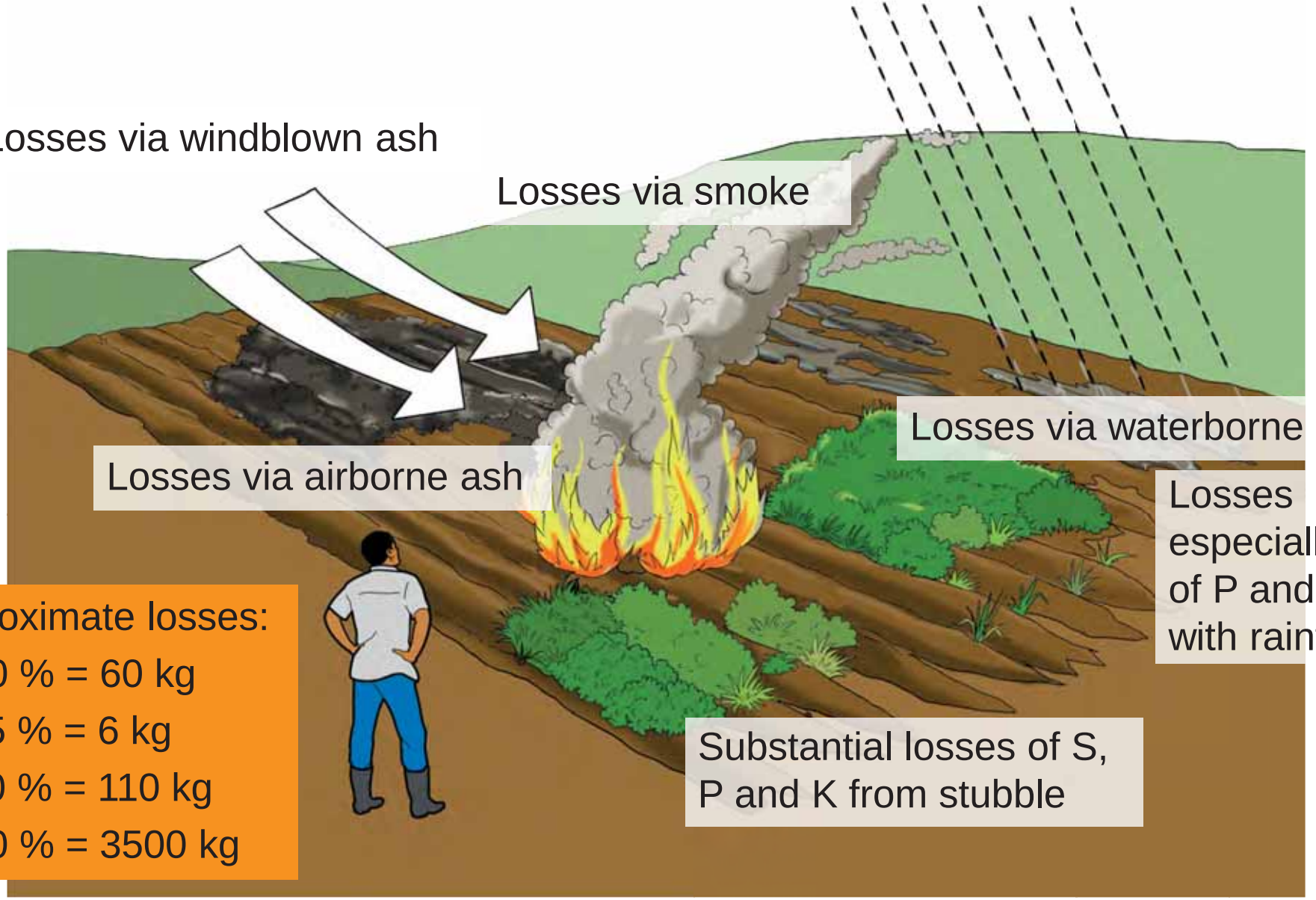
Repeated stubble burning runs down soil fertility



Approximate losses:

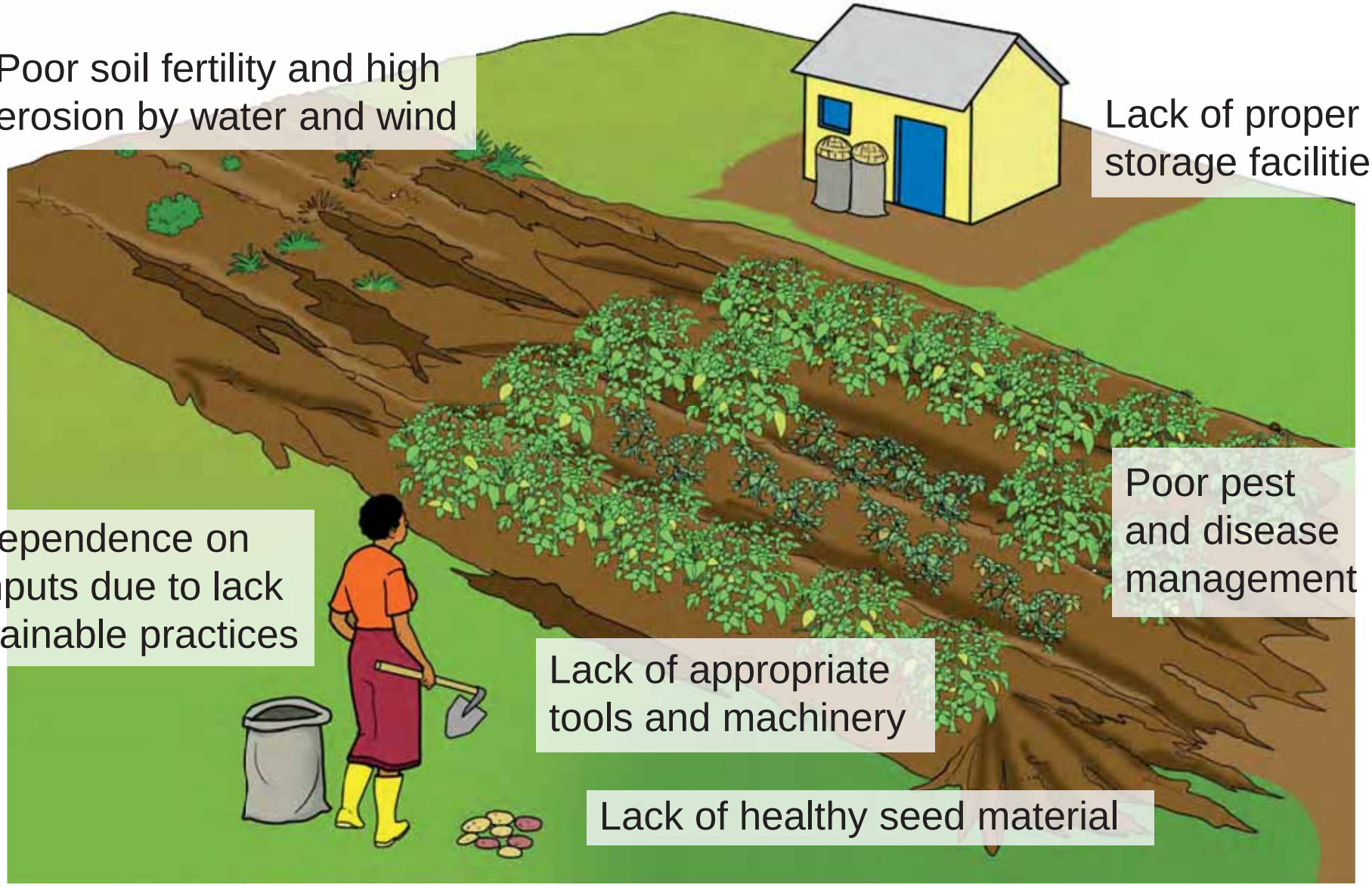
N: 80 % = 60 kg

P: 45 % = 6 kg

K: 40 % = 110 kg

C: 80 % = 3500 kg

Common challenges related to potato production



IFOAM Principles of Organic Agriculture

Health

No chemical pesticides

No livestock feed additives

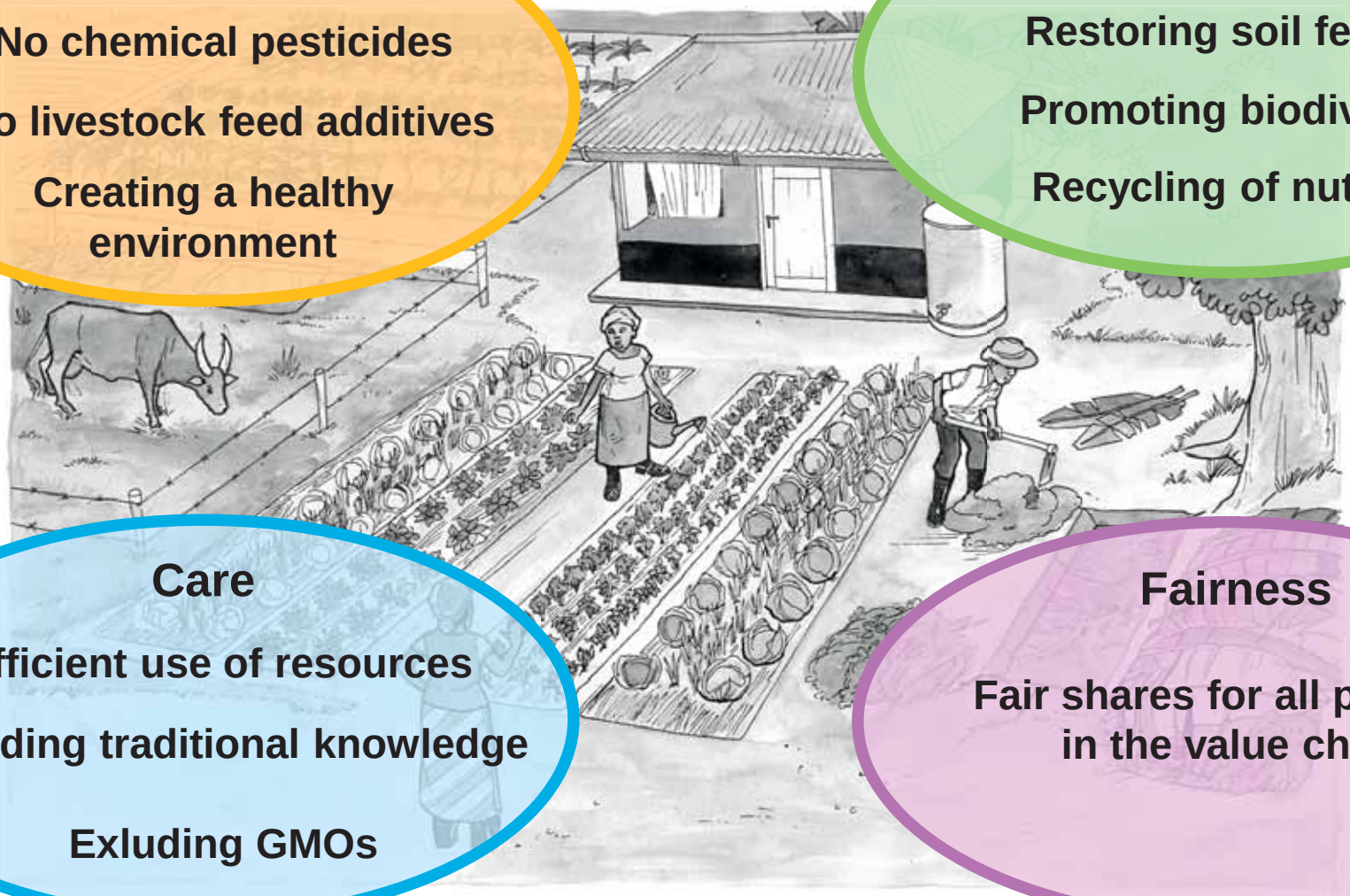
Creating a healthy environment

Ecology

Restoring soil fertility

Promoting biodiversity

Recycling of nutrients



Care

Efficient use of resources

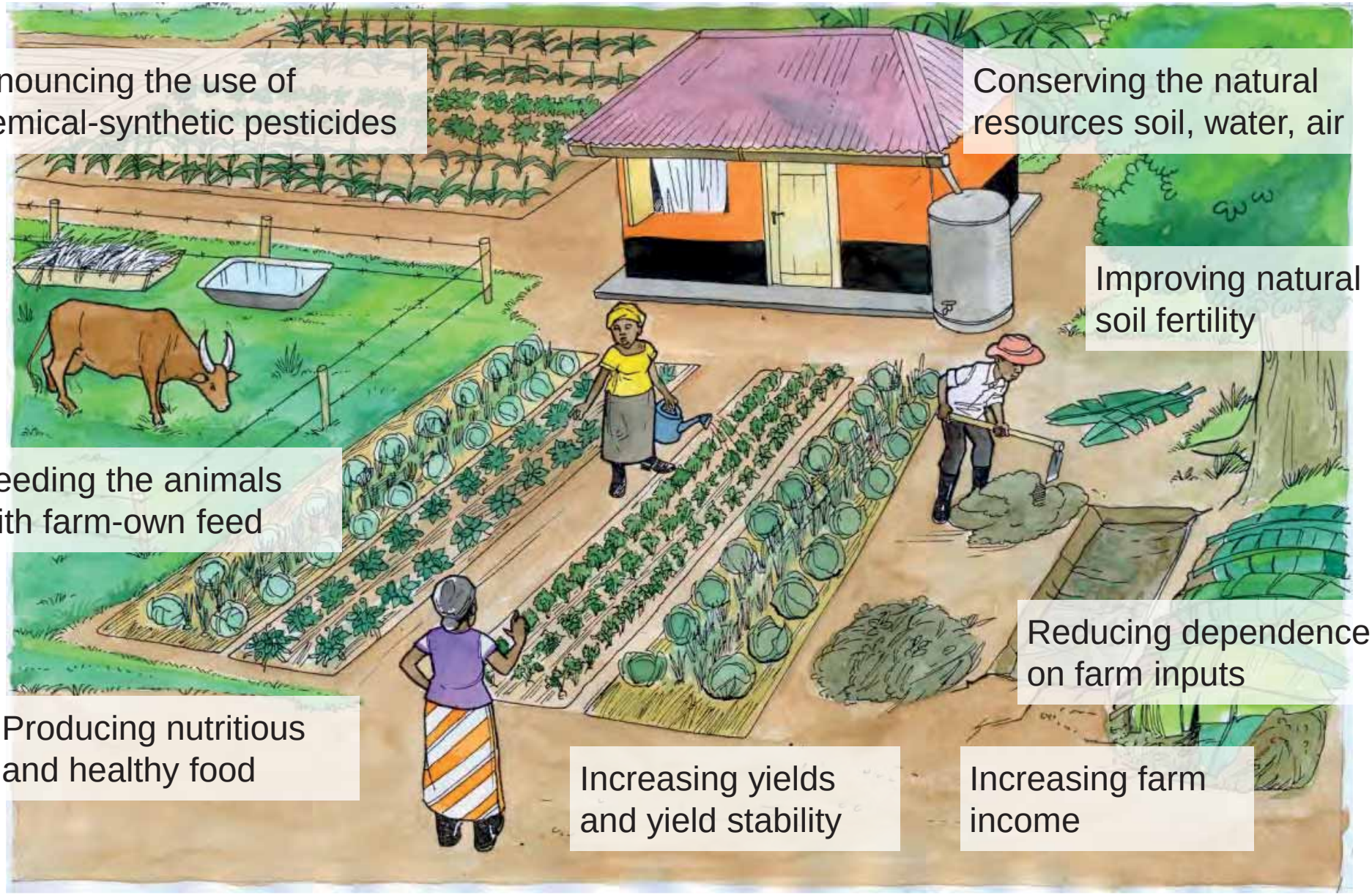
Including traditional knowledge

Exluding GMOs

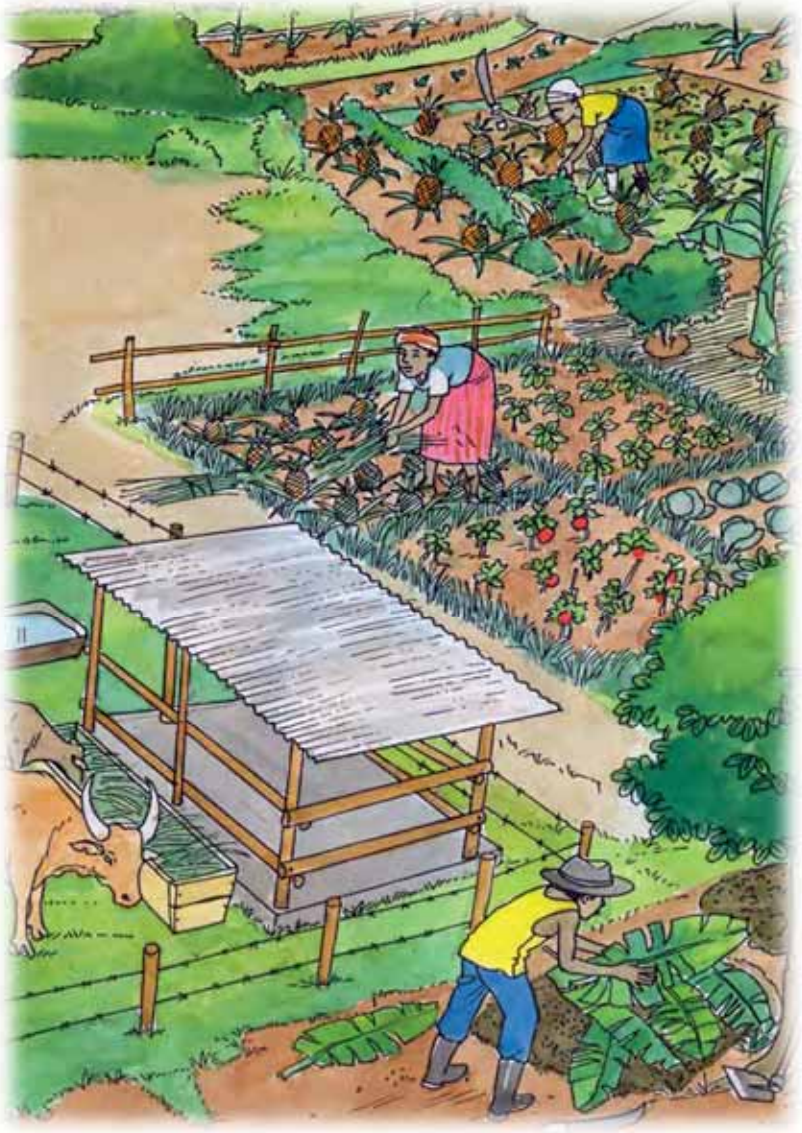
Fairness

Fair shares for all partners in the value chain

Motivations for organic farming



Organic farmers strive for …

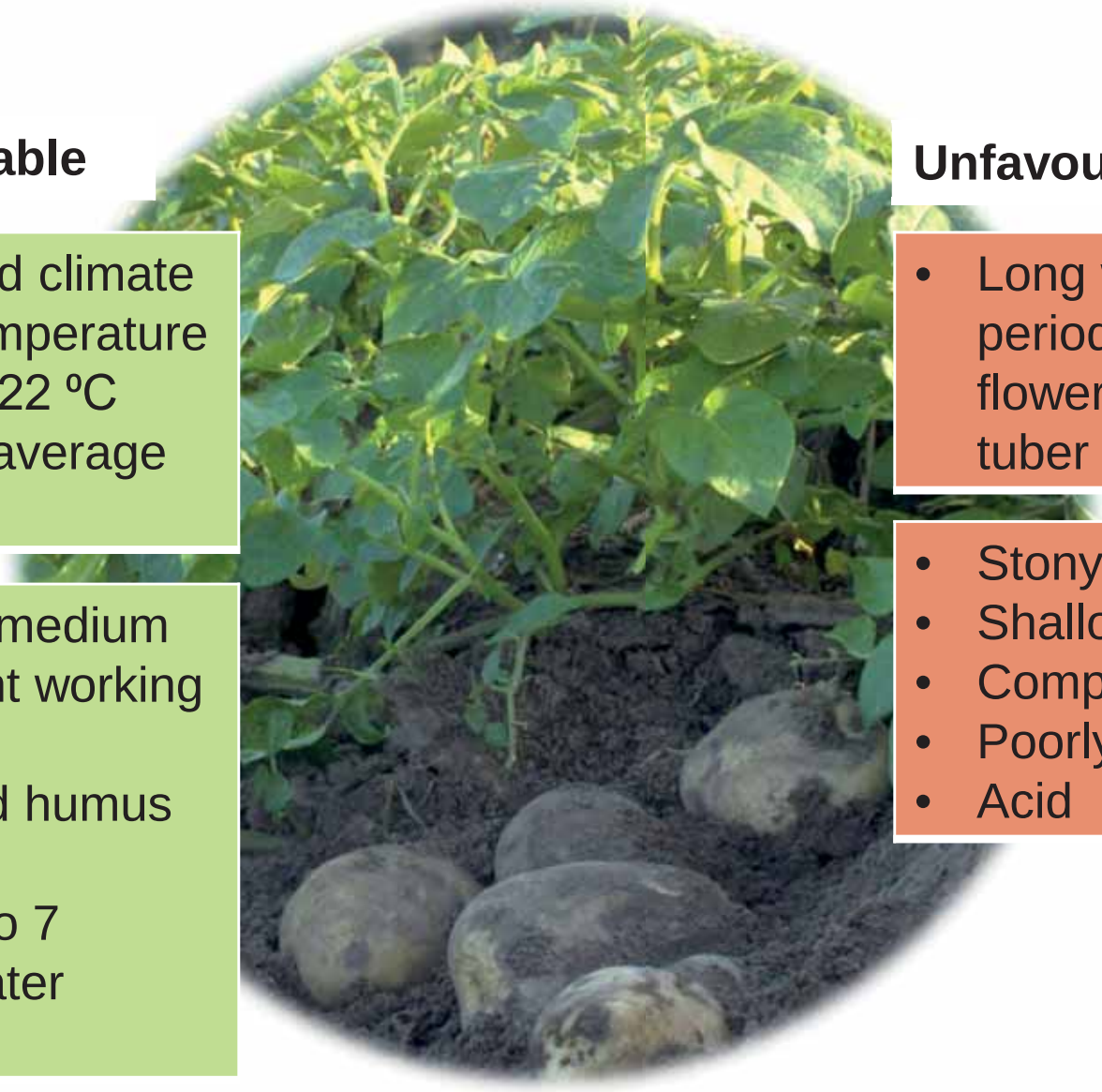


- Careful use of resources
- Preserving and promoting soil fertility
- Minimizing soil erosion, limiting nutrient losses
- Creating diverse production systems
- Creating optimal growth conditions for the crops, managing the crops well
- Respecting the species-specific needs of farm animals
- Ensuring healthy and robust farm animals
- Producting high quality food
- Stable and transparent market relations, and fair prices
- Sustainable development of the farm enterprise

Organic farmers renounce …

- Chemically synthesized pesticides
- Mineral nitrogen fertilizers
- Herbicides
- Easily soluble P, K, Mg and trace element fertilizers
- Growth regulators for plants (hormones)
- Genetically modified micro-organisms, plants and animals
- Routine use of veterinary medicinal products (antibiotics)
- Antimicrobial growth promoters
- High amounts of farm inputs for maximum yields

General growth requirements of potato



Favourable

Climate

- Balanced climate
- Daily temperature of 10 to 22 ºC with an average of 15 ºC

Soil

- Light to medium
- Sufficient working depth
- Elevated humus content
- pH 5.5 to 7
- Even water supply

Unfavourable

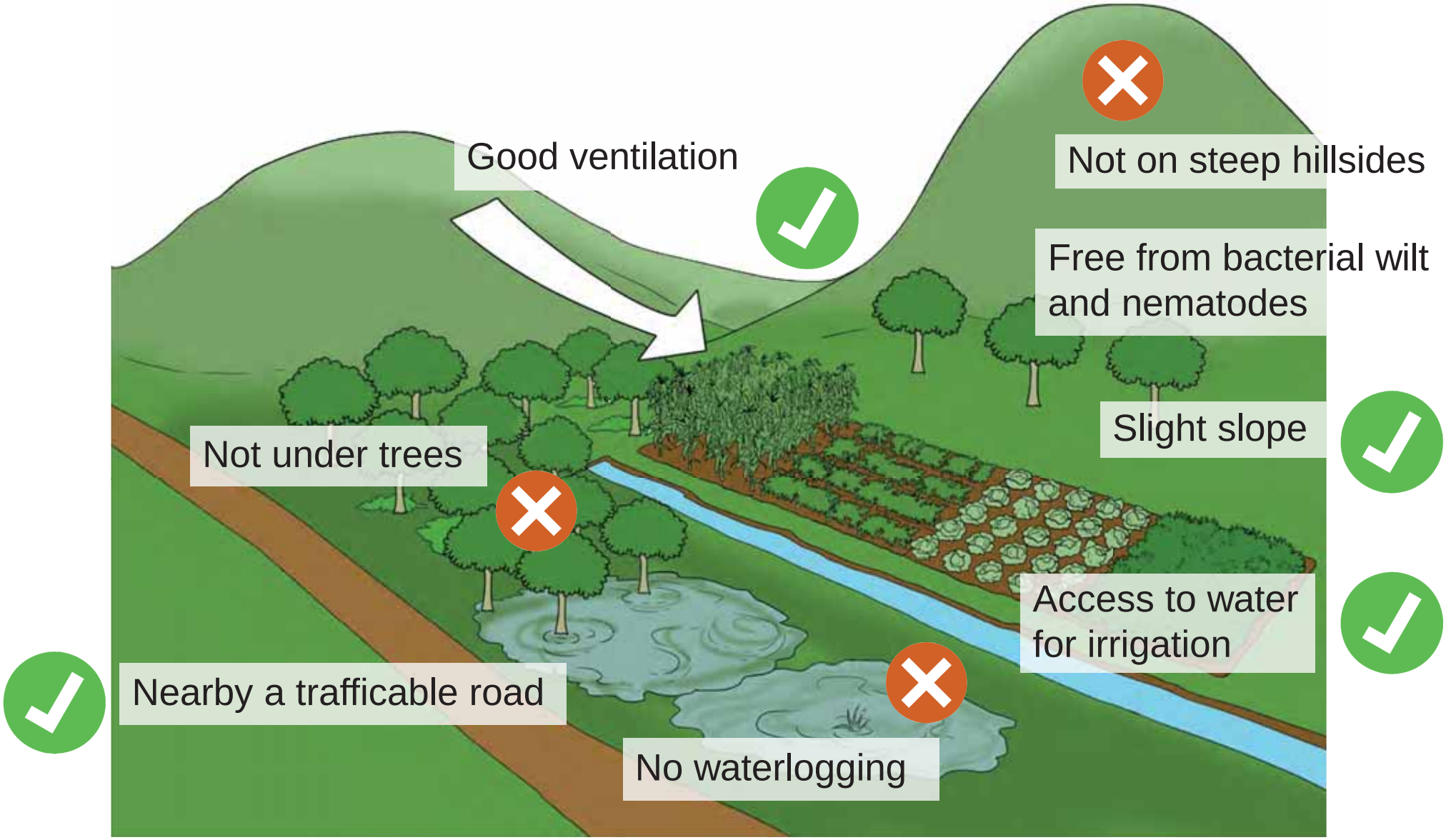
Climate

- Long wet or dry periods during flowering and tuber formation

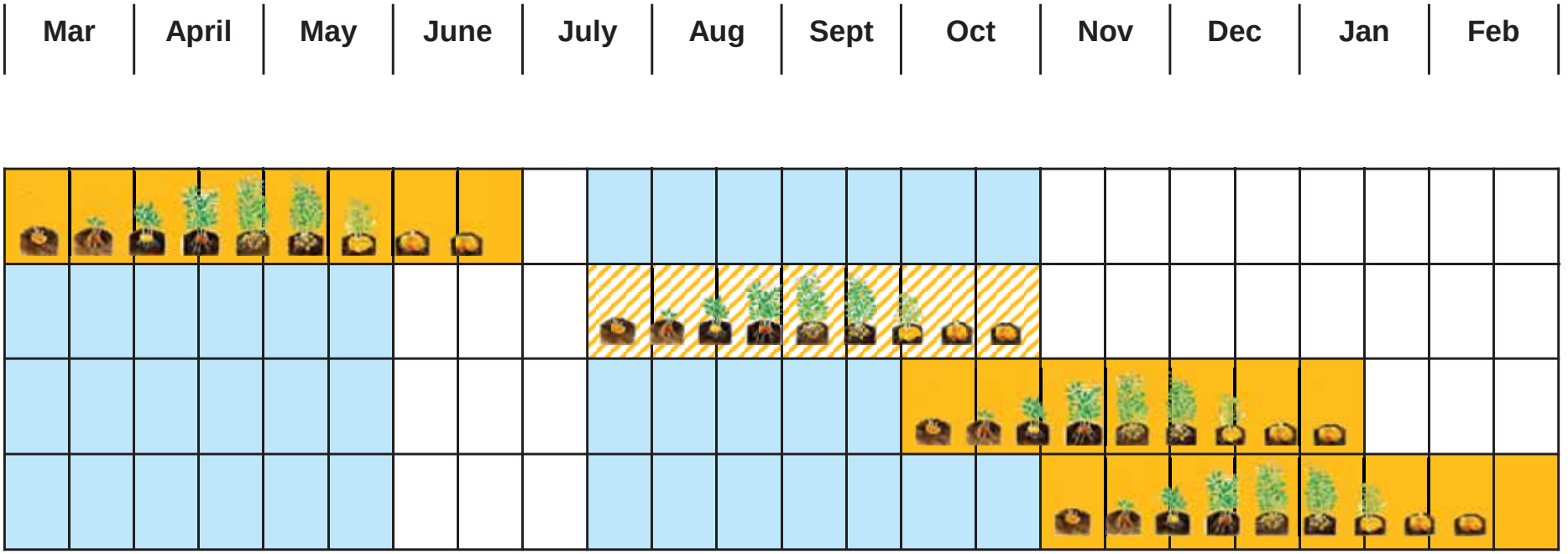
Soil

- Stony
- Shallow
- Compacted
- Poorly drained
- Acid

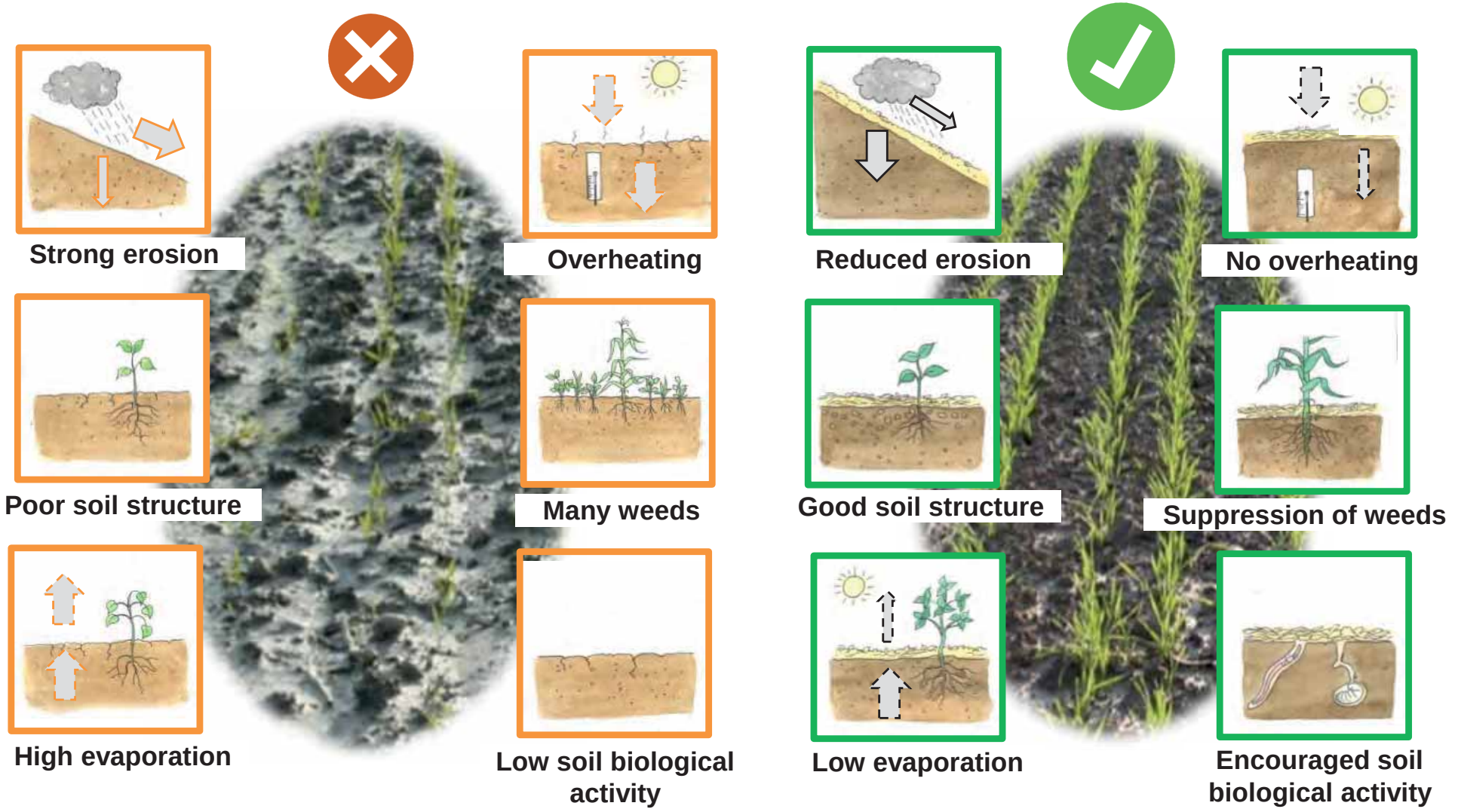
Suitable and unsuitable sites for potato cultivation



Potato production calendar for Cameroon



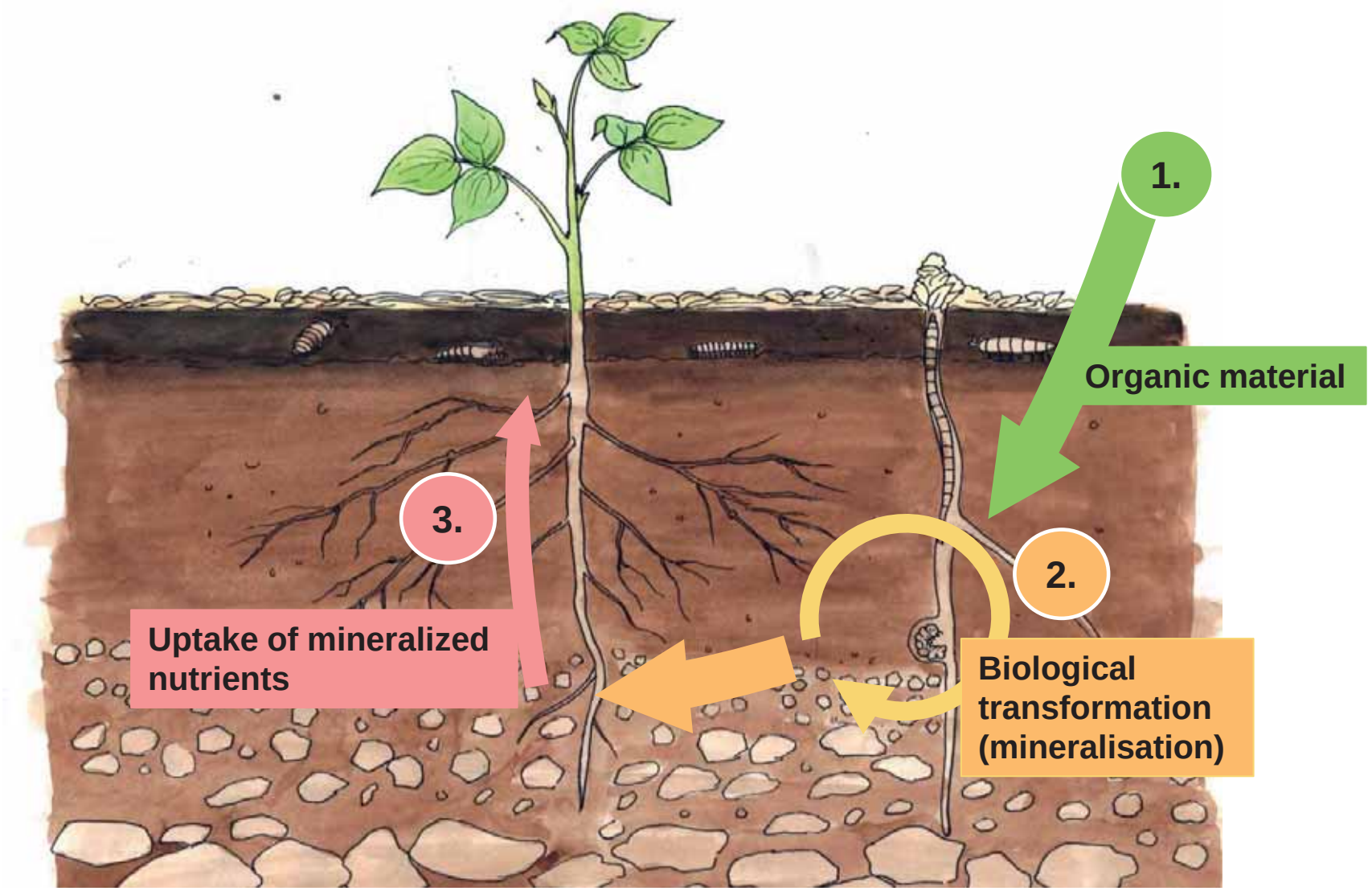
Advantages of good soil and water conservation



Poor soil and water conservation

Good soil and water conservation

Feeding the soil



Three steps of organic soil fertility management

3rd step

Application of supplements

Enhancing and balancing plant nutrition through application of fertilizers, soil amendments and irrigation

2nd step

Soil organic matter management

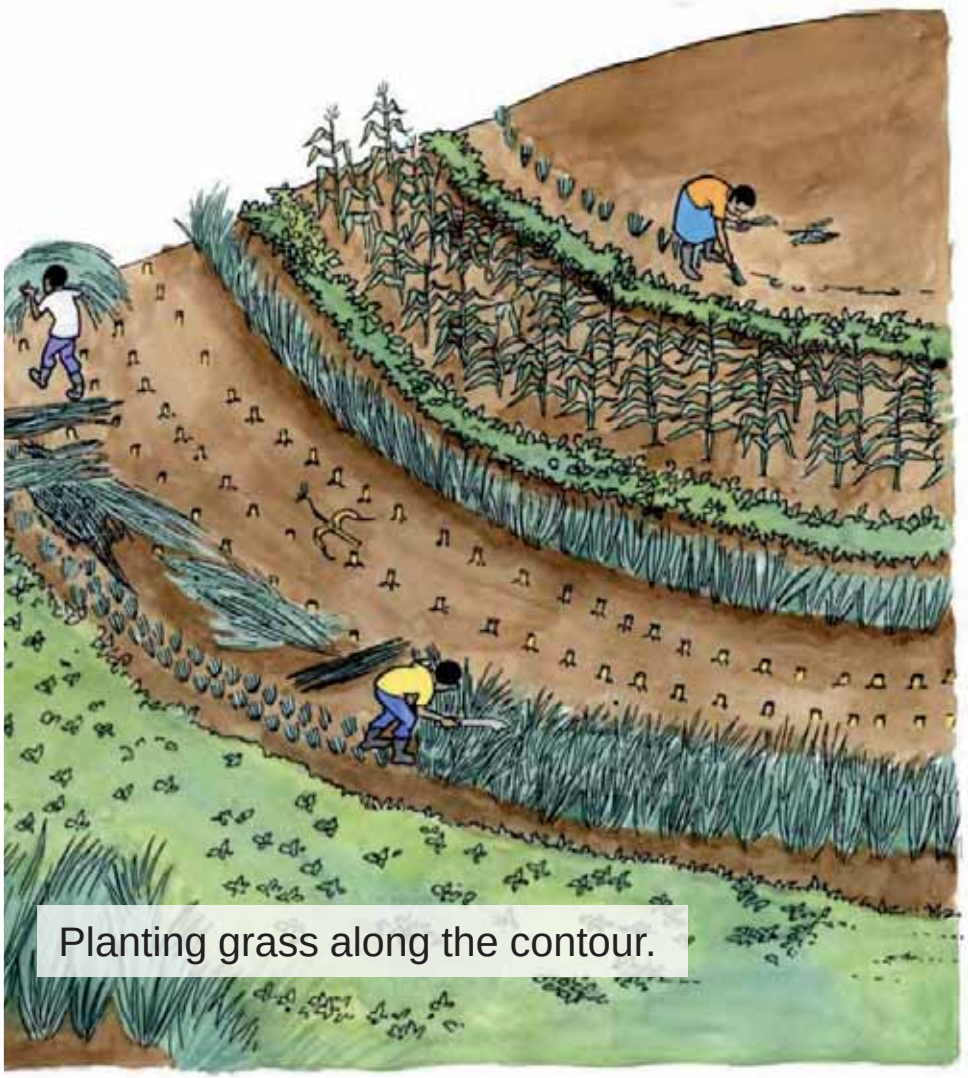
Enhancing soil organic matter content through application of organic material

1st step

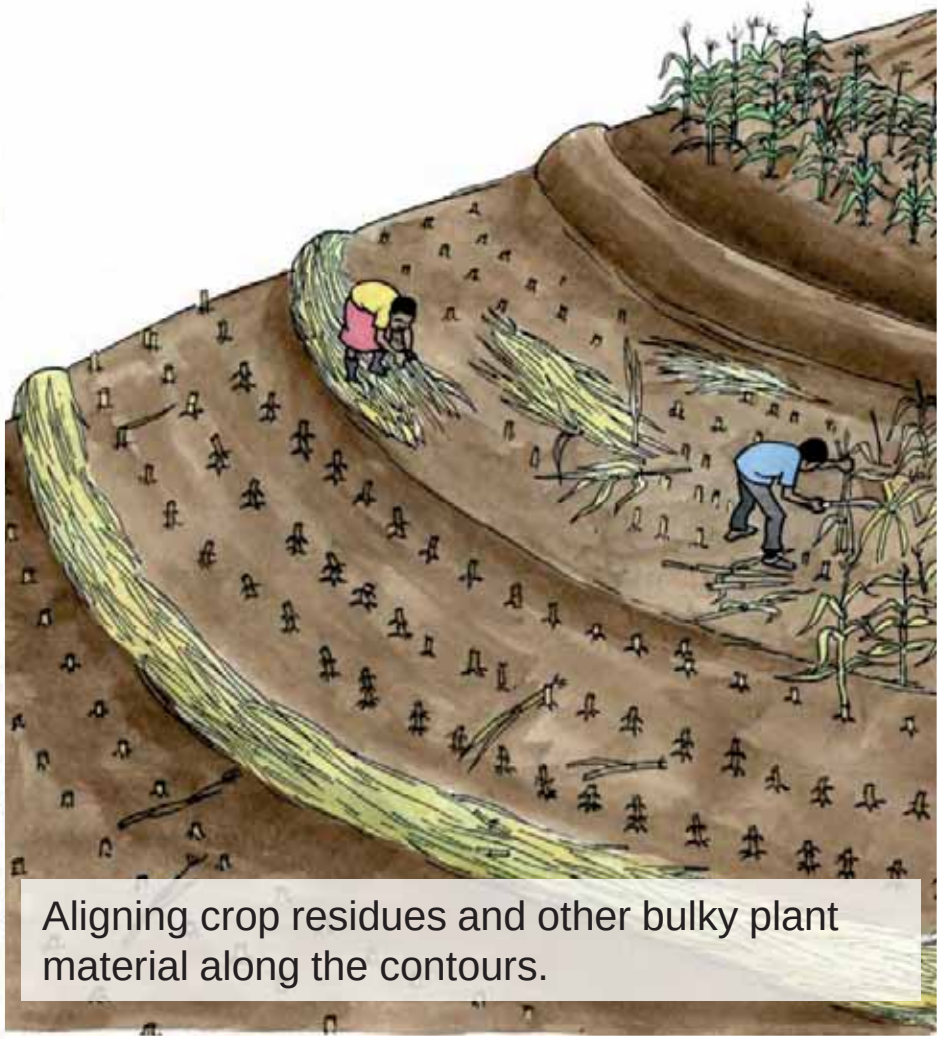
Soil and water conservation

Stabilizing and protecting the soil and harvesting and conserving water

Minimising soil erosion on slopes



Planting grass along the contour.



Aligning crop residues and other bulky plant material along the contours.

The soil fertility management tools

3rd step

Commercial fertilizers

Liquid fertilizers

Soil amendments

Microbial inoculations

Irrigation water

2nd step

Green manures

Compost

Farm-own animal manures

Mulching

1st step

Contour ridges and bunds

Mulching

Terraces

Reduced tillage

Cover crops

Grass strips

Water catchments

Advantages of green manures

Add many tons of organic matter to the soil

Provide large quantities of nitrogen for the soil

Protect the soil from wind and water erosion

Preserve soil moisture and organic matter

Can control weeds

Do not require capital or inputs

Do not require transportation

Some provide food

Some provide high protein fodder for animals

Criteria for green manure selection

- ☒ Fast growing with vigorous and non-woody growth.
- ☒ Grows well in poor soils without fertilizer.
- ☒ Adapted to local climate. No irrigation required.
- ☒ Can be grown without pesticides.
- ☒ Not closely related to the incoming crop.
- ☒ Drought-resistant, when grown into or through the dry season.
- ☒ Leguminous to collect nitrogen, non-legumes if better adapted to local conditions.
- ☒ Readily available and affordable seeds.
- ☒ Provides food or feed, if required.

Green manure plants (1): Cowpea (Niebe)

- Multi-purpose legume providing leaf, grain and forage with a very high nutritive value and high palatability
- Improves soil fertility
- Easy to establish
- Better aptated to acid soils than other green manure crops
- Quite drought tolerant
- Produces high yields in a short period of time
- High seed production

Green manure plants (2): Tithonia

Photo: A. J. T. Johnsingh, WWF-India and NCF

- Shrub relative of the sunflower growing to a size of 1.5 m to 4.0 m
- Grown in hedges
- Only recommended where already present
  (can grow to a weed, if not managed properly)
- Leaves and stems of young plants are cut for mulch or mixed into the soil
- Regular cutting back of the hedgerows required
- Interplanting in crops not recommended

Green manure plants (3): Black Sunnhemp

- From 0 to 1900 m asl; on poor soils also
- Drought tolerant
- Annual, takes 3-4 months to maturity
- Grows 3 m high, high biomass production
- Fixes 100 to 200 kg of nitrogen per ha
- Fair weed control
- Only young leaves for food
- Fodder: max. 10 % for cattle, non to pigs
- Insect repellant, controls nematodes
- Regrows when cut before flowering
- Mature crop provides good mulch
- Intercropping with taller grain crops
- Intercropping or relay cropping with vegetables, beans, potatoes, sweet potatoes, cassava or pineapples

Green manure plants (4): Velvet bean

Photo: Dinesh Valke from Thane, India

- Up to 1800 m asl
- Grows on severely degraded soils also as improved fallow
- Climbing; prefers humid climates, tolerates some drought; dies during the dry season
- High biomass production within 6 months; 4 to 12 months to maturity
- Fixes up to 150 kg of nitrogen per ha
- Suppresses broad leaved weeds, striga and nematodes
- Food: young leaves as vegetables, beans must be cooked
- Planting at the onset of the rainy season
- Relay cropped in cereal crops with repeated pruning (and subsequent fallow)
- Sowing of the following crop into dead mulch

Green manure plants (5): Lablab bean

- From 0 to 1900 m asl
- Time to maturity: 3-12 months
- Climbing, with high biomass production within 3 to 5 months
- High drought tolerance when established; may stay green throughout the dry season
- Medium to high nitrogen fixation
- Similar weed suppression as mucuna
- Edible leaves, flower buds and green pods
- High forage quality mixed with grass
- Improved fallow after maize during the dry season

Green manure plants (6): Jackbean

- For humid and sub-humid climates; but high drought tolerance
- Grows on poor or degraded soils
- Moderate biomass production
- N fixation up to 230 kg per ha
- Mature crop provides good mulch
- Food: young leaves, tender pods
- Forage: as fodder in small proportions of the diet; mature seeds ground
- Intercropping in young banana, cocoa or coffee, cassava or sweet potatoes
- Relay cropping in cereal crops

Green manure plants (7): Pigeon pea

- Grows well under dry conditions
- Shrubby growth habit
- Perennial, new varieties producing seeds within 3 to 4 months
- N fixation around 90 kg per ha
- Edible fresh, dried, cooked, milled or sprouted
- Animal fodder

Green manure plants (8): Fish poison bean

- Shrubby growth habit with up to 4 m of height
- Perennial, but produces first seeds after 3 months
- Very adaptive tolerating different climates, poor soils, droughts and strong wind
- Requires at least 850 mm of annual rainfall
- Poisonous to fish, if the extract has contact with water
- Leaves are toxic to livestock
- Extract can be used as an acaricide on livestock
- Potential agent against insect pests (to be tested)

Benefits of compost

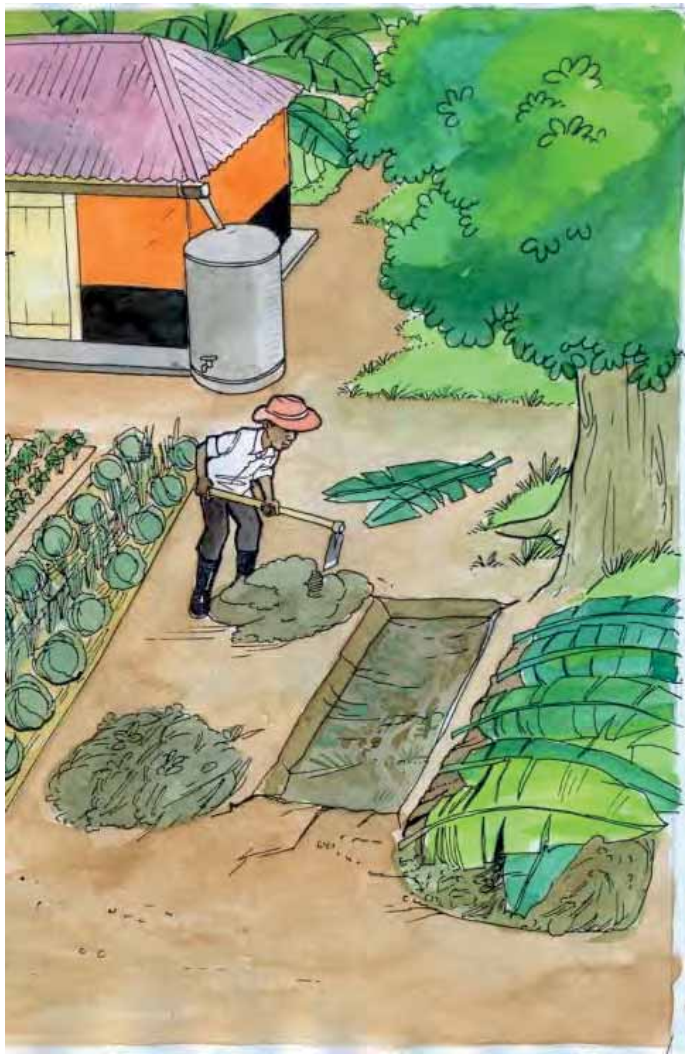
Compost …

… is a well balanced fertilizer.

… increases the pH of the soil.

… increases the water retention in the soil.

… improves soil fertility on a long term.

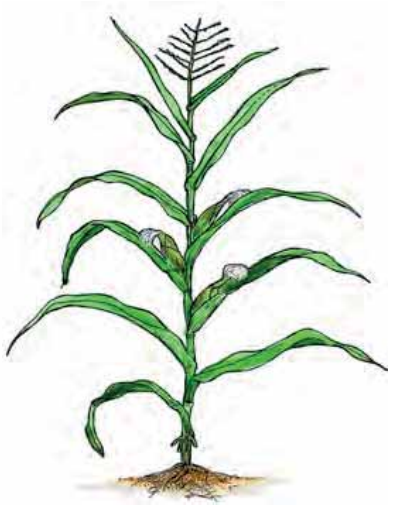


… can suppress soil borne diseases.

… destroys diseases on composted crop residues and weed seeds.

… improves the value of animal manure when composted together.

Grouping of crops for rotation planning



Crops can be grouped based on …

1. **Nutrient needs**
2. **Sensitivity to pests and diseases (plant families)**
3. **Root depth**
4. **Weed suppression**
5. **Climatic requirements (water and temperature)**
6. **Market demand / Use**

Grouping of crops based on nutrient needs

Heavy feeders
(high nitrogen demand)

Examples:
- **Corn**
- **Brassicas** (Cauliflower, Cabbage, Broccoli etc.)
- **Sunflower**
- **Celery**
- **Leek**

Moderate feeders
(moderate nitrogen demand)

Examples:
- **Root and tuber crops** (Carrot, Garlic, Potato, Sweet potato, etc.)
- **Fruit crops** (Tomato, Peppers, Pumpkin, Zucchini, etc.)
- **Leaf crops** (Lettuces, etc.)

Soil builders (= nitrogen fixing, high biomass production for soil fertility)
- **Leguminous crops** (Beans, Peas, Peanuts etc.)
- **(Leguminous) Green manure crops**

Grouping of crops based on susceptibility to diseases and pests (botanical families)

Cucurbits
Gourds, Cucumber, Melons, Pumpkins, Squash

Brassicas
Broccoli, Cabbage, Cauliflower, Mustard, Radish, Turnip

Nightshades
Potato, Tomato, Pepper, Eggplant

Alliums
Chive, Garlic, Leek, Onion, Shallot

Root crops
Cassava, Sweet potato, Taro, Yam, Water chestnut

Carrot family
Carrot, Celery, Dill, Parsnip, Parsley

Grains & Cereals
Corn, Rice, Sorghum, Wheat, Oat, Barley, Millet

Mallows
Cotton, Okra

Aster
Lettuce, Artichoke

Legumes
Beans, Peas, Peanut

Grouping of crops by rooting depth

Shallow rooting
(50 to 60 cm)

Examples:

- **Brassicas** (Cauliflower, Cabbage, Broccoli etc.)
- **Celery**
- **Corn**
- **Leek**
- **Leaf crops** (Lettuces, etc.)
- **Potato**

Moderate rooting
(90 to 120 cm)

Examples:

- **Bush beans, pole beans**
- **Peas**
- **Carrots**
- **Peppers**
- **Squash**

Deep rooting
(more than 120 cm)

Examples:

- **Sunflower**
- **Alfalfa**
- **Sweet potato**
- **Tomato**
- **Watermelon**

Basic rules for crop rotations

- **Pause between crops of the same family** (or with sensitivity to same soil-borne pathogens) of at least 2 years
- At least one **soil building crop** (legume or green manure crop replacing the traditional fallow with an intensive fallow)
- **Heavy feeders** after a nitrogen-fixing or green manure crop
- **Less nitrogen demanding crops** in the second or third year after a legume crop
- No root crop after root crop
- **Alternation** of **deep-rooted** with shallow, **fine-rooted crops**
- Alternation of **weed suppressing crops** with crops with low weed suppression

Evaluation of crops preceding potato

Preceding crop		Suita-bility	Comments
Grain cereal	Potato	+++	• Neutral pre-crop • Standard nitrogen fertilisation required to potato
Grain legume	Potato	+++	• Moderate nitrogen fertilisation required to potato
Green manure	Potato	+++	• No additional nitrogen fertilisation required • Nitrogen supply may be too high for potato
Brassica vegetable	Potato	++	• High nitrogen fertilisation required to potato • Brassicas contribute to nematode control
Root crops	Potato	++	• Not ideal (two root crops following each other) • Standard nitrogen fertilisation required
Maize	Potato	+	• Only in very fertile soils, as the soil is depleted after maize; Leguminous cover crop in maize can provide some nitrogen to potato
Nightshades	Potato	-	• Not recommended due to build-up of soil-borne diseases and pests (two nightshades following each other)

Evaluation of crops following potato

	Following crop	Suitability	Comments
Potato	Grain cereal	+++	• Good uptake of nutrients provided by potato
Potato	Brassica vegetable	+++	• Good uptake of nutrients provided by potato
Potato	Maize	+++	• Good uptake of nutrients provided by potato
Potato	Vegetable	++	• Good uptake of nutrients provided by potato

Examples of 3-year potato crop rotations

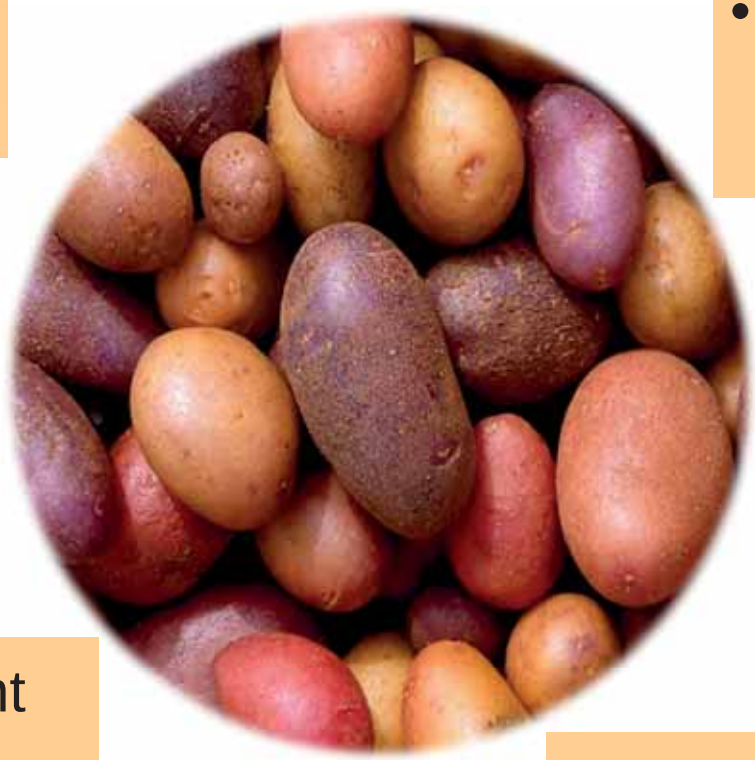
Season 1	Season 2	Season 3
Potato	*Two seasons without potato or other nightshades*	
Potato	Maize	Beans
Potato	Maize	Leguminous green manure
Potato	Brassica	Leguminous crop, e.g. beans
Potato	Other vegetable	Grain legume
Potato	**?**	**?**

Examples of 4-year potato crop rotations

Season 1	Season 2	Season 3	Season 4
Potato	*Three seasons without potato or other Solanaceae*		
Potato	Maize	Low feeder	Leguminous crop, e.g. beans
Potato	Brassica	Leguminous crop, e.g. beans	Cereal crop
Potato	Maize or other cereal	Green manure	Brassica
Potato	Maize/Vetch or Maize/Mucuna intercrop	Brassica	Leguminous crop, e.g. beans
Potato	**?**	**?**	**?**

Criteria for potato variety selection

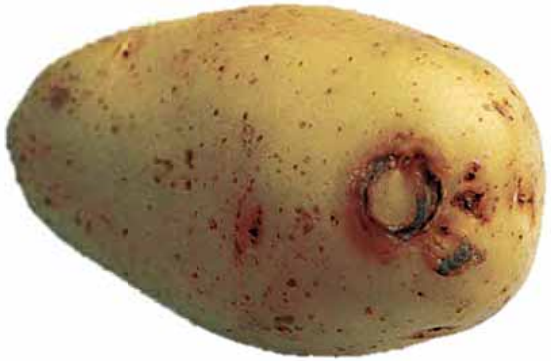
- Low susceptibility to diseases
- Intended use (fresh consumption, long storage, frying etc.)



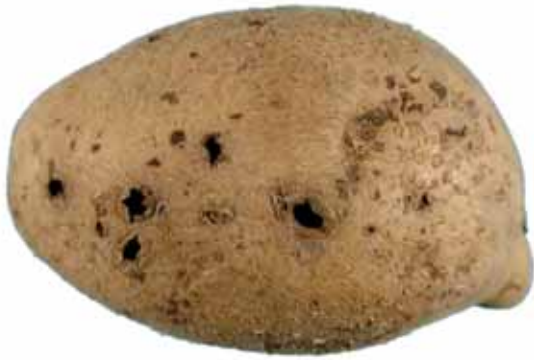
- Low nitrogen requirements
- Yield potential adapted to local conditions
- Quick development of a canopy to suppress weeds
- Customer wishes/market requirements (colour, taste, form, size etc.)

Detection of tuber diseases

Bacterial soft rot



Necrotic ringspots
(Virus PVYNTN)



Drycore

Tuber blight

Healthy tuber

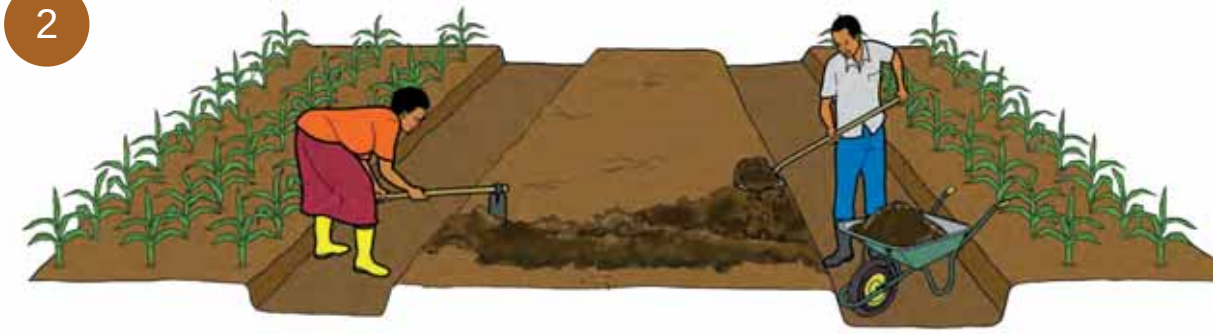
Streptomyces

Producing quality potato seed (Seed plot method) (1)

1

- Select a place with fertile soil (ideally with leguminous pre-crop or virgin soil)
- Plow the soil and make a raised bed of 15 cm height and 1.5 m width

2



- Apply about 9 litres of ripe compost per m2, if available, and incorporate it into the soil
- Ideally plant maize around the seed plot to keep air-borne pests and diseases away

3

- Plant disease free and true to type seed from a certified seed producer
- Plant 15 cm deep at 30 x 30 cm, and cover with soil

Producing quality potato seed (2)

4

- Remove diseased plants
- Remove weed by hand (not with tools)

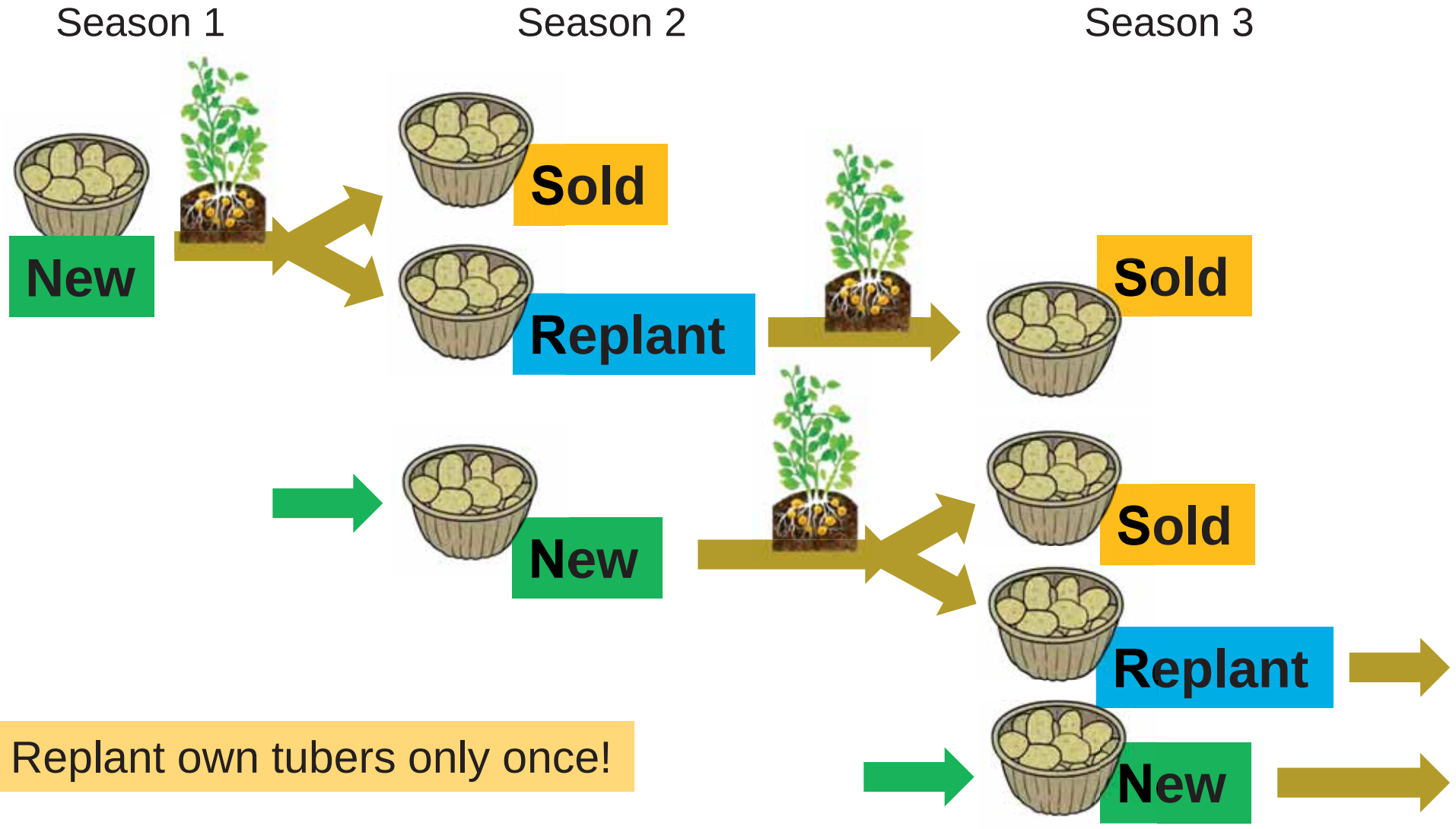
5

- Check tuber sizes regularly from the end of flowering onwards
- Cut the foliage close above the ground, when 70 to 80 % of the tubers have 30 to 60 mm size
- After 1 week cut re-growth of leaves to avoid virus infection by aphids

6

- When tubers have a firm skin, dig them out carefully
- Check the tubers for signs of diseases or pests. Save healthy tubers only

Seed replacement strategy



Replant own tubers only once!

Working steps to pre-germination of potato

1

Storage at 3-5 °C

Many sprouts

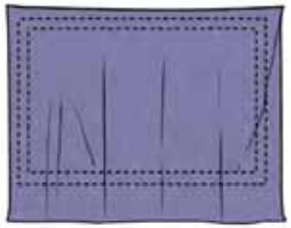
Small tubers

Storage at 7-8 °C

Few sprouts

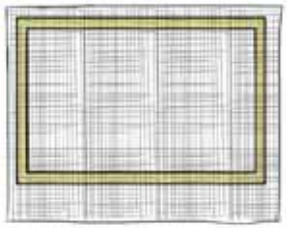
Large tubers

2



Dark room

Long, weak sprouts

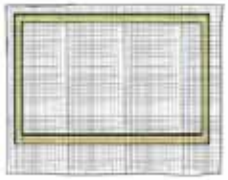


Indirect daylight

Short, strong sprouts

3

Indirect daylight



1-2 layers of tubers

4

Ideal, short sprouts after pre-germination

Manual potato cultivation

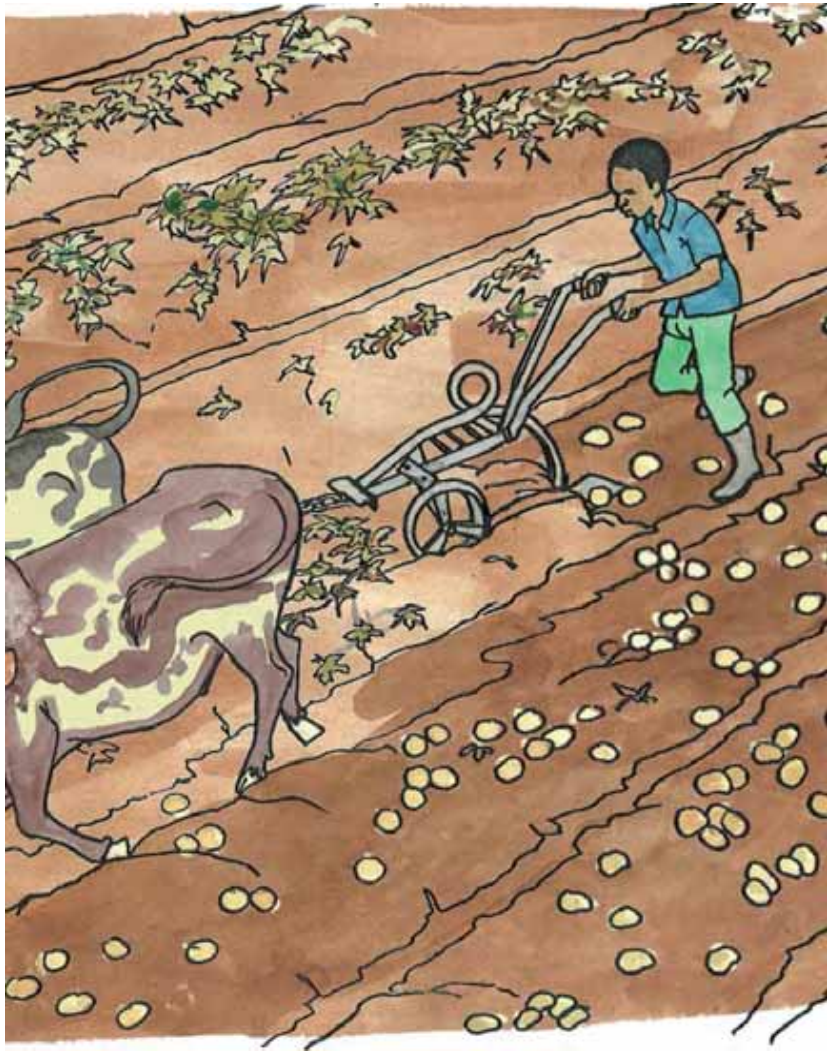
Advantages

- Low costs for tools, little maintenance
- Tools are always available
- Gentle soil cultivation possible
- Number of people can be adapted depending on amounts of work

Disadvantages

- Strenuous and harmful
- Low productivity
- Seasonal labour shortages can affect timely operations such as harvesting
- Careful planning required for efficient use of labour
- Risk of damages to tubers with the hoe

Mechanical potato cultivation



Advantages

- Higher productivity
- Can contribute to better growth conditions and higher yields
- No dependence on labour, no additional labour cost, less need for hiring and managing people
- Facilitates harvesting of large areas

Disadvantages

- High initial costs to buy the machines and high maintenance costs
- High productivity required for all operations
- Risk of damages to the soil structure and the crop
- Reduces the number of people benefiting from farm employment
- Dependence on the functioning of the devices

Seedbed preparation

Single-axle tractors

Rotary hoe for use on heavy soils mainly

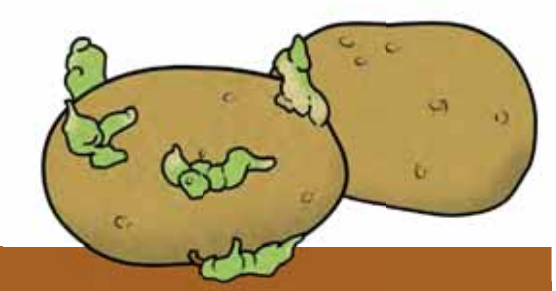
Tractor powered

Spring tine cultivator with a cage roller / packer for use on light soils

!

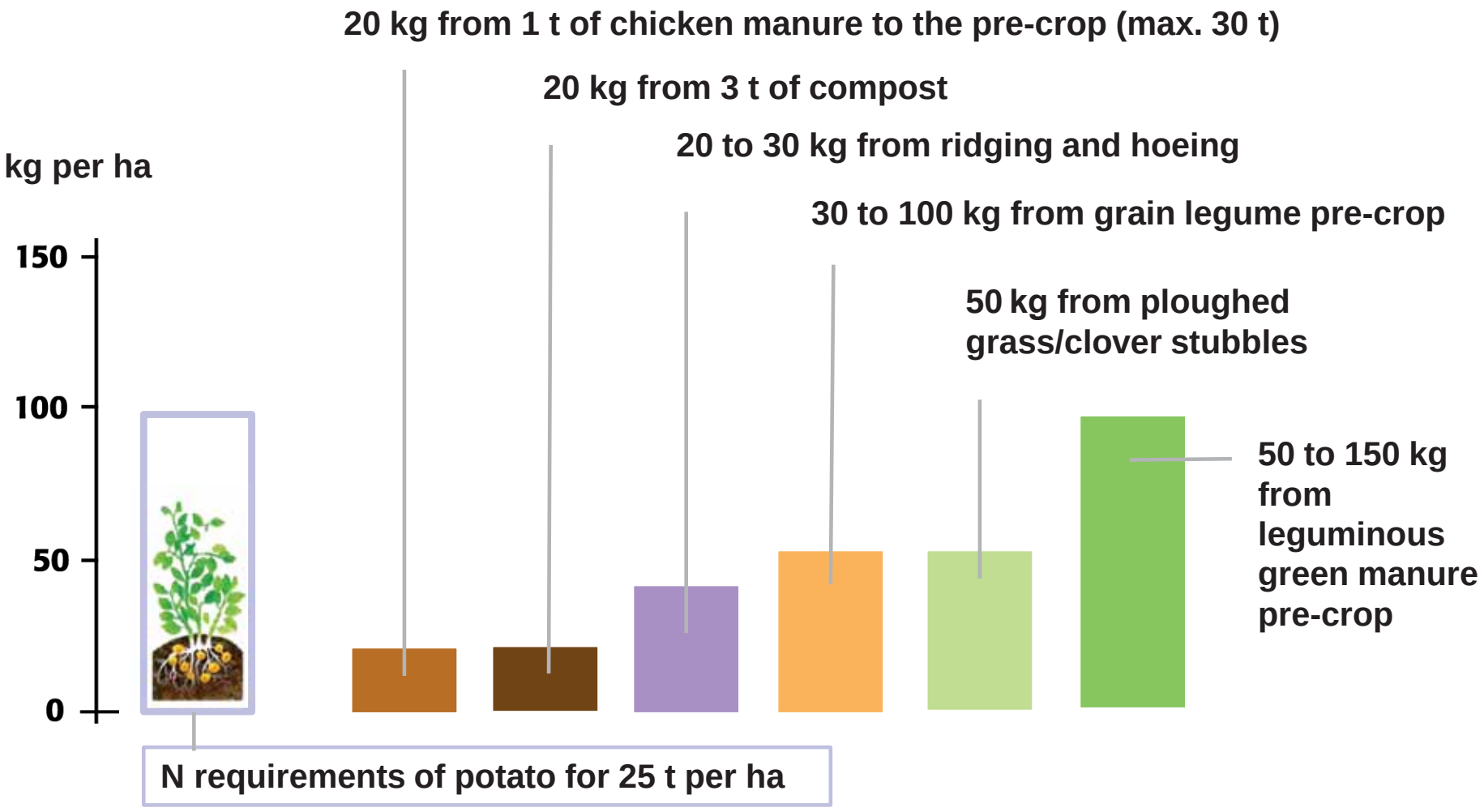
- Limit intensive soil cultivation, as it degrades soil structure
- Avoid soil compaction

Planting distances for potato



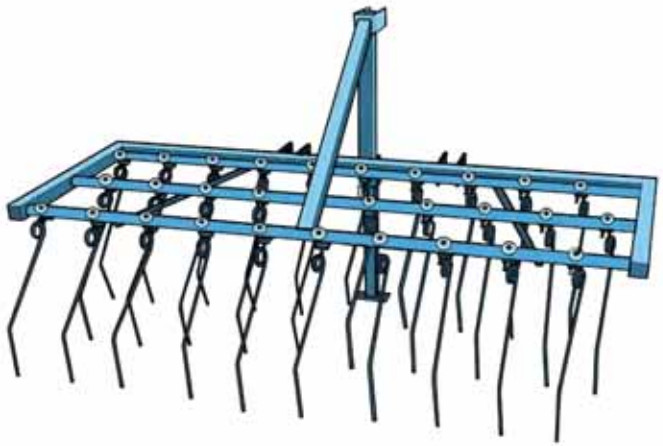
Number of tubers required for different spacing levels per hectare			
Distance between rows	**Distance in the row**		
	25 cm	**30 cm**	**40 cm**
75 cm	53333	44444	33333
80 cm	50000	41667	31250
90 cm	44444	37037	27778
100 cm	40000	33333	25000

Nitrogen supply to potato



Tools for weed control in potato (1)

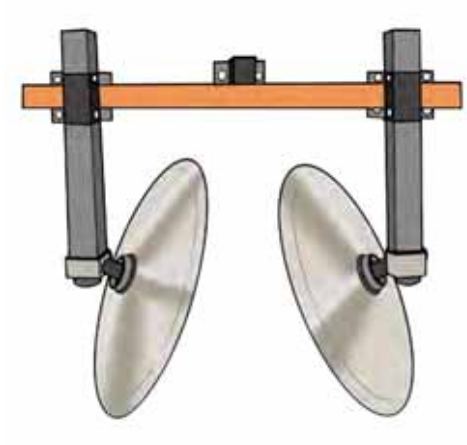
Tined weeder / Harrow / Ridge harrow

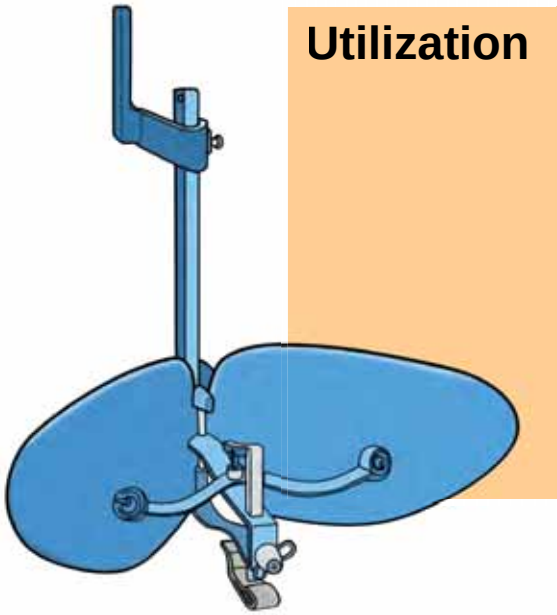


Advantages	• Versatile and quickly employable • Good adjustment to the ridge shape • Can be combined with the hoe
Disadvantages	• Only effective against small weeds before the 2-leaf stage • Only on the ridge crest, if no adjustment to the ridge shape
Utilization	• First passage before rising of potatoes • 2nd passage when potato plants are 10 cm high (no passage between rising and plant size of 10 cm)

Tools for weed control in potato (2)

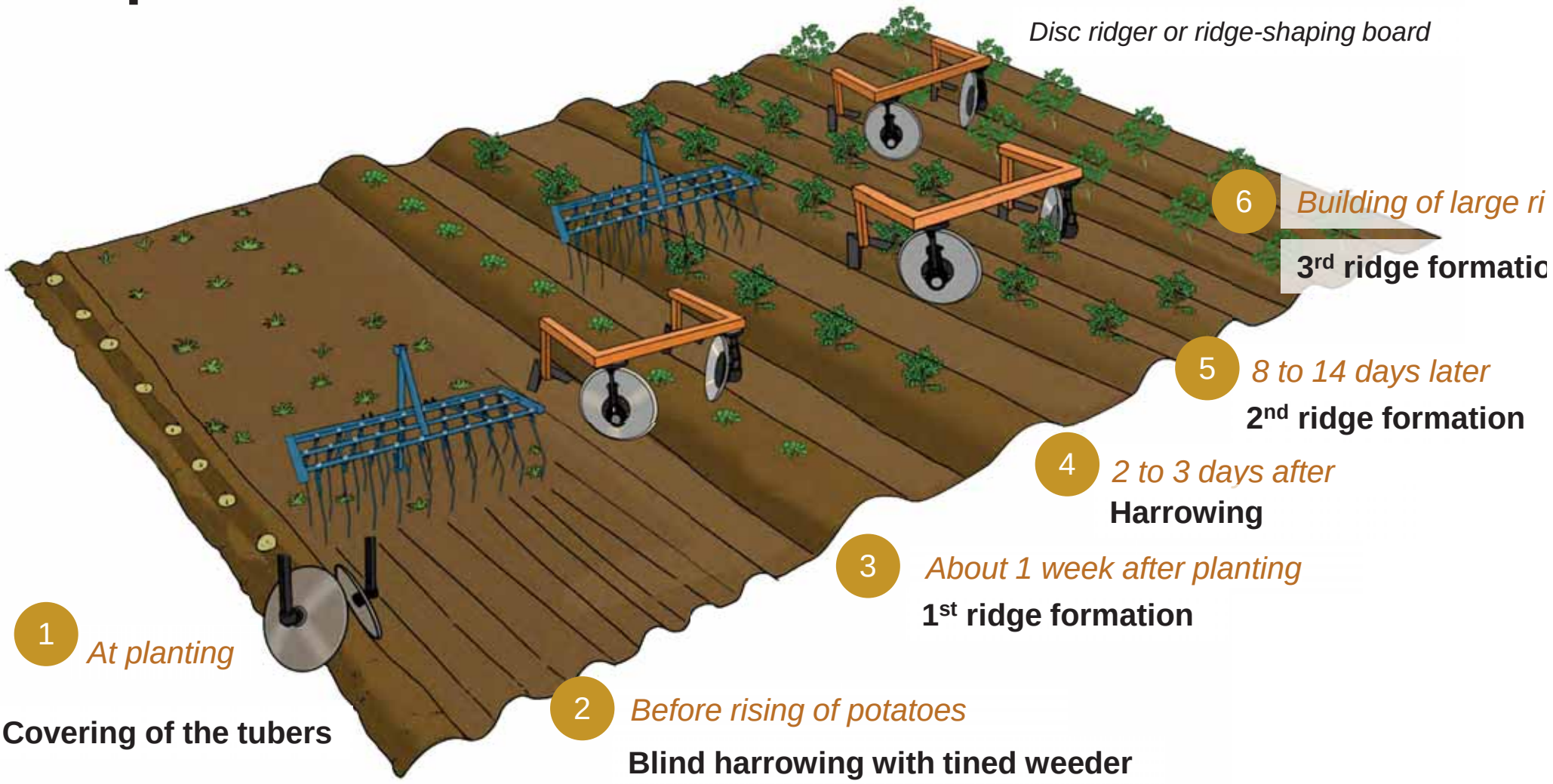
Duck foot hoe and ridgers





Advantages	• Effective against larger weeds between dams • Most effective device against perennial weeds
Disadvantages	• Can damage the tubers in the 3rd passage
Utilization	• Combined hoeing and ridging with mounting boards or disc ridger • Combination with harrow possible • Preferably apply at the end of the day, when the potato leaves are upright

Possible procedure in weed management in potato



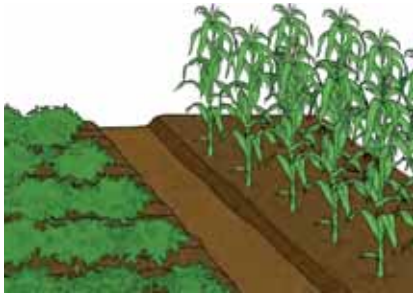
Three-step pest and disease management

3rd step

Direct control
Applying physical control measures and natural pesticides

2nd step

Habitat management
Enhancing natural enemies, distraction of enemies and good aeration of the crop



1st step

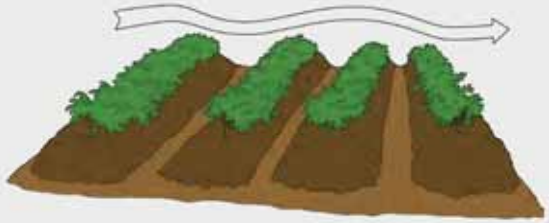
Crop management
Providing good growing conditions for strong plants

Late blight control

Symptoms

Infection

Through infected planting material



Through air- and soil-borne fungal spores at >90 % rel. hum. and >18 °C

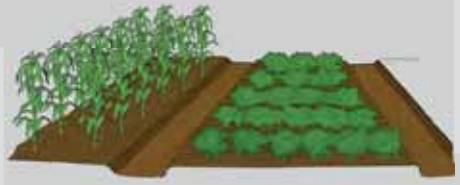
Prevention

Resistant varieties

Healthy seed tubers

Pre-germination of seed tubers

Well-ventilated location



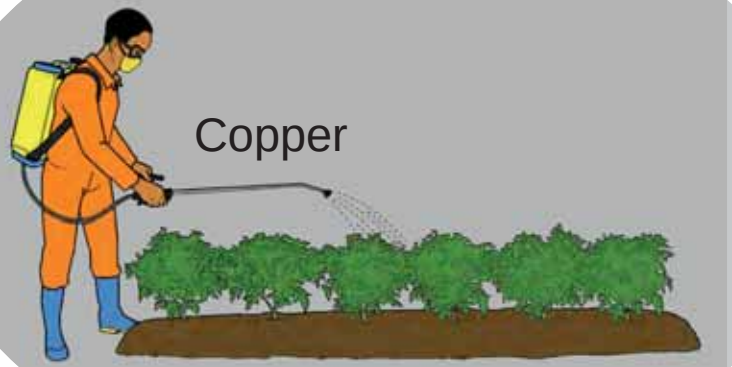
Barrier crop

Wide planting

Checking the crop every two days

Removing potential sources of infection

Protection



Copper

Plant strengtheners

Common products used for late blight control

Effect proven:

- Copper

Effect presumed or claimed:

- Stone powder
- Macerated papaya leaves
- Tithonia
- Wood-ash
- Charcoal
- Garlic
- Baking powder
- Effective micro-organisms (EM)
- Stinging nettle and Omo

How to prepare Bordeaux mixture

Use proper protection

1

Protect nose and mouth with a dust- and mist-filtering respirator, and wear goggles or safety glasses to protect the eyes. Wear protective clothing.

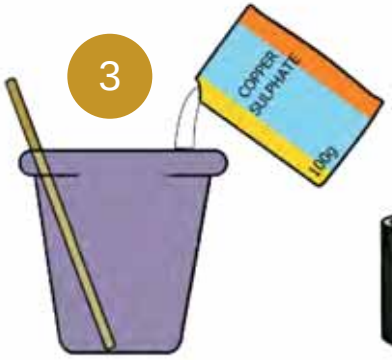
Dilute the lime

2

Fresh hydrated lime (calcium hydroxide) only, not from last season

Dilute the copper

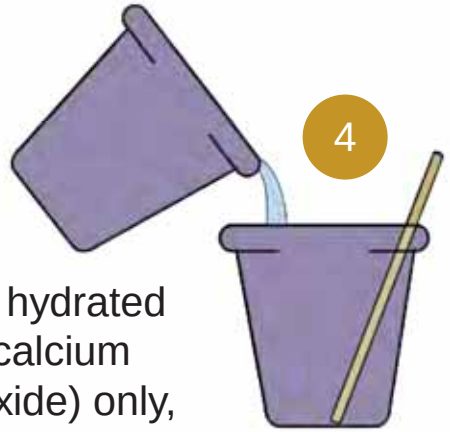
3



Store copper sulfate in a dry place in a closed box with no contact to air

Pour diluted lime into diluted copper

4



Apply soon

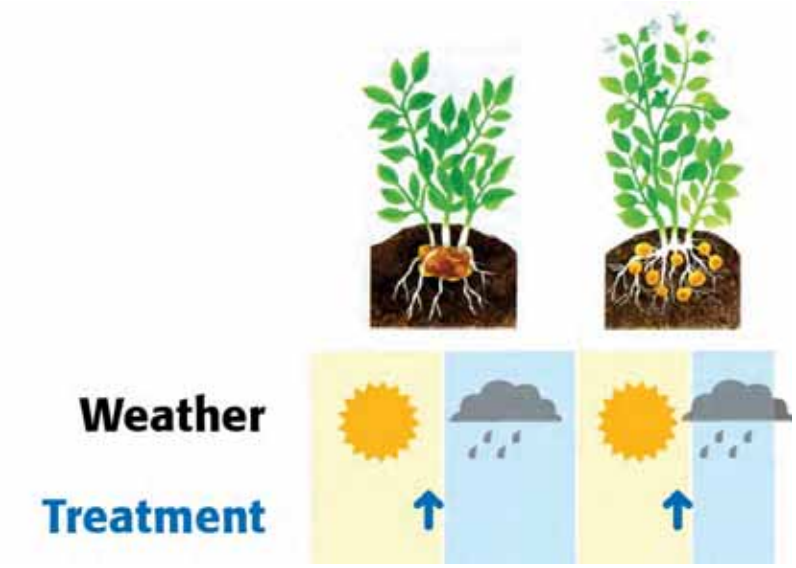
5

10 litres of Bordeaux mixture with 25 g of pure copper

Graduated dosage of copper

Level of infection	No infection within the region	Infection within the region	Infection in neighbouring crops or within the crop
Risk of leaf blight	Low	Medium	High
Dose of copper	None	Low 200 to 300 g per ha	High 800 to 1000 g per ha

Application of copper to potato



Basic rules:

- Apply product before precipitations in order to protect the crop
- Apply early enough to let the copper dry
- Apply onto the upper and lower sides of the leaves

Spray the plants from above and below

Repeat the treatment:

- after 30 mm of rain *or*
- after 7 days

Bacterial wilt control

Symptoms:

- First wilting at the ends of the branches during the heat of the day
- Rapid wilting of the entire plant without yellowing or spotting of leaves
- Leaves with a bronze tint
- Black or brown rings in tubers cut in half
- Squeezed tubers exude a thick white fluid
- Soil sticking to tuber eyes at harvest
- Rotting tubers with very bad smell

Preventative measures:

- Effective biodiversity
- Tolerance or genetic resistance of the variety
- Crop rotation
- Cropping season

Direct methods:

- Commercial plant protection agents
- On-farm production (efficacy not proven)

Prevention and management of virus infection

Infection

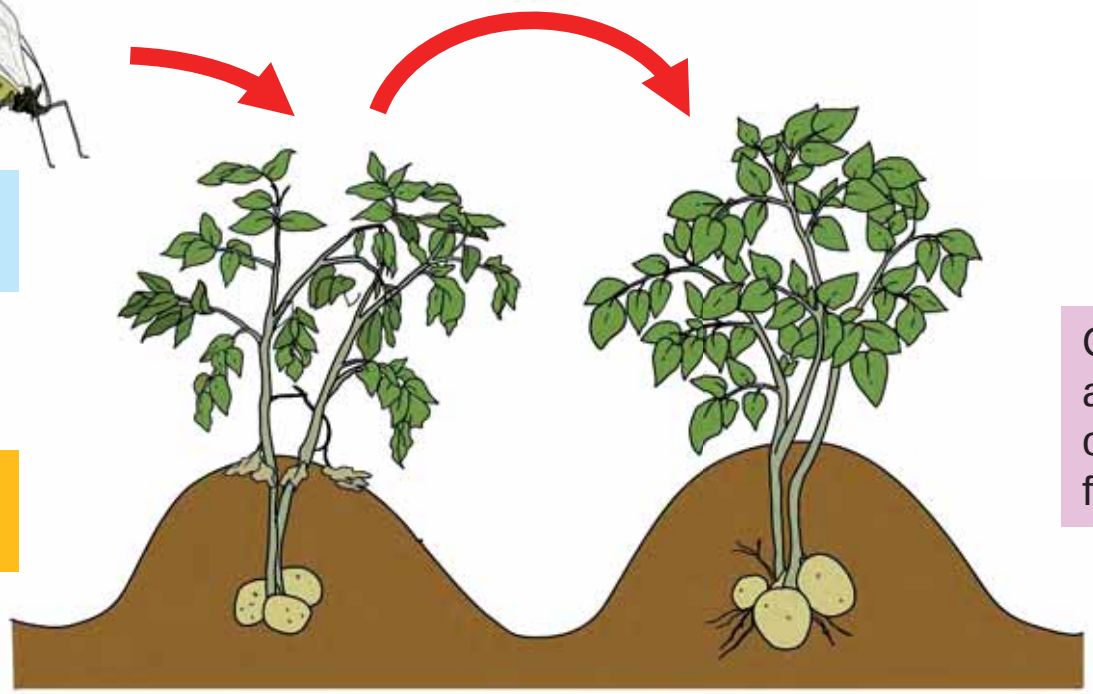
With infected planting material

By sucking insects carrying viruses

Control

Early rogueing of diseased plants

Controlling sucking insects



Prevention

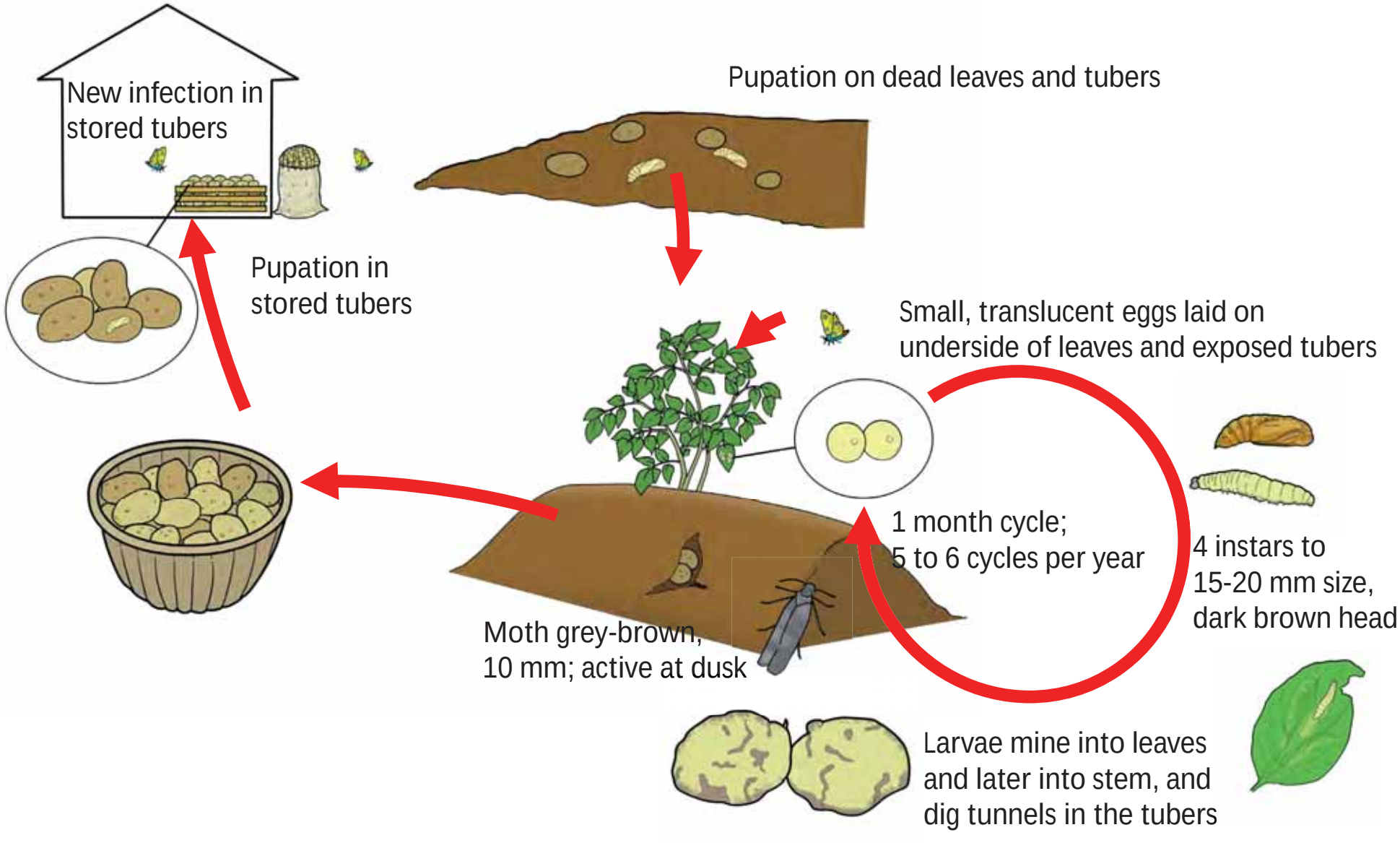
Virus-free seed tubers

Resistant varieties

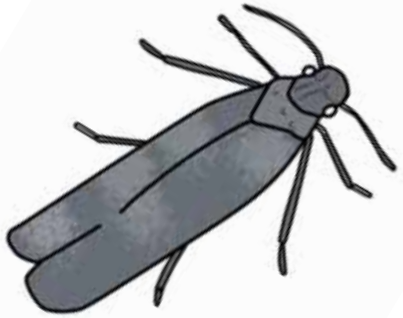
No overlapping of potato crops

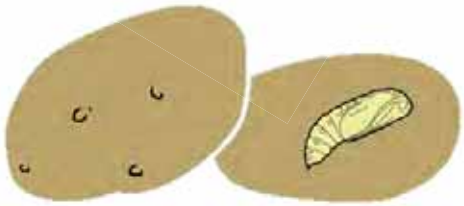
Controlling nightshades and volunteer potatoes on own and neighbouring fields

Potato tuber moth cycles



Potato tuber moth: prevention and control





Prevention:

- Use healthy, clean seed.
- Avoid planting in rough soil.
- Plant as deeply as possible (10 cm deep)
- Ridge at least three times during the growing season.
- Ensure compact hilling to prevent moths from reaching the tubers to lay eggs.
- At harvest, avoid exposure of tubers to moths.
- Destroy all infested potatoes immediately.
- Remove all plant residues from the field and destroy all volunteer potato plants before planting new potato crops.
- Encourage natural enemies such as ladybird, lacewing and parasitic wasps (e.g. Diadegma mollipla, Chelonus spp.).

Dehaulming

- When sample digs show that the tubers have reached the required size and desired starch content.
- In a healthy crop, when half of the leaves have turned yellow.
- In the case of leaf blight, to prevent the blight from reaching the tubers.
- Industrial potatoes: only when starch content and test baking meet the requirements.
- Seed potatoes: the date depends on the size of the tubers. Starch content and the occurrence of aphids may be important.
- In the case of regrowth repeat the measure.