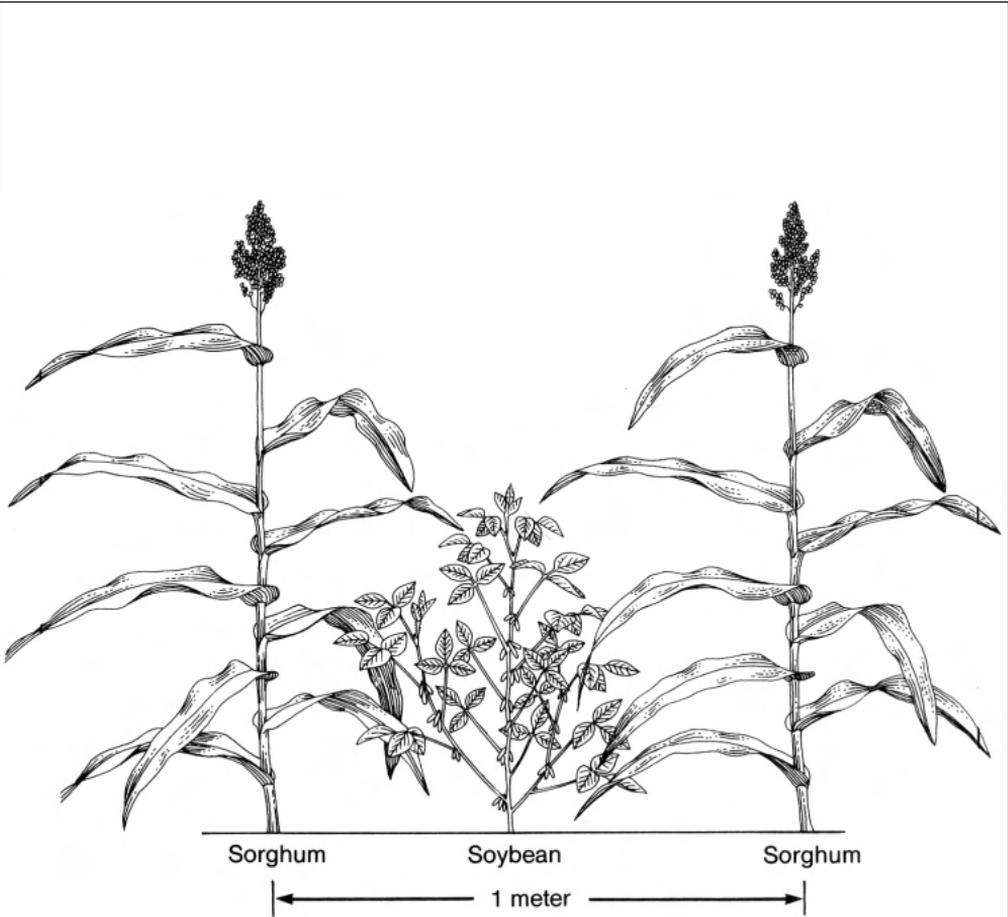
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# Intercropping — maize and soybean

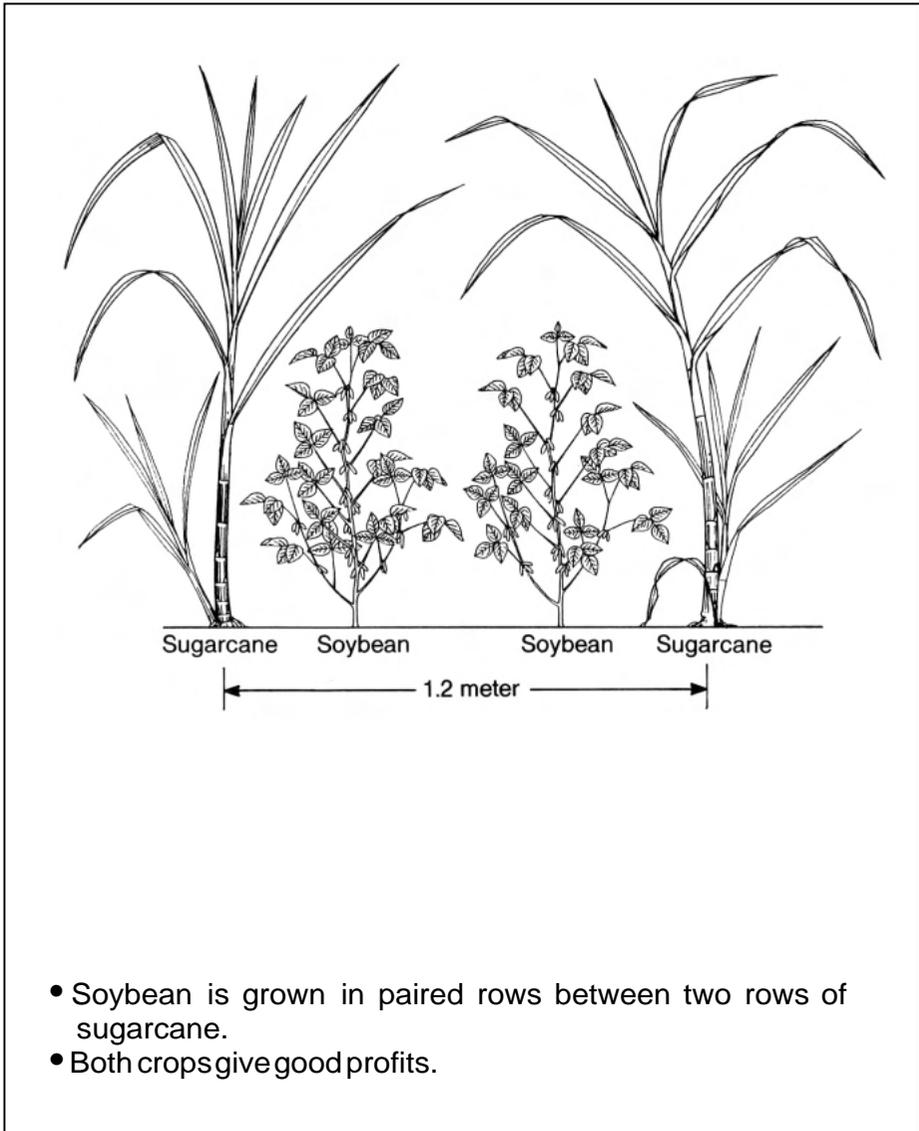


# Sorghum and soybean

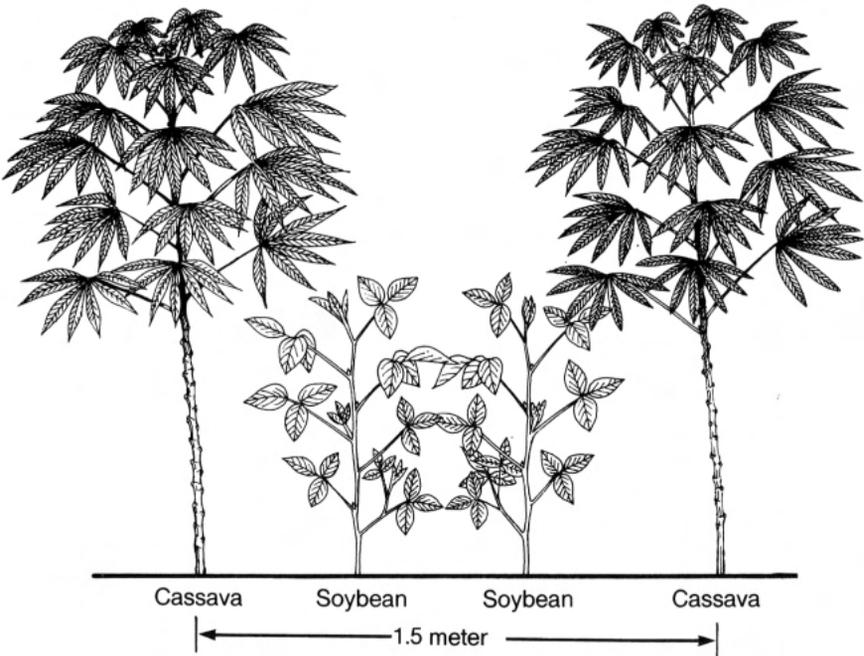


- Soybean is grown between two rows of sorghum. Both crops are planted at the start of the rains.
- This cropping system produces more food grain from the same land.

# Sugarcane and soybean



# Cassava and soybean



- Soybean is planted in paired rows between two rows of cassava.
- Soybean makes a nutritious supplement that adds protein to the starchy cassava diet.

# Plantation crops and soybean



Banana and soybean



Rubber and soybean



Oil palm and soybean



Coconut and soybean

- Soybean is planted in the vacant spaces of plantation crops such as coconut, oil palm, banana, and rubber.
- This makes full use of the land area and gives added income.

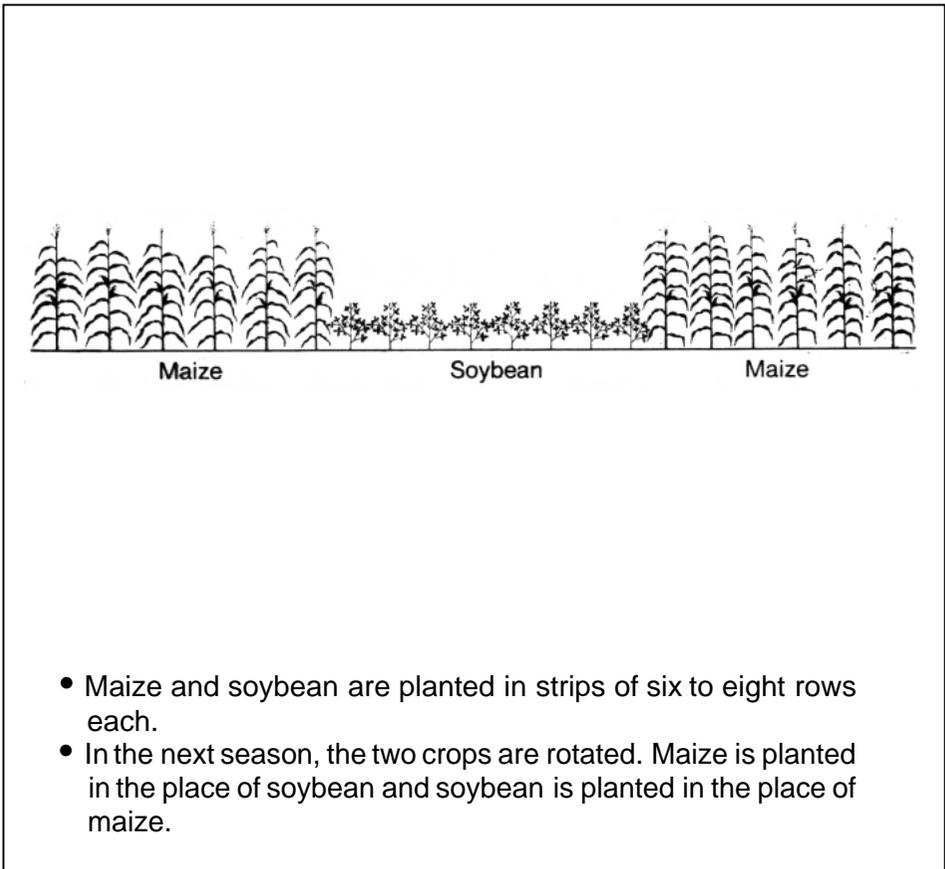


# Soybean in other cropping systems — strip-cropping

Strip-cropping maize and soybean	215
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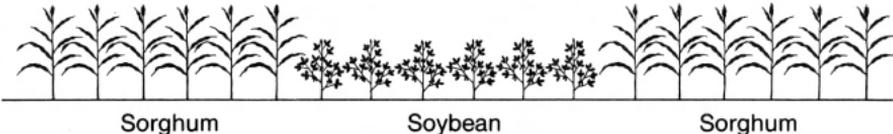


# Strip-cropping maize and soybean

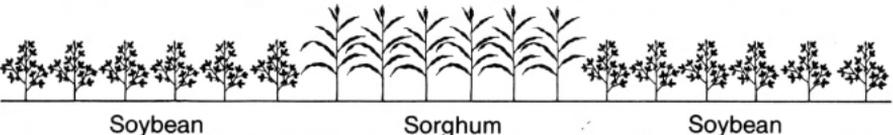


# Strip-cropping sorghum and soybean

First season



Second season



- Sorghum and soybean are planted in strips of six to eight rows each.
- In the next season, the crops should be rotated on the two strips.