

Oat field. Photo: W.carter, CC0, via Wikimedia Commons

Laisha *Review*

ISSUE 2
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Finland and the turn of the farming year

Oats in the north and the south, a caterpillar that crossed continents, animals in heat and cold, the honey bee's year, and how much water a crop really drinks.

LAISHA KIDS
Seeds and sprouts

VETERINARY
Animals in the season's extremes

CROP
Oats: the cool-season cereal

FROM THE LAISHA LIBRARY
Reading a soil test report

AROUND THE WORLD
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SUSTAINABILITY
The honey bee's year, north and south

CROP HEALTH
Fall armyworm: a decade on three continents

FROM THE LAISHA LIBRARY
When to water, and how much

WELCOME

One magazine, two seasons

December is early summer in the south and early winter in the north. This issue is written for both.

This issue reaches you at the turn of the farming year, and the turn looks different depending on where you stand. South of the equator, December is early summer: maize is racing up in southern Africa and South America, oats are being harvested across Australia, beehives are at their busiest, and dairy cows are looking for shade. North of it, the fields are resting, hives are clustered against the cold, cattle are on winter feed, and farmers are planning next season at the kitchen table.

So Issue 2 is written for both halves of the world at once. Our crop health story follows the fall armyworm, a caterpillar that has crossed continents in a decade, and what a careful farmer can do about it. Our crop is the oat, sown in spring in Finland and harvested in early summer in Australia. Our veterinary pages are about animals in the season's extremes, heat in one hemisphere and cold in the other. The bees get their own story, and so does the water: how to work out how much your crop drinks, with nothing more than a weather figure and a pencil.

Our happy country this time is Finland, ranked first in the World Happiness Report 2026 for a record ninth year in a row. Its farmers make the most of a short summer, under a sun that in the far north does not set at all for weeks. Children get a story of seeds and sprouts, with a bean to grow on a windowsill. And we show you the parts of Laisha that cost nothing at all.

This is also a bigger issue than our first, with more to keep and use. A tour of the world's fields in December and January opens it. There is a guide to reading a soil test report, a chapter on keeping the harvest you grew, and a farm cash book worked through line by line. Students get 33 exam-style practice questions with answers, and a glossary at the back explains every technical word in the issue. Several pages are made to be copied into a notebook: a fall armyworm scouting sheet, a water balance, a table of crop coefficients and a season checklist for each kind of livestock.

Tell us what to write next

This magazine is made for you, so we would like to hear from you. Which article did you read to the end? Which one did you skip? What should we explain next: a crop from your country, a pest in your fields, a question your teacher could not answer? Write to us at the address on laisha.ai/contact, or, if you have a Laisha account, through Feedback and Ideas in the app. Every message is read, and the best ideas become articles.

If this issue was useful, pass it on to one person who grows, studies or simply loves plants. It is free, and it stays free.

— *The Laisha team*

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Seeds and sprouts

Inside every dry bean is a baby plant with a packed lunch. What wakes it up, which part comes out first, and a bean in a jar to watch on your windowsill.



Seeds sprouting in a germination test. Photo: USFS Region 5, CC BY 2.0, via Wikimedia Commons

Hold a dry bean in your hand. It feels like a little stone. It does not move, it does not grow, and it does not need anything from you. But inside that bean is a tiny baby plant, fast asleep, with a packed lunch beside it. Give it the right things, and in a few days it will wake up.

What is inside a seed?

Every seed has three parts, and you can find all three in a bean.

WORDS TO KNOW

seed coat — the seed's jacket. It keeps the inside safe and stops it drying out.

embryo — the baby plant. It already has a tiny root and a tiny shoot.

stored food — the packed lunch. In a bean it is in two thick halves called cotyledons, or seed leaves.

germination — when a seed wakes up and starts to grow.

Soak a bean in water overnight. In the morning it will be fatter and softer. Gently rub off the seed coat, and the bean will split into its two halves. Look closely where they join and you will see the baby plant tucked between them. A magnifying glass helps.

What does a seed need to wake up?

A seed needs three things to start growing:

1. **Water.** The seed drinks it in and swells. That is why the soaked bean was fatter.
2. **Air.** A seed is alive and needs to breathe. Seeds drowned under deep water for too long cannot grow well.
3. **The right warmth.** Not too cold and not too hot. Most garden seeds like the warmth of a classroom or a kitchen.

What about light? Most seeds do not need light to wake up, because they usually start their lives under the soil, in the dark. (A few kinds of flower seed, such as begonias, are different and do need some light.) The new plant needs light later, once its green leaves have opened, to make its own food.

Which part comes out first?

The root. It pushes out of the seed and grows down, whichever way up the seed is lying. Then the shoot grows up towards the light. In many beans, the shoot comes up bent over like a hook, pulling its seed leaves gently out of the soil behind it, so the soft tip is not scraped.

First a root goes down, then a shoot comes up. Every plant you have ever seen started this way.

TRY THIS: A BEAN IN A JAR

You need a clear glass jar, some paper towels, water and two or three dry beans.

1. Fold the paper towels and line the inside of the jar with them. Push a little crumpled paper towel into the middle to hold them against the glass.
2. Slide the beans between the paper towel and the glass, about halfway down, so you can see them from outside.
3. Pour a little water into the bottom of the jar, so the paper towel stays damp but the beans are not sitting in water.
4. Stand the jar somewhere warm and check it every day. Add a little water if the paper starts to dry.
5. Each day, draw what you see. Which comes first, the root or the shoot? How many days did it take?

What you might see in your jar

Every jar is different, because every kitchen and classroom is a little warmer or cooler, but here is what many children see.

For the first day or two, it looks as if nothing is happening. Look closely, though: the beans are getting fatter as they drink, and their wrinkly seed coats are stretching smooth. This is the seed waking up inside, where you cannot see it.

Then one morning there is a crack in the seed coat, and a tiny white tip pokes out. That is the root. Over the next days it grows longer, and then very fine hairs appear along it, like fuzz. These root hairs help the root drink.

A little later, the shoot appears. It is pale at first and grows upwards, even though the bean is lying on its side. Once its leaves open in the light, they turn green. Now the young plant can start to make its own food, and the seed leaves that fed it slowly shrink as their packed lunch is used up.

If one of your beans does not sprout, that is normal too. Not every seed wakes up. That is exactly why farmers test their seeds before sowing a whole field.

When the shoot has two or three leaves, your bean plant can be planted in a pot of soil with a grown-up's help, and put in a sunny window.

Seeds big and small

Seeds come in every size. A coconut is a seed, and so is a grain of rice. Some seeds are so small that you could hold hundreds on a fingertip. Seeds travel, too. Some float on the wind with little parachutes, like dandelion seeds. Some hook onto animal fur and ride away. Some are hidden in sweet fruit, so that birds and animals eat the fruit and drop the seeds somewhere new.

Farmers all over the world start almost every crop from seed: wheat and oats, rice and maize, beans and peas. Before they sow, many farmers test a few seeds first, just like your jar, to see how many wake up. If most of them sprout, the seeds are good to sow.

TALK ABOUT IT

- Why do you think the root comes out before the shoot?
- What would happen if you put the jar in the fridge?
- Can you find seeds in your kitchen? Look in an apple, a tomato or a pea pod.

FOR GROWN-UPS

Beans, peas and cress are reliable first seeds. Keep the paper towel damp but not soaking, since seeds left sitting in water can rot. Wash hands after handling seeds, and use seeds sold for eating or sowing, not seeds coated with a treatment, which is usually shown on the packet. Children should not eat raw dry beans.

SOURCES

- Penn State Extension, Seed and Seedling Biology: the embryo, food reserves and seed coat; the radicle emerges first; a few species need light. extension.psu.edu/seed-and-seedling-biology
- University of Illinois Extension, The Great Plant Escape: seeds need water, oxygen and the right temperature to germinate. web.extension.illinois.edu/gpe
- Laisha Kids, Class 1: What Is a Plant? laisha.ai/kids/class-1/what-is-a-plant

Read the Class 1 book

laisha.ai/kids/class-1/what-is-a-plant

What Is a Plant? Laisha Kids, Class 1: roots, leaves, seeds and sunlight, to read aloud together.

AROUND THE WORLD · CROP CALENDAR

December and January in the world's fields

Planting in the southern rains, harvest across Australia and Argentina, rice in the Asian lowlands and winter wheat asleep under snow: what is happening in the fields of every region this month and next.

On any day of the year, somebody somewhere is sowing, somebody is weeding and somebody is harvesting. December and January show it more clearly than any other months, because the two hemispheres are at opposite ends of their seasons. This article takes a tour of the world's fields in these two months, region by region, using the crop monitoring reports of the Food and Agriculture Organization of the United Nations (FAO), the GEOGLAM Crop Monitor and national agencies.

Two kinds of source stand behind it. For the usual timing of each season we use FAO's GIEWS country briefs, the early warning system's notes on each country's crops, some of them written during last year's season; they show the normal rhythm, so we describe them as what typically happens. For this season, 2026/27, we use the November 2026 GEOGLAM Crop Monitor reports and the latest national releases. Local timing always varies with altitude, rainfall and variety, so treat this as a map, not a timetable.

Southern Africa: planting with the rains

In Malawi, Zambia, Zimbabwe and South Africa, the main maize season follows the summer rains. FAO's briefs describe planting of the summer cereal crops getting under way in November and December and, in Zimbabwe, running into January. The crop grows through the hot, wet months and is harvested from about April, with the main harvest in Zambia typically beginning in May. In Zimbabwe, irrigated winter wheat has already been harvested in October and November.

For 2026/27, the November Crop Monitor for Early Warning reports land preparation and planting under way for the main season. It also notes forecasts of below-normal rainfall from November 2026 to March 2027 linked to a strengthening El Niño, which is a reason to follow national seasonal forecasts and extension advice on planting dates and drought-tolerant varieties closely this year.

East Africa: one harvest ends, another season grows

In Ethiopia the main Meher season harvest runs from October and is expected to finish in December, according to FAO's November 2026 brief. In Somalia, crops of the Deyr season, sown with the October to December rains, are due for harvest in January 2027. Across Kenya and the eastern Horn, the short rains of October to December carry a second season of crops. The November Crop Monitor reports below-average yields in many areas for the main season in the northern part of the region, including Sudan, Ethiopia and South Sudan.

West Africa and the Sahel: the dry season

Across the Sahel, the rainy season typically runs from June to September, so by December the main cereal harvest of millet, sorghum and maize is finished or finishing. In Senegal, FAO's briefs show the coarse grain harvest ending in early December and the rice harvest running into January. The November Crop Monitor describes main-season harvests as mostly favourable outside conflict-affected areas, with rainfall shortfalls in parts of the Sahel, worst in Chad.

North Africa and the Middle East: winter cereals in the ground

Here the cropping season is the cool, wet winter. In Egypt, FAO reports that land preparation for the 2026/27 winter wheat started in November and planting is expected to continue through December. In Iran, planting of the 2027 winter cereals began in late September. In Morocco, winter wheat and barley are sown in autumn and harvested from May, so in December and

January the crop is establishing and growing, depending entirely on winter rain where it is not irrigated. The November Crop Monitor notes a dry start to the season in Algeria and Tunisia.

South Asia: rabi crops sown, kharif rice harvested

India has two main seasons. The kharif crops, above all rice, grow with the summer monsoon and are harvested in autumn; FAO's brief for last season reported the main rice crop harvested by January, and the November 2026 Crop Monitor reports kharif harvesting progressing in the northern states. The rabi crops, led by wheat, are sown after the monsoon and grow through the cool, dry winter. Last season FAO reported a record rabi wheat area estimated at 33.4 million hectares, with harvest starting in late March.

Southeast Asia: rice, season after season

In Viet Nam, FAO's briefs show the main paddy season finishing in December and the winter-spring rice crop planted through to early March; in November 2026, the Crop Monitor reports wet-season rice harvesting under way in the north. In Thailand, the main paddy harvest typically finishes by the end of January, while second-season irrigated rice is planted; the Crop Monitor reports that drought and recent floods have reduced wet-season rice yields this year in parts of the region. In Indonesia, the main rice crop is sown with the wet season from about November and harvested from February; the November Crop Monitor reports sowing of wet-season rice beginning.

East Asia: winter wheat at rest

In China, winter wheat is sown in autumn. FAO's brief for last season describes planting finished in November and, in early January, the crop dormant in the north and tillering in the milder centre and south. The North China Plain's wheat will wake with the spring and be harvested in early summer.

Europe, Russia and North America: winter crops established

Across Europe, Russia, Ukraine and the United States, winter wheat, barley and rapeseed are sown in autumn and pass the winter as young plants, growing slowly or not at all in the cold, before racing ahead in spring. The November 2026 Crop Monitor for AMIS reports sowing of the 2026/27 crop progressing in the EU under contrasting conditions, with drought slowing emergence in southern and central Europe; conditions favourable in Russia, where sowing of winter wheat has caught up; and winter wheat sowing progressing in the United States, with rain easing drought in the Plains.

South America: soybean and maize going in, wheat coming out

In Brazil, December is the heart of the planting and early growth of the main summer crops. Brazil's national supply company, CONAB, reported on 13 November 2026 that 66.8 per cent of the 2026/27 soybean area had been planted by the first week of November, and that planting of the first-season maize had passed half its area. Last season, FAO reported the first-season maize harvest starting in February. In Argentina, FAO's brief for last season shows the wheat and barley harvest finishing in January, while maize for harvest from March was sown; in November 2026 the Crop Monitor reports the wheat harvest beginning in the north.

Australia: the winter crop harvest

In Australia, wheat, barley, canola, oats and pulses sown in autumn are harvested from about October through the early summer. The November 2026 Crop Monitor reports harvesting ongoing, with above-average yields expected in South Australia and Victoria and below-average yields in Queensland. As this issue's oat story describes, Western Australian oats are typically harvested between October and December.

THE WORLD'S FIELDS AT A GLANCE, DECEMBER AND JANUARY

Southern Africa — maize planting with the rains; harvest from about April

East Africa — Ethiopia's Meher harvest ending; short-rains crops growing; Somalia's Deyr harvest in January

Sahel and West Africa — main harvest done; dry season

North Africa and Middle East — winter wheat and barley sown and growing

South Asia — rabi wheat growing; kharif rice harvest finishing

Southeast Asia — wet-season rice harvest in some places, planting in others

China — winter wheat dormant in the north, tillering further south

Europe, Russia, North America — winter cereals and rapeseed established, slow or dormant

Brazil — soybean and first maize planted and growing

Argentina — wheat and barley harvest; maize growing

Australia — winter crop harvest

How to use a crop calendar

A regional calendar tells you what is normal. Your own field tells you what is true. Use the calendar to plan: when seed and fertiliser must be bought, when labour and machines will be in demand, when prices often move as a harvest comes in. Then adjust it every season with your own records of sowing and harvest dates and with your national meteorological service's seasonal forecast. Laisha's monthly farming calendar on laisha.ai lists what is commonly sown and harvested each month.

Half the world is planting while the other half harvests. Every month is somebody's busiest month.

SOURCES

- FAO GIEWS country briefs (fao.org/giews/countrybrief): Malawi (December 2025), Zimbabwe (December 2025), South Africa (April 2026), Zambia (April 2026), Ethiopia (November 2026), Somalia (September 2026), Senegal (December 2024), Niger (August 2026), Egypt (November 2026), Iran (November 2026), Morocco (July 2026), India (February 2026), Viet Nam (February 2026), Thailand (January 2026), Indonesia (January 2026), China (January 2026), Brazil (March 2026), Argentina (February 2026).
- GEOGLAM Crop Monitor for AMIS, No. 144, and Crop Monitor for Early Warning, No. 121, November 2026. cropmonitor.org
- CONAB (Companhia Nacional de Abastecimento, Brazil), 2026/27 grain crop estimate, 13 November 2026. gov.br/conab
- Department of Primary Industries and Regional Development, Western Australia, and GRDC, for Australian oat harvest timing (see this issue's oat article).

December's farming calendar What to sow, grow and harvest this month, on laisha.ai.
laisha.ai/calendar/2026-12

VETERINARY · DEGREE MANUAL

Animals in the season's extremes

December brings summer heat to cattle in the south and winter cold to herds in the north. How to read an animal's comfort, and the simple things that keep it inside its comfort zone.



Dairy cows at pasture. Photo: Karl and Ali, CC BY-SA 2.0, via Wikimedia Commons (Geograph)

In December the same cow faces opposite problems depending on where she lives. In Australia, New Zealand, South Africa, Argentina and Brazil it is the start of summer, and a high-yielding dairy cow on a humid afternoon is working hard just to stay cool. In Canada, northern Europe, northern China or the American Midwest it is the start of winter, and a beef cow on a wet, windy day is burning feed just to stay warm. Laisha's degree manual on Environment & Environmental Hygiene starts both stories in the same place: the animal's comfort zone.

The comfort zone

Every warm-blooded animal has a range of temperatures, the thermoneutral zone, in which it keeps its body temperature with little effort. Below the lower critical temperature it has to make extra heat, and that heat comes from feed. Above the upper critical temperature it has to spend energy and water getting rid of heat, and it eats less and produces less. Where those limits sit depends on the species, age, size, coat, feeding level and how much milk or meat the animal is producing. A high-yielding cow makes a great deal of heat from digesting her feed, which is why she feels the heat sooner than a dry cow.

Animals lose heat in four ways: radiation, conduction, convection and evaporation. As the air gets close to skin temperature, the first three stop working, and the animal depends on evaporation, from sweating and from panting. Evaporation depends on how dry the air is. That is why humid heat is harder on animals than dry heat at the same temperature.

Measuring heat stress: the THI

Farm advisers combine temperature and humidity into one number, the temperature-humidity index, or THI. Several formulas exist, and a threshold must be used with the formula it was worked out for. The figure most extension services now give for dairy cows is low: Penn State Extension says productive dairy cows may experience heat stress at a THI of 68 or more, and the University of Georgia's dairy extension says that when the daily average THI reaches 68, milk yield starts to decline and cooling should begin. A THI of 68 is not a hot day by human standards: by the widely used US National Research Council formula it is about 22 °C at 50 per cent relative humidity.

SIGNS OF HEAT STRESS IN CATTLE

- Faster breathing, then panting and open-mouth breathing
- Drooling and excess saliva
- More time standing, less time lying down
- Eating less, drinking more
- Restlessness and a higher body temperature
- Less milk, and weaker signs of heat (oestrus) in cows to be bred

The cost does not stop with milk. Penn State reports that pregnancy rates can fall by as much as 53 per cent during heat stress, and a heat wave in late pregnancy can affect the calf's later performance.

Cooling, in order of cost

1. **Water, and plenty of it.** Penn State gives 30 to 50 US gallons a day for a lactating dairy cow, about 115 to 190 litres, and says intake can double in heat stress. Provide enough drinking space for about one cow in five in a group to drink at once, and keep troughs clean and close to where cows rest and are milked.
2. **Shade.** Sunshine adds a large heat load to an animal outdoors, so shade is the cheapest intervention there is. Penn State suggests shade structures at least 12 feet (about 3.7 metres) high, so air can move underneath.
3. **Soak, then blow.** Sprinklers with coarse droplets that wet the skin through the coat, followed by fans moving air over the cows, cool them by evaporation. The University of Georgia notes that airflow and direct wetting together work better than either alone. Misting that only dampens the coat surface is far less useful in humid climates.
4. **Work them in the cool.** Move, handle and treat animals early in the day, not in the afternoon heat.

Pigs and poultry in the heat

Pigs sweat very little, so they depend on wallows, sprinklers, shade and moving air. Birds cannot sweat at all. Penn State's poultry advisers describe heat-stressed birds panting, crouching and holding their wings away from their bodies. Cool water, shade, ventilation and avoiding disturbance in the hottest hours are the first steps for both.

Cold stress: the wet coat problem

In winter the question is the lower critical temperature, the point below which an animal needs extra feed just to keep warm. For beef cattle, Penn State and South Dakota State University extension give these approximate figures:

LOWER CRITICAL TEMPERATURE OF BEEF COWS, BY COAT

Summer or wet coat — 15 °C (59 °F)

Autumn coat — 7 °C (45 °F)

Winter coat — 0 °C (32 °F)

Heavy winter coat — −8 °C (18 °F)

The striking line is the first one. A cow in a thick, dry winter coat is comfortable at well below freezing; the same cow soaked by rain or sleet loses most of that insulation and starts to feel the cold at 15 °C. Both extension services give the same rule of thumb: for every degree Fahrenheit below the lower critical temperature, a cow's energy needs rise by about one per cent. Wind makes it worse.

That is why the most useful winter jobs are about keeping animals dry and out of the wind: a windbreak, which can be a building, woods, a fence line, a hollow or a stack of big bales, and dry bedding that insulates them from mud and frozen ground. Extra energy in the ration matters most in cold, wet spells. And water still matters in winter: South Dakota State University notes that when water is limited, cattle eat less.

A season checklist for each species

These checklists gather the points above, and add what Laisha's degree manuals on livestock and poultry production say about each species. Use the summer list from December to February south of the equator, and the winter list in the north. Then swap in six months.

DAIRY COWS

Summer: water at every exit from the milking parlour and in every paddock, with room for one cow in five to drink at once. Shade over the holding yard and the feeding area. Soak-and-blow cooling in the holding pen. Feed and move cows in the cool of the morning. Count breaths on hot afternoons. Expect weaker heats, and plan breeding records with that in mind.

Winter: dry, deep bedding where cows lie. Shelter from wind and driving rain. Check water troughs every morning for ice. Watch body condition, because cold raises energy needs. Calves: colostrum early, deep straw, and a jacket in cold, wet weather.

BEEF CATTLE

Summer: shade for every animal, including in feedlots and on pasture. Clean water, with more trough space than you think you need. Work cattle only early in the day.

Winter: a windbreak of woods, a fence line, a hollow or bales. Dry ground or bedding to lie on. More energy in the ration in cold, wet spells, remembering that a wet coat raises the lower critical temperature to about 15 °C. Water that the cattle can actually reach.

PIGS

Summer: the manual is blunt: the pig has no functional sweat glands and a thick layer of fat, so adult pigs cope poorly with heat. They cool themselves by panting, lying on cool or wet floors and wallowing. Give shade, sprinklers or drip cooling for sows, good air speed, and wallows outdoors. White pigs outdoors also get sunburnt.

Winter: newborn piglets have the opposite problem. They are born wet, with little fat, and chill quickly. The manual gives approximate comfort zones of about 30 to 34 °C for the newborn piglet, 26 to 28 °C for a newly weaned pig, and 15 to 21 °C for growing pigs and sows. A farrowing pen therefore needs two climates: a cooler room for the sow and a warm covered creep area for the piglets. Watch the piglets: huddled piglets are cold, piglets spread away from the heat are too warm.

POULTRY

Summer: cool, clean water at all times. Poultry drink roughly twice as much water as they eat feed by weight at moderate temperatures, and more in heat. Shade, ventilation and no disturbance in the hottest hours. Laying hens in a heat wave lay thinner-shelled eggs, because panting upsets the blood chemistry the shell gland depends on.

Winter, and brooding at any time of year: chicks cannot keep themselves warm for their first two to four weeks. Pre-heat the house so the floor and litter are warm, not just the air. Strain guides typically start at the low to mid 30s °C at chick level for spot brooding, falling by roughly 2 to 3 °C a week. Chicks that huddle under the heater and cry loudly are cold; chicks that pant, droop their wings and crowd at the walls are too hot.

SHEEP AND GOATS

Summer: shade and water on every paddock. In temperate flocks, shearing and fly-strike prevention are the main warm-weather jobs; check the flock daily for struck animals in warm, humid weather.

Lambing and kidding, often in late winter or spring: the manual notes that lamb and kid losses concentrate in the first few days of life, from starvation, hypothermia, mismothering and predation, so the greatest return comes from watching births and the first week. Make sure every newborn sucks early, give shelter from wind and rain, and bring chilled lambs or kids somewhere warm quickly.

Newborns first

A newborn calf has little fat and a large surface for its size, so it feels the cold far sooner than its mother. Penn State gives a lower critical temperature of about 10 °C (50 °F) for young calves and recommends deep straw bedding and calf jackets in cold weather. The first defence, in any season, is colostrum: the UK's Agriculture and Horticulture Development Board (AHDB) recommends a first feed of 3 litres of good colostrum within two hours of birth.

An animal's behaviour tells you it is too hot or too cold long before the milk records do. Watch breathing, standing and drinking.

TRY THIS: A FIVE-MINUTE COMFORT CHECK

1. Count breaths for one minute on three cows lying down in the shade. Write the number and the time of day.
2. Note how many cows are standing in the hottest hour, and how many are lying down.
3. Check that every trough is full, clean and reachable.
4. In winter, look at the coats after rain: wet and flat, or dry and fluffed?

Do it on a cool day and a hot day, and compare.

SOURCES

- Penn State Extension: Heat Stress Abatement Techniques for Dairy Cattle; Heat Stress and the Often Forgotten Heifers; The Value of Water; Heat Stress and Beef Cattle; Cold Stress and Beef Cattle; Using Calf Jackets to Avoid Heat Loss; Summer Flock Care. extension.psu.edu
- University of Georgia Extension, dairy: preparing for cooling cows (2025). site.extension.uga.edu/dairy
- South Dakota State University Extension: cold weather management options. extension.sdstate.edu
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- Laisha degree manuals: Environment & Environmental Hygiene (chapter 4, The thermal environment and heat stress indices; chapter 1, water requirement); Livestock Production Management II: Monogastric and Laboratory Animals (swine housing and environment); Livestock Production Management I: General Principles and Ruminants (sheep and goats); Avian and Poultry Production Management (brooding); Livestock Farm Practices (the sheep year).

Read the full manual
laisha.ai/degrees/veterinary/environmental-hygiene

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SUSTAINABILITY · DEGREE MANUAL

The honey bee's year, north and south

In December one half of the world's hives are clustered against the cold while the other half are at their busiest. What bees do in each season, and what farmers can do for them.



A honey bee on broccoli flowers. Photo: Phytism, CC BY-SA 4.0, via Wikimedia Commons

Open a hive in Pennsylvania, Poland or northern Japan in December and you will find the bees packed into a ball, keeping each other warm on a diet of stored honey. Open one in New South Wales, the Western Cape or Patagonia and you will find them flying hard, bringing in nectar and pollen, and perhaps getting ready to swarm. The honey bee lives the same year in both hemispheres, six months apart. Knowing where the bees are in that year helps every farmer who depends on them.

Why farmers should care

Laisha's degree manual on Ecosystem Services & Pollinators starts from a simple idea: every farm borrows services from nature, and pollination is one of the most valuable. The global assessment by IPBES, the intergovernmental science panel on biodiversity, found that more than three-quarters of the world's food crops rely at least in part on pollination by insects and other animals, and put the annual value of the crops directly affected at between US$235 billion and US$577 billion. FAO adds that there are more than 20,000 species of bees. The honey bee is only one of them, but it is the one farmers can move, manage and rent.

Northern winter: the cluster

A honey bee colony does not sleep through winter. When it gets cold, the bees gather into a tight ball, the winter cluster, spread across several combs. Penn State Extension describes it as warmest in the centre and cooler at the edge. Bees in the cluster make heat by vibrating their flight muscles. Researchers at the United States Department of Agriculture give the best core temperature of a winter cluster as about 34 to 35 °C, even when the air outside is far below freezing.

That heat is paid for in honey. A colony in a cold climate needs a large store to last until spring flowers come: one Penn State beekeeping system aims for a hive weighing about 120 pounds, around 60 pounds or 27 kilograms of it stored food, going into winter. A colony that runs out of food in late winter, just when it starts raising young again, can starve with honey only a few centimetres away on a frame the cluster cannot reach.

BEES THAT LIVE LONGER IN WINTER

Summer worker bees live about six weeks, worn out by foraging. The bees raised in autumn are different. Penn State Extension says winter bees can live up to six months, long enough to carry the colony through to spring.

Southern summer: the busy season

South of the equator, November and December are late spring and early summer. Flowers are everywhere, colonies grow fast, and the instinct to swarm is strong. The Queensland Government's beekeeping guidance says swarms naturally occur in spring to early summer, and that beekeepers should take responsibility for a swarm that has come from one of their hives. Regular inspections, giving the colony more room, and splitting strong colonies are the usual ways beekeepers manage it.

It is also the season when crops need bees and bees meet sprays. Orchards, oilseeds, pulses, melons and many vegetables flower in the southern summer, at the same time as insecticides are being applied against summer pests.

Varroa: a mite that changed the map

The varroa mite, *Varroa destructor*, feeds on honey bees and spreads viruses between them. For many years Australia kept it out. Plant Health Australia records that varroa was introduced to New South Wales in June 2022. In September 2023 Australia's national management group agreed that eradication was no longer technically feasible, and the response moved to managing the mite. Australian beekeepers now monitor and treat for varroa, as beekeepers in most of the world have done for decades. The lesson for every country is the same: check hives regularly, follow your government's rules on moving hives, and report anything unusual.

What farmers can do for bees

Most of what helps bees costs little:

1. **Do not spray flowering crops.** The University of California's integrated pest management programme advises avoiding any pesticide on plants that are flowering, particularly insecticides and miticides.
2. **Watch for drift onto blooms.** The same guidance warns against drift onto nearby flowering plants, including flowering weeds in and around the field.
3. **Read the label.** Many products carry specific warnings for bees. Follow the directions for use exactly.
4. **Talk to your beekeeper.** If hives are in or near your fields, agree a simple system: warn the beekeeper before spraying so the hives can be closed or moved.
5. **Keep some flowers in the landscape.** FAO notes that sustainable agriculture can reduce risk to pollinators by diversifying the agricultural landscape. Field margins, hedges and patches of flowering plants feed bees when the crop is not in flower.

A bee that visits your crop is working for you. A spray on open flowers can undo that work in one afternoon.

A calendar for both halves of the world

THE HONEY BEE YEAR

- **Winter** (north: December to February; south: June to August): the cluster. Check food stores by lifting the back of the hive, and disturb the bees as little as possible.
- **Spring** (north: March to May; south: September to November): the colony builds up, first inspections, and swarm season begins.
- **Summer** (north: June to August; south: December to February): the main nectar flow. Add space, manage swarming and watch for sprays on flowering crops.
- **Autumn** (north: September to November; south: March to May): winter bees are raised. Check stores and pests before the cold.

Exact months depend on your climate, altitude and flowers, so use the calendar as a guide and your local beekeeping association for the detail.

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Read the full manual

laisha.ai/degrees/sustainability/ecosystem-services-pollinators

Ecosystem Services & Pollinators in Agricultural Landscapes: ten chapters.

CROP · GROW GUIDE

Oats: the cool-season cereal

Sown in spring in Finland and harvested at the start of summer in Australia, the oat is a hardy grain with a long record on poorer soils. How it is grown, and what to watch for.



Oat harvest. Photo: W.carter, CC0, via Wikimedia Commons

In Finland, oats go into the ground in spring, as soon as the snow has gone and the soil can be worked, and come out in late summer or early autumn. In Western Australia, they are sown in autumn, in April and May, and harvested between October and December. At this time of year, while Finnish fields lie under snow, Australian growers are heading oats for grain and baling them for hay. The same plant, Avena sativa, is at home in both places, because what it likes is a cool growing season.

A grain that likes it cool

The oat is a cereal grass. Instead of a tight ear like wheat, it carries its grains in an open, nodding head called a panicle. It grows best in cool, moist conditions and does not like heat at flowering, which is why it is a spring crop in the north and a winter crop in warm countries such as Australia, where it grows through the cool, wet months.

Oats have a reputation as a forgiving crop. Ireland's agriculture and food development authority, Teagasc, puts it simply: oats are more forgiving of low soil fertility than wheat and barley. That is one reason oats are often grown on lighter or poorer land, and why many farmers use them to break a run of other cereals.

Who grows the world's oats?

According to the United States Department of Agriculture's November 2026 world grain report, world oat production in the 2025/26 season was about 26 million tonnes. The European Union grew the most, almost 9 million tonnes, followed by Canada, Russia, Australia, Brazil, Argentina, the United States, the United Kingdom and China. Canada and Australia are the biggest exporters.

QUICK FACTS: OATS IN FINLAND

Area in 2025 — 320,000 hectares, the country's second-largest cereal after barley

Harvest in 2025 — 1.13 million tonnes

Exports, 2024/25 — almost 470,000 tonnes (July to June), a record for the second year running

Source — Natural Resources Institute Finland (Luke)

Finland, this issue's happy country, is one of the world's leading oat exporters, and oats are an ever larger share of the grain it sells abroad.

Grain and hay

In Australia oats have two lives. Some are grown for grain, much of it for milling into oat flakes and flour. Many are grown for hay. Western

Australia's agriculture department says the state produces over 40 per cent of Australia's export hay, and that oaten hay goes mainly to Japan, South Korea and China. For hay, timing is everything: the same department recommends cutting at the watery-ripe stage of the grain, within a window of about five to seven days, and warns that heavy rain on cut hay can spoil its quality.

How oats are grown

Sowing. Seed is drilled into a firm, moist seedbed. Seeding rates are set by the number of plants wanted per square metre, so they change with rainfall. Western Australia's 2026 sowing guide targets about 160 plants per square metre in low-rainfall areas, a seeding rate of 55 to 85 kilograms per hectare, and 240 plants per square metre in wetter areas, about 85 to 130 kilograms per hectare. Early sowing matters there: the guide says sowing milling oats in early April significantly reduces the risk of small, thin grains, called screenings.

Nutrition. Oats need nitrogen, but too much makes them lodge. Penn State Extension notes that oats may be prone to lodging in nitrogen-rich soil, and the Western Australian guide warns that some varieties carry a higher lodging risk at high nitrogen rates. A flattened crop is slow to dry, hard to harvest and loses grain.

Harvest. Oats shed their grain more readily than other cereals once ripe, so they are harvested as soon as they are ready. Australian growers generally head oats for grain between October and December. The Western Australian research quoted in its sowing guide found that a three-week delay cut grain yield by 10 per cent, and a six-week delay by 25 per cent. Grain is best harvested below 12 per cent moisture; wetter grain needs aeration or drying before storage.

What to watch for

TWO PROBLEMS EVERY OAT GROWER SHOULD KNOW

crown rust — Bright orange pustules on the leaves, worst in warm, humid weather. Teagasc lists it, with mildew and fusarium, as a key disease threat. Resistant varieties are the first defence.

yellow dwarf — Barley yellow dwarf virus, spread by grain aphids. In oats the infected leaves turn red, and plants can be stunted. The University of California's IPM programme notes that oat leaves redden while barley leaves turn yellow.

Look for rust on the upper leaves from stem elongation onwards, and for aphids and reddening patches in early growth, especially after a mild autumn. Laisha's grow guide on oats has photographs of both.

How much nitrogen does an oat crop take up?

Oats need nitrogen, because like every grass they have no nitrogen-fixing partner of their own. But they need less than wheat or barley for a similar yield, and too much makes them lodge. The UK's Opti-Oat project, a research partnership of the James Hutton Institute, ADAS, Aberystwyth University and NIAB, measured how much nitrogen well-grown crops actually took up, and its Oat Growth Guide (2019) gives figures that are useful anywhere as a reference:

NITROGEN TAKEN UP BY FULL PANICLE EMERGENCE, OPTI-OAT TRIALS

Winter oats, benchmark crop of 8.1 t/ha — about 154 kg N per hectare

Spring oats, benchmark crop of 7.0 t/ha — about 112 kg N per hectare

Soil supply after another cereal — often only about 20 to 40 kg N per hectare

Uptake per unit of green area index — about 24 kg N per hectare

In the benchmark winter crop, uptake was slow early on, about half a kilogram of nitrogen per hectare a day up to the start of stem extension, then 1.0 to 1.4 kilograms a day from stem extension to panicle emergence. That is why nitrogen is best split into stages rather than given in one early dose, and why a heavy, late dose on a tall variety invites lodging. These are measured uptakes, not fertiliser recommendations: what you

apply depends on your soil, your previous crop and your yield target, so follow a local soil test and local guidance.

Phosphorus and potassium go on once, at or before sowing, at rates set by a soil test.

Crown rust in more detail

Crown rust, caused by the fungus *Puccinia coronata* f. sp. *avenae*, is described in a 2018 review in Molecular Plant Pathology as a major threat to oat production worldwide. Its life cycle is unusual. The damaging stage, with orange pustules spreading from leaf to leaf through the summer, happens on oats. The sexual stage happens on a completely different plant, buckthorn (*Rhamnus*), which is why buckthorn hedges near oat fields matter in Europe and North America. The fungus keeps producing new races that overcome resistant varieties, so variety choice needs checking every few years against local advice.

Oats from field to mill: what buyers measure

A crop grown for milling is judged on a few numbers, and growers who know them in advance negotiate better. For monitored commercial winter oat crops, the Opti-Oat guide reports mean values of 53.5 kilograms per hectolitre specific weight, 2 per cent screenings and about 73 per cent kernel content, the share of the grain that is groat once the husk is removed. Moisture is checked on delivery too. A lot that misses milling specifications is not wasted: it becomes feed oats, at a lower price.

OATS, SEASON BY SEASON

Choose land — well drained; a break from oats, wheat, barley and rye, which share diseases such as crown rust, yellow dwarf virus and cereal cyst nematode

Seed — certified and treated against the seed-borne smuts, which replace the grain with black spores

Sowing — spring oats as early as the soil allows in cold countries; autumn or early winter sowing where winters are mild

Early growth — check emergence within one to two weeks; watch for aphids and reddening patches

Stem extension — split nitrogen; scout for rust on the upper leaves

Grain fill — watch for lodging after storms; a ripe grain resists denting with a fingernail

Harvest — promptly, because oats shed grain; dry to safe storage moisture

Storage — clean, cool and dry; keep any gluten-free lot fully separate from other cereals

From the field to the bowl

Oats are eaten as porridge, flakes, oatcakes, bread and, more recently, oat drinks. Two facts are worth knowing precisely, because they are often stated loosely.

The first is about labels. Oats contain a protein called avenin, which is similar to gluten, and ordinary oats are often mixed with traces of wheat, barley or rye in the field, the truck or the mill. In the United Kingdom, Coeliac UK explains that only uncontaminated oats that test at 20 parts per million of gluten or less may be labelled gluten free, and in the United States the Food and Drug Administration sets the same 20 ppm limit for oats labelled gluten-free. People with coeliac disease should follow their own medical advice.

The second is about health claims. Regulators in the United States and the European Union allow food labels to mention oat beta-glucan, a soluble fibre, in connection with blood cholesterol, but only under exact conditions set in law, built around 3 grams of beta-glucan a day as part of an overall diet. These are statements about an everyday diet, not about treating any illness.

The oat asks for a cool season, a firm seedbed, not too much nitrogen and a prompt harvest. Give it those, and it is one of the most forgiving cereals there is.

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Read the full grow guide Oats from choosing land to harvest and storage, free to read.

laisha.ai/guides/oat

CROP HEALTH · PEST WATCH

Fall armyworm: a decade on three continents

A caterpillar from the Americas reached Africa in 2016 and has since spread across Asia and into Australia. How to recognise it, how to scout for it, and why spraying first is rarely the answer.



A fall armyworm caterpillar on maize. Photo: Wee Hong, CC BY-SA 4.0, via Wikimedia Commons

Ten years ago, a farmer in Nigeria, Kenya or India could have grown maize for a lifetime without meeting the fall armyworm. Today it is one of the first things maize growers across Africa, Asia and the Pacific look for. As the southern hemisphere's maize season gets under way in November and December, from Zambia and Malawi to Brazil and Queensland, and as the tropics grow maize all year, it is worth knowing this caterpillar well.

A traveller from the Americas

The fall armyworm, *Spodoptera frugiperda*, is the caterpillar of a moth native to the Americas. The International Plant Protection Convention, hosted by FAO, records that its arrival in Central and Western Africa was officially reported in early 2016. It spread across sub-Saharan Africa, reached India in 2018, where a national pest alert was issued that July, and was trapped on two islands in Australia's Torres Strait in January 2020 before turning up on the mainland. By April 2022 FAO counted 78 countries in Africa, the Near East, Asia and the Pacific reporting it. It has kept moving since: Fiji reported its first detection in April 2025, and in November 2025 three male moths were caught in a trap in a maize field in southern Spain, a find the European plant protection organisation lists as transient and under surveillance.

Part of the reason is the moth itself. IPPC notes that it can fly more than 100 kilometres in a single night. Where it is warm all year, there is no winter to break the cycle: the FAO and CABI field handbook says up to 12 overlapping generations can hatch in a year, against only one or a few in cooler places.

Know it when you see it

The caterpillar eats more than 80 kinds of plant, but maize is its favourite. The damage follows the caterpillar's size:

- **Young caterpillars** scrape the leaf surface and leave clear, papery patches called windowpanes.
- **Larger caterpillars** chew ragged, elongated holes, and the leaves unfold from the whorl already torn.
- **Frass**, the caterpillar's droppings, looks like moist sawdust and collects in the funnel of

the plant.

HOW TO RECOGNISE THE CATERPILLAR

inverted Y — a pale, upside-down Y on the dark head

four spots — four dark spots forming a square on the second-to-last body segment

size — up to about 4 cm when fully grown

eggs — laid in masses of often 100 to 200, covered with grey scales from the moth's body

A female moth lays about 1,500 eggs in her lifetime, according to the FAO and CABI handbook. The eggs hatch in two or three days in warm weather. The caterpillar passes through six growth stages in about two to three weeks, then drops to the soil to pupate.

Scout before you spray

FAO's guidance begins in the field, not in the shop. Walk the field in the shape of a letter W, so that you cover all of it. At the start and at each turn, five stops in all, inspect ten plants in a row, fifty plants altogether. Count the plants with fresh damage or fresh frass, not old scars. The handbook suggests walking the field every three to four days while the plants are young.

What you are looking for is a trend. A few damaged plants early in the season are normal and are often cleared up by natural enemies. A rising share of plants with fresh damage, week after week, is the signal to act. Ask your local extension service for the action threshold used in your region, because thresholds depend on the crop stage, the variety and what the grain is worth.

What the damage looks like at each stage

Laisha's pest encyclopedia sets out the signs stage by stage, because the same pest does different harm as the crop grows:

SIGNS BY CROP STAGE

Seedling — Windowpanes where young larvae scrape the leaf but leave the clear membrane. Heavy feeding can cut seedlings or kill the growing point, leaving a dead heart.

Whorl — Ragged, elongated holes as the leaves unroll, and moist, sawdust-like frass packed in the funnel. Usually only one or two large larvae per whorl, because older larvae eat each other.

Tassel and silk — Larvae feed on the tassel before it emerges and on the silks, which can reduce pollination.

Cob — Larvae bore through the husk or enter at the tip and eat the kernels. Damaged ears are more likely to be invaded by ear-rot fungi and contaminated with mycotoxins.

Maize can make up for a good deal of leaf loss in the whorl, so the leaves often look worse than the final yield loss turns out to be. Damage to the growing point of seedlings and to the cob matters far more.

Thresholds: an example, and why yours may differ

An action threshold is the level of damage at which acting pays for itself. For fall armyworm it is measured as the share of scouted plants with fresh damage or live larvae, not by counting moths in traps. As one example, New Zealand's Foundation for Arable Research publishes thresholds from Western Australia's Department of Primary Industries for maize:

AN EXAMPLE OF ACTION THRESHOLDS FOR MAIZE

Seedling — more than 5% of plants cut

Early whorl, knee high — more than 20% of plants infested

Late whorl, shoulder high — more than 40% of plants damaged, with live larvae present

Tasselling and early silking — more than 20% of plants infested

Published thresholds differ between regions and farming systems, and many are still being tested for smallholder maize in Africa and Asia. They also assume that any spray used is registered and effective where you farm. Use your own national or regional guidance where it exists.

A season plan for maize

1. **Before planting:** agree a planting window with neighbours; plant early in the rains rather than late; if push-pull plots are

possible, prepare the desmodium and border grass.

2. **Emergence to early whorl, the first two to three weeks:** scout every three to four days with the W method. On small plots, crush egg masses and young larvae by hand. This is when the growing point is most at risk.
3. **Mid to late whorl:** keep scouting weekly or more. Record the size of the larvae as well as the share of damaged plants: small larvae are much easier to control by any method than large ones deep in the funnel. If the threshold is reached, act while larvae are small, directing any treatment into the whorl.
4. **Tasselling and silking:** check tassels and silks; ear damage now costs grain directly.
5. **Grain fill and harvest:** look for entry holes on cobs. Dry and store grain well, and keep damaged, mouldy cobs out of food and feed because of the mycotoxin risk.
6. **After harvest:** note which fields and planting dates suffered most. That record is next season's plan.

SCOUTING SHEET: COPY THIS INTO YOUR NOTEBOOK

Field and date — _____

Crop stage — seedling / early whorl / late whorl / tassel / cob

Stop 1, 10 plants — fresh damage ___ ; live larvae ___

Stop 2, 10 plants — fresh damage ___ ; live larvae ___

Stop 3, 10 plants — fresh damage ___ ; live larvae ___

Stop 4, 10 plants — fresh damage ___ ; live larvae ___

Stop 5, 10 plants — fresh damage ___ ; live larvae ___

Total of 50 plants — fresh damage ___ = ___ %

Larvae mostly — small / medium / large

Natural enemies seen — ants, earwigs, wasps, spiders, others

Decision — no action / scout again in ___ days / act

To turn the count into a percentage, multiply the number of damaged plants out of 50 by 2. Twelve damaged plants out of 50 is 24 per cent.

What helps

Plant together, plant on time. The handbook warns that if your field is one of the few late-planted plots in an area, all the female moths around will come to it to lay their eggs. Planting at the same time as your neighbours, rather than in staggered plots of different ages, dilutes the attack.

Look after natural enemies. Ants, earwigs, parasitic wasps, spiders, birds and diseases all kill fall armyworms. FAO's 2018 guide for Africa reports that a virus, nucleopolyhedrovirus or NPV, a bacterium, *Bacillus thuringiensis* or Bt, and fungi such as *Metarhizium* and *Beauveria* have all shown promise, along with tiny *Trichogramma* wasps that parasitise the eggs. Broad-spectrum sprays kill these allies too.

Push-pull. Researchers at icipe, the International Centre of Insect Physiology and Ecology in Kenya, developed a system in which maize is intercropped with a legume, desmodium, that repels the moths, and bordered by a grass that attracts them. In their 2017 study in Kenya, Uganda and Tanzania, fall armyworm infestation was more than 80 per cent lower in plots with the climate-adapted version.

Traditional remedies, tested honestly. Many farmers put ash, sand or soil into the whorl. FAO lists practices like these among those that still need proper trials. If you try one, the handbook's advice is sensible: try it on part of the field, compare it with an untreated part, and share what you find.

If you must spray

Pesticides are a last step, not the first, and they work best against young caterpillars before they bury themselves deep in the whorl. Use only products registered for maize in your country, follow the label, and wear protection. The FAO and CABI handbook gives two rules that protect everyone's future: to prevent resistance, rotate between pesticide groups with different modes of action, and use no more than two or three sprays a season. FAO also advises avoiding highly hazardous pesticides altogether.

A field walked in a W every few days tells you more than any spray calendar.

Where the world is now

FAO ran a Global Action for Fall Armyworm Control from December 2019, extended to the end of 2023, to help countries share what works. The lesson of those years is not that the pest can be wiped out. It is that farmers who scout, plant in step with their neighbours, protect natural enemies and spray only when needed can live with it and still harvest a good crop.

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Read the pest page
laisha.ai/pests/fall-armyworm

Fall armyworm in Laisha's pest and disease encyclopedia: identification, life cycle and management.

Reading a soil test report

pH, organic matter, CEC, salinity and the nutrient numbers: how to take a sample the laboratory can trust, and what each line on the report means for your field.

A soil test is the cheapest piece of farm science there is. For the price of a few bags of fertiliser it tells you whether you need those bags at all, whether the soil is too acid for the crop you plan, and whether salt is building up in an irrigated field. But a soil test report can look like a page of chemistry homework: pH, OM, CEC, EC, P, K, ppm, meq. This article, based on Laisha's degree manual on Soil Science for Sustainability and on university extension guidance from several countries, walks through it line by line.

December and January suit soil sampling in many places: after the winter-crop harvest in the southern hemisphere, and ahead of spring planting in the north wherever the ground is not frozen. The rule that matters most is to sample at the same time of year each time, so one test can be compared with the next.

Step one: a sample the laboratory can trust

A laboratory tests a few grams of soil. That few grams has to stand for a whole field, so the way the sample is taken matters more than anything that happens in the laboratory. Penn State Extension and Oregon State University Extension give the same core advice:

HOW TO TAKE A SOIL SAMPLE

Area — one sample for each field or part of a field managed the same way; Penn State suggests no more than about 4 hectares (10 acres) per sample

Number of cores — 15 to 20 small subsamples, mixed together

Pattern — walk the field in a zigzag and take the cores at random along it

Depth — the depth of cultivation, about 15 to 18 cm (6 to 7 inches) in cropland; shallower, about 8 to 10 cm, in permanent pasture

Avoid — wet spots, old manure or lime heaps, fertiliser bands, fence lines, gateways and anything else unusual

Mixing — in a clean plastic bucket, not a galvanised one

Drying — in the air if the laboratory asks; never in an oven

Labelling — field name, date and depth, on the bag and in your notebook

A sample taken from one corner, or from the spot where the trailer always stands, will give a precise answer to the wrong question. Laisha's own question bank puts it simply: composite many cores from a zigzag pattern, avoiding unusual spots.

Step two: pH, the master number

Soil pH measures how acid or alkaline the soil is. North Carolina State University Extension explains the scale: 7.0 is neutral, values below 7 are acid and above 7 alkaline, and each whole unit is a tenfold change. A soil at pH 5 is ten times more acid than one at pH 6.

pH matters because it controls how available most nutrients are, how active soil life is and whether some elements, such as aluminium in very acid soils, reach toxic levels. The target depends on the crop and the region. Many extension services aim for about 6.0 to 7.0 for most field crops; Midwestern US guidance cited by NC

State aims for 6.5 to 7.0, while North Carolina's recommendation for its mineral soils is 5.8 to 6.2. Oregon State notes that most crops grow well between about 6.0 and 8.2. Use your own country's target for your crop.

Liming raises pH: Oregon State's guide describes applying calcium carbonate, limestone, to increase it. How much lime a field needs is not set by pH alone. As the manual explains, a clay soil needs more lime than a sand at the same pH, because clay and organic matter hold more reserve acidity, which is why many laboratories report a separate buffer pH or lime requirement.

Organic matter

Organic matter, OM on the report, is the decomposed remains of plants, animals and soil organisms. It holds water and nutrients, feeds soil life and helps soil crumbs stick together. Penn State gives 2 to 5 per cent as a good target for its clay field soils. Oregon State adds a useful dose of realism: a soil with 2 per cent organic matter will not rise to 10 per cent under normal farming. Organic matter changes slowly, so it is a number to follow over years, not to chase in one season.

CEC, the soil's nutrient store

Cation exchange capacity, CEC, measures how many positively charged nutrients, such as calcium, magnesium and potassium, the soil can hold on its clay and organic matter. Penn State gives typical values in milliequivalents per 100 grams of about 1 to 5 for sands and more than 30 for clays. Oregon State's guide puts it simply: soils high in clay or organic matter have a high CEC; sandy, low-organic-matter soils have a low CEC.

What CEC tells you in practice: a low-CEC sandy soil holds little in reserve, so nutrients are better applied in smaller, more frequent doses, and it needs less lime to change its pH. A high-CEC clay holds more and changes more slowly. One cmol(+)/kg, the unit some laboratories use, is the same number as one meq per 100 grams.

EC: salt

Electrical conductivity, EC, measures dissolved salts. Reports may give it in millimhos per centimetre or decisiemens per metre; Oregon State notes that the two are the same. On its saturated-paste test, Oregon State rates an EC below 1.0 as suitable for most crops, 1.0 to 2.5 as marginal and above 2.5 as poor for many crops. Salt matters most in irrigated fields in dry climates, where water evaporates and leaves its salts behind. A rising EC from one test to the next is a warning to check irrigation water quality and drainage, and to plan some extra water to wash salts below the roots.

Nitrogen, phosphorus and potassium

Nitrogen is the hardest nutrient to judge from a soil test. Oregon State's guide explains that a test measures nitrate and ammonium at the moment of sampling but does not reflect future conditions, because nitrogen moves and changes with rain, temperature and soil life. Many laboratories therefore base nitrogen advice on the crop, the yield target and the previous crop, and use soil nitrate tests only at particular times and places.

Phosphorus is tested by several different methods, and their numbers are not interchangeable. The University of Minnesota Extension explains that the Bray-P1 test works well for soils of pH 7.4 or less and the Olsen test for soils of pH 7.4 or more, that some tests correlate well with each other and some do not, and that Mehlich-3 phosphorus measured by one instrument needs its own set of correlations. So a phosphorus figure means nothing until you know the method, and a recommendation must use interpretations calibrated for that method. If you change laboratories, ask which method they use; Oregon State advises contacting the laboratory that did the analysis when in doubt.

Potassium, calcium, magnesium and sodium are usually reported as exchangeable amounts, and are more stable from year to year than nitrogen.

Low, medium, high: what the categories mean

Most reports put each nutrient into a band. Oregon State's interpretation guide explains them in terms a farmer can act on. **Low** means that adding the nutrient will likely increase growth and yield. **High** means that adding more will likely not. The band in the middle is a "maybe": the crop might respond, depending on season and management. The aim is not the highest possible number but enough, and money saved on a nutrient already at a high level can go where it will pay.

What about the "ideal ratio" of calcium to magnesium?

Some advisers recommend balancing calcium, magnesium and potassium to an ideal ratio, sometimes called the base cation saturation ratio. Iowa State University Extension is blunt: the calcium to magnesium ratio concept is unproven and should not be used as a basis for fertilisation or liming. The UK's AHDB reaches the same view, noting that the evidence relating specific cation ratios to crop productivity is inconsistent and that plants do well over a broad range of ratios as long as there is enough potassium. Oregon State notes that base saturation is not needed for lime or fertiliser recommendations. A report that asks you to buy products to reach an ideal ratio deserves a second opinion.

A WORKED READING

Here is how one line of a made-up report might be read.

pH 5.4 — acid for most field crops; lime is likely to pay; check the lime requirement or buffer pH line for the rate

OM 2.1% — typical for a cropped mineral soil; protect it with residues and cover

CEC 8 meq/100 g — a light soil with modest reserves; split fertiliser doses

EC 0.4 dS/m — no salt concern

P (Olsen) 9 mg/kg, Low — phosphorus is likely to increase yield; use the method's own recommendation table

K 180 mg/kg, High — more potassium unlikely to pay this season

The figures are invented to show the method, not to describe any real field.

How often?

Penn State's rule of thumb is to test sandy soils every two to three years and clay soils every three to four years; Oregon State suggests every two to three years for annual crops, pastures and legumes and every three to five for trees, berries and grapes. Test at the same season each time, keep every report, and write the results into your field records. The trend tells you more than any single test.

Test, don't guess. A soil test turns a fertiliser bill into a decision.

Laisha's Soil Test Interpreter, part of Laisha Smarter, reads a laboratory report you upload and turns it into a fertiliser plan; the free soil science notes on laisha.ai explain every term used here.

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Read the full manual
laisha.ai/degrees/sustainability/soil-science-for-sustainability

Soil Science for Sustainability: soil testing, soil reaction, CEC and soil health.

FROM THE LAISHA LIBRARY · AGRICULTURAL ENGINEERING

When to water, and how much

How much water does a crop really use in a day? The FAO method the world's irrigation engineers use, done with a weather figure, a crop coefficient and a pencil. A tour of Laisha's manual on Irrigation Engineering.



Drip irrigation. Photo: Lance Cheung / USDA NRCS, CC BY 2.0, via Wikimedia Commons

December pulls the world's fields in two directions. South of the equator it is early summer: maize in Brazil, Argentina and southern Africa is growing fast, orchards in Australia, Chile and South Africa are carrying fruit, and the sun is close to its highest. North of it, most fields are resting, winter wheat is barely growing, and the work is planning next season's water. Both halves are asking the same question: how much water does this crop actually use, and when should I put it back?

Laisha's degree manual on Irrigation Engineering answers it the way engineers do worldwide, with a method published by the Food and Agriculture Organization of the United Nations in 1998 as FAO Irrigation and Drainage Paper 56. It sounds technical. The idea underneath is simple enough to do on the back of an envelope.

Step one: how thirsty is the weather?

Start with the weather, not the crop. FAO-56 imagines a reference field: a wide stretch of well-watered green grass, 0.12 metres tall. The water it would lose in a day, through evaporation from the soil and transpiration through its leaves, is called the reference evapotranspiration, written ETo and measured in millimetres a day. It depends only on the weather: sunshine, temperature, humidity and wind. FAO recommends one equation for it, the FAO Penman-Monteith equation, as the standard method, because it responds to all four.

You do not have to solve that equation yourself. Many national weather services and irrigation advisory services publish ETo every day, and Laisha's weather screen shows evapotranspiration beside the forecast. What matters is the size of the number. On a cool, cloudy day it may be one or two millimetres. On a hot, dry, windy summer day it can be six, eight or more.

Step two: how thirsty is the crop?

A crop is not grass, so FAO-56 multiplies ETo by a crop coefficient, Kc, to give the crop's own water use:

THE ONE FORMULA

$$ETc = Kc \times ETo$$

ETc — the crop's water use, in mm a day

Kc — the crop coefficient for its stage of growth

ETo — the reference evapotranspiration from the weather

Kc changes through the season. A newly sown field is mostly bare soil, so Kc is low; at full canopy and flowering it is at its highest; as the crop matures it falls again. FAO-56 tabulates typical values for a sub-humid climate with moderate wind. For grain maize they are about 0.3 at the start, 1.20 in mid-season and 0.35 to 0.60 at the end, depending on how dry the crop is harvested. For tomato they are about 0.6, 1.15 and 0.7 to 0.9. In very dry, windy places tall crops use a little more, and FAO-56 gives the correction.

Step three: how much can the soil hold?

The soil is the crop's water tank. After a thorough wetting, once the free water has drained away, the soil is at field capacity. At the other end is the wilting point, where roots can no longer pull water out. The water between the two, over the depth the roots reach, is the total available water (TAW). A crop cannot use all of it without stress, so FAO-56 uses a fraction, p, to give the readily available water: RAW = p × TAW. For many crops p is around 0.5, which means you water when about half of the tank is used.

A WORKED EXAMPLE

A grain maize crop at mid-season on a loam soil, in a hot, dry week with no rain.

Root depth — about 1 m

Available water — about 140 mm per metre, so TAW ≈ 140 mm

p for maize — 0.55, so RAW ≈ 77 mm

ETo — 6 mm a day

ETc — 1.2 × 6 = 7.2 mm a day

Trigger — 77 ÷ 7.2 ≈ 10 to 11 days

Refill — about 77 mm, plus losses

FAO-56 gives 130 to 180 mm of available water per metre for loams (its Table 19) and p = 0.55 for grain maize (its Table 22).

One millimetre of water over one hectare is ten cubic metres, or 10,000 litres. Refilling 77 mm on a hectare is therefore about 770 cubic metres of water reaching the root zone, and more must leave the pump, because no system delivers every drop where the roots are. A well-run drip system loses far less on the way than a flooded furrow, which is why the efficiency of the system matters as much as the arithmetic.

Rain counts, but not all of it

Rain resets the balance only partly. Some runs off, some soaks below the roots, and a light shower on a hot afternoon may wet only the surface. The manual calls the part that stays in the root zone effective rainfall. A field record that adds up each day's ETc, subtracts the effective rain and each irrigation, and shows when the depletion reaches RAW is called a soil water balance. It is the same sum a professional irrigation scheduler runs, written in a notebook.

Check the arithmetic with your hands

A number on paper is only as good as the soil it describes. Before you trust a schedule, dig. The United States Department of Agriculture's Natural Resources Conservation Service publishes a simple feel-and-appearance method: take a handful of soil from the root zone, squeeze it, and compare how it holds together with photographs for each soil texture. With practice it estimates soil moisture well enough to catch a schedule that has drifted. Tensiometers and soil moisture sensors do the same job continuously. Advisers at the University of California suggest pairing them: one at shallow root depth tells you when to start watering, one deeper down tells you when to stop.

Water when the soil says so, not when the calendar says so. The arithmetic tells you when to go and look.

A second example: tomatoes on a sandy loam

Tomatoes are shallower-rooted and less forgiving than maize, and they show it in the numbers. FAO-56 gives tomato a depletion fraction of 0.40, against 0.55 for maize, so the trigger comes sooner. Take a tomato crop at full canopy, with roots working the top 0.7 metres of a sandy loam that holds about 100 mm of available water per metre.

TOMATO, MID-SEASON

TAW — 100 × 0.7 = 70 mm

RAW — 0.40 × 70 = 28 mm

ETo, a warm week — 5 mm a day

ETc — 1.15 × 5 ≈ 5.8 mm a day

Trigger — 28 ÷ 5.8 ≈ every 5 days

Each refill — about 28 mm in the root zone

The tomato field needs water twice as often as the maize field, in smaller amounts. That is the pattern for most vegetables, and it is the reason drip irrigation, which can deliver small, frequent doses without wetting the whole field, suits them so well. The figure of 100 mm per metre is an assumption for this example; FAO-56 lists typical available water for each soil texture, and a local soil survey or soil test is better still.

Keeping a water balance for a week

A soil water balance is a running total of how much of the readily available water has been used. Start the day after a full irrigation or a soaking rain, with depletion at zero. Each day, add that day's ETc and subtract any effective rain or irrigation. When the total reaches RAW, it is time to irrigate. Here is a week for the maize field above, with a RAW of 77 mm.

MAIZE WATER BALANCE, ONE WEEK

Day 1 — ETo 6.0, ETc 7.2, no rain, depletion 7.2 mm

Day 2 — ETo 6.4, ETc 7.7, no rain, depletion 14.9 mm

Day 3 — ETo 5.1, ETc 6.1, rain 12 mm (about 9 mm effective), depletion 12.0 mm

Day 4 — ETo 4.0, ETc 4.8, no rain, depletion 16.8 mm

Day 5 — ETo 6.2, ETc 7.4, no rain, depletion 24.2 mm

Day 6 — ETo 6.8, ETc 8.2, no rain, depletion 32.4 mm

Day 7 — ETo 7.0, ETc 8.4, no rain, depletion 40.8 mm

After a week, about half of the readily available water is used, so the next irrigation is still several days away. The rain on day 3 counted for less than it measured, because part of a summer shower runs off or evaporates before it soaks in; the figures here are illustrative, and the manual explains the methods for estimating effective rainfall. A notebook with these seven lines, filled in each evening from a published ETo, is a real irrigation schedule.

A table to keep: crop coefficients and depletion fractions

These are the FAO-56 standard values for a sub-humid climate with moderate wind. Kc ini is the group value for the crop's family where FAO-56 gives one; Kc ini for any field also depends on how often the soil surface is wetted. Use them as a starting point and adjust with local advice.

FAO-56 VALUES FOR COMMON CROPS (KC INI / KC MID / KC END; P)

Maize, grain — 0.3 / 1.20 / 0.35 to 0.60; p 0.55

Wheat, spring — 0.3 / 1.15 / 0.25 to 0.4; p 0.55

Barley — 0.3 / 1.15 / 0.25; p 0.55

Oats — 0.3 / 1.15 / 0.25; p 0.55

Sorghum, grain — 0.3 / 1.00 to 1.10 / 0.55; p 0.55

Rice — 1.05 / 1.20 / 0.60 to 0.90; p 0.20 of saturation

Soybeans — 0.4 / 1.15 / 0.50; p 0.50

Groundnut — 0.4 / 1.15 / 0.60; p 0.50

Beans, green — 0.5 / 1.05 / 0.90; p 0.45

Potato — 0.5 / 1.15 / 0.75; p 0.35

Tomato — 0.6 / 1.15 / 0.70 to 0.90; p 0.40

Cabbage — 0.7 / 1.05 / 0.95; p 0.45

Onion, dry — 0.7 / 1.05 / 0.75; p 0.30

Cotton — 0.35 / 1.15 to 1.20 / 0.50 to 0.70; p 0.65

Sugarcane — 0.40 / 1.25 / 0.75; p 0.65

Banana, first year — 0.50 / 1.10 / 1.00; p 0.35

Grapes, table or raisin — 0.30 / 0.85 / 0.45; p 0.35

Citrus, 70% canopy, bare soil — 0.70 / 0.65 / 0.70; p 0.50

Two patterns stand out. Shallow-rooted, sensitive crops such as onion, potato and banana have low depletion fractions, so they must be watered before the soil dries far. Deep-rooted, tough crops such as cotton and sugarcane tolerate a drier root zone. And almost every field crop at full canopy uses more water than the reference grass, which is why the mid-season Kc is above 1.

Water and salt

Every irrigation water carries some dissolved salt, and the crop leaves most of it behind in the soil. Where rain is scarce, salts build up in the root zone unless some extra water is applied now and then to wash them below the roots. Laisha's companion manual on Drainage Engineering calls this the leaching requirement: the smallest extra share of water that keeps root-zone salinity acceptable for the crop. If leaf edges burn on a well-watered crop, or a white crust appears on dry soil, have the water and soil tested for salinity before adding more fertiliser.

What usually goes wrong

Watering on a fixed calendar in a season whose weather is not fixed. Using a mid-season Kc for a young crop, which wastes water early. Ignoring rain that has already refilled the profile. Applying more than the soil can hold, so that the extra drains below the roots and carries fertiliser with it. And on sandy soils, which hold little, applying a big volume rarely instead of a smaller volume often.

Agriculture uses most of the fresh water people take from rivers, lakes and aquifers: 69 percent of all withdrawals worldwide, according to FAO's AQUASTAT. Irrigated land is only about a fifth of the world's cultivated land, yet FAO reckons it gives about two-fifths of all agricultural production. Every millimetre that is matched to what the crop actually uses is water left in the river, the well and the next farmer's field.

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Read the full manual

laisha.ai/degrees/agri-engineering/irrigation-engineering

Irrigation Engineering: soil water, FAO-56 evapotranspiration, crop coefficients and scheduling, in eleven chapters.

AFTER THE HARVEST · STORAGE

Keeping the harvest you grew

A large share of food is lost between the field and the market. Drying, clean stores, airtight bags and a few habits that keep grain and fresh produce safe.

A farmer can do everything right in the field, choose the seed, feed the crop, scout the pests and bring in a good harvest, and still lose a large part of it afterwards. Grain goes mouldy because it was not dried in time. Weevils hollow out the kernels in a sack. Rats eat from the corner of the store. Tomatoes cook in the sun on the edge of the field while waiting for a truck. None of this shows up in yield figures, but all of it is food and money that never reaches a plate or a pocket.

This is the season it matters most for half the world: Australia, Argentina and much of the southern hemisphere are harvesting winter cereals now, and northern farmers are several months into storing last summer's crops.

How big is the loss?

According to FAO, around 14 per cent of the food produced in the world is lost between harvest and retail, and a newer FAO estimate cited by the United Nations Environment Programme puts it at about 13 per cent. That is loss in the supply chain: in the field after harvest, in drying, storage, transport and processing. It is a separate measure from food waste further along the chain: UNEP's Food Waste Index Report 2024 found that 1.05 billion tonnes of food were wasted in 2022 in retail, food service and households, 19 per cent of the food available to consumers, with households responsible for about 60 per cent of it. The two figures are measured on different bases, so they should not simply be added together.

For cereals in Africa, the African Postharvest Losses Information System, APHLIS, estimates post-harvest losses for eight crops, maize, sorghum, millet, wheat, barley, rice, teff and fonio, at provincial, national and regional levels across sub-Saharan Africa. Its estimates are built from each step of the post-harvest chain, which is useful for farmers because it shows that losses are not one big event but many small ones, at harvest, drying, threshing, transport and storage.

Rule one: dry it, and dry it fast

Moisture is the enemy of stored grain. Wet grain heats, moulds and sprouts, and insects breed faster in it. For maize, an FAO technical document on grain drying gives a clear target: dried within 48 hours to 14 per cent moisture, with no part above 15 per cent, maize can be stored safely for at least two months. The same FAO source warns that aflatoxin, a poison produced by the *Aspergillus* moulds, can become a serious problem when wet grain cannot be dried quickly, and that contamination in stored maize was closely associated with weevil infestation, because insect damage opens the grain to the mould.

MOISTURE: WHAT THE NUMBERS MEAN

Wet basis — water as a share of the total weight of the grain; the figure moisture meters and grain buyers usually use

Dry basis — water as a share of the dry matter; always a bigger number for the same grain

Why it matters — drying 1,000 kg of paddy from 22% to 14% moisture (wet basis) removes about 93 kg of water, not 80 kg

That last line is a classic exam question in Laisha's question bank, and a classic mistake in the field: subtracting percentages instead of working from the dry matter, which stays the same. In the example, the dry matter is 780 kg; at 14 per cent moisture it makes 780 ÷ 0.86, about 907 kg of grain, so about 93 kg of water has gone.

Drying is faster in warm, dry air. Laisha's question bank on post-harvest engineering explains why: at the same relative humidity, warmer air leaves less water in the grain at equilibrium, which is also why cooling stored grain makes it

hold a little more moisture. A cheap moisture meter, checked against a laboratory reading now and then, pays for itself in one season.

Rule two: a clean, dry, dull store

FAO's guidance on storage is practical and blunt. Its storage guidance says to keep the store and its surroundings clean, calling the broom the most effective and economic instrument in storage. Its other rules are just as simple:

STORE RULES FROM FAO

Pallets — always stack bags on pallets, about 10 cm high, so air can move underneath and damp cannot rise

First in, first out — sell or use the oldest stock first

Quarantine — keep infested produce apart from clean produce

Bags — replace or repair damaged bags

Spills — remove spilt grain immediately, because it attracts rodents

Doors and walls — repair damage at once, especially to doors, to keep rodents out

Rodents are best handled by an integrated programme, FAO advises: good housekeeping, proofing the building and removing food sources first, rather than relying only on poison. Before a new harvest goes in, empty the store, sweep out old grain and dust, where insects survive to attack the new crop, and repair the roof.

Airtight bags

Hermetic storage starves insects of air. The best-known example is the Purdue Improved Crop Storage bag, PICS, developed at Purdue University in the United States: two liners of high-density polyethylene inside an outer woven polypropylene bag. Once the bag is sealed, the insects and the grain itself use up the oxygen inside. Researchers at Purdue reported that once oxygen fell to around 5 per cent, oxygen use slowed noticeably and insect feeding stopped. Purdue reported that by 2017 the project had reached more than 56,000 villages and more than 12.5 million bags had been sold.

Hermetic bags are not magic. The grain must already be dry, because airtight storage of wet grain traps the moisture. Each liner must be sealed carefully, following the bag's instructions, and the bag protected from rats and sharp edges, because one hole lets the air back in. Results vary between trials, so test a few bags against your usual storage before trusting a whole harvest to them.

Fresh produce: beat the heat

Fruit and vegetables are alive after harvest. They keep breathing, and the warmer they are the faster they use up their own reserves and the sooner they spoil. FAO's manual on small-scale post-harvest handling gives three habits that cost little:

1. **Harvest cool.** Picking at night or in the early morning, when the produce is coolest, is sometimes possible and worthwhile.
2. **Keep it in the shade.** FAO notes that produce left in sunlight can become 4 to 6 °C warmer than the air around it. Put field bins in the shade or cover them loosely.
3. **Cool it quickly.** Any delay in cooling shortens the produce's life and lowers its quality.

Handle gently, too: a bruise or cut is an open door for rot, and one rotting fruit in a crate spreads to the rest.

A storage checklist for the season

BEFORE, DURING AND AFTER STORAGE

Before harvest — clean and repair the store; check pallets, bags and moisture meter

At harvest — harvest at the right maturity; avoid leaving cut crop in the rain

Drying — dry within a day or two to safe moisture; check several samples, not just one

Sorting — remove damaged, mouldy and insect-hit grain before storing

Storing — bags on pallets, away from walls; hermetic bags sealed tight

Regularly — check for heat, smell, insects, rodent signs and damp patches

Selling — oldest stock first; keep a note of losses for next year

The cheapest grain you will ever have is the grain you already grew. Keeping it is cheaper than growing more.

Laisha's free post-harvest guidance on laisha.ai sets out drying, storage and low-cost storage technologies crop by crop, and the Stack Calculator works out how much is in a stack at stock-taking time.

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Post-harvest guidance on laisha.ai

laisha.ai/tools/post_harvest_advisory

Drying, storage and low-cost storage technologies, crop by crop, free to browse.

FARM BUSINESS · DEGREE MANUAL

A farm cash book, worked through

Which crop made money, and which quietly lost it? A notebook, ten minutes a week and a gross margin will tell you. A worked example from Laisha's manual on Farm Management.

At the end of a season most farmers know roughly what they sold. Far fewer know which crop or which animals actually made money, and which quietly lost it. The difference is a notebook. December is a good month to start one: the harvest is in or nearly in for half the world, the new season is being planned for the other half, and the calendar year is ending.

This article follows Laisha's degree manual on Farm Management, which treats records as the base of every decision a farm makes. It needs no software and no accounting training: one notebook, a pen, and ten minutes a week.

Why keep records at all?

The manual gives four reasons. Records measure performance, so you can see which enterprise made money. They support planning, because a budget needs yields, input rates and costs that are realistic for your own farm, not a brochure's. They meet outside requirements: a loan application, a tax return, an insurance claim, a certification audit or a traceability rule in a livestock or food chain. And they feed research and policy, since national cost-of-production surveys depend on farms that keep accounts.

There are two kinds. Physical records describe what happened in the field and the shed: the farm map with field areas, crop records with variety, sowing date, seed rate, fertiliser and sprays, and livestock records with births, deaths, treatments and milk. Financial records describe money: what came in, what went out, and what the farm owns and owes.

The single-entry cash book

The simplest financial record, and the one the manual recommends for most family farms, is the single-entry cash book. Every time money moves, write one line: the date, what it was for, which enterprise it belongs to, and the amount, either in the money-in column or the money-out column. That is all.

THE COLUMNS OF A CASH BOOK

Date — when the money moved

Details — what it was, with quantity and price if you know them

Enterprise — which crop, animal group or "whole farm" it belongs to

Money in — sales, payments received, loans received

Money out — purchases, wages, rent, repayments

The manual is honest about its limits. A single-entry cash book is easy to keep and is enough for a simple receipts-and-payments summary, but on its own it does not show how the farm's assets and debts have changed, and arithmetic errors are hard to spot. Large commercial farms use double-entry accounts, in which every transaction is recorded twice. For a family farm, a cash book kept faithfully, plus an inventory once a year, gets most of the benefit.

A worked example

Here is one month in the cash book of a small mixed farm with two enterprises: two hectares of maize and a small dairy herd. The amounts are in money units; use your own currency. The figures are made up to show the method, not to describe any real farm.

ONE MONTH IN A FARM CASH BOOK

1st, maize: fertiliser, 4 bags — out 240

3rd, dairy: milk payment for last month — in 1,150

5th, dairy: concentrate feed, 10 bags — out 380

9th, maize: hired labour for weeding, 6 days — out 180

12th, dairy: vet visit and treatment — out 95

15th, whole farm: diesel — out 120

18th, maize: insecticide for armyworm, after scouting — out 70

22nd, dairy: sale of a bull calf — in 300

28th, whole farm: loan repayment — out 200

Totals — in 1,450; out 1,285

The month closed with 165 more in than out. That says the farm had enough cash. It does not yet say whether either enterprise is profitable, because the maize has not been sold, and the loan repayment and diesel belong to the whole farm. For that, the lines are sorted by enterprise at the end of the season.

From cash book to gross margin

The manual's most useful planning figure is the gross margin: the value of what an enterprise produced, minus the variable costs that belong to it. Variable costs are those that rise and fall with the size of the enterprise, such as seed, fertiliser, sprays, hired labour, fuel used in that field, feed and veterinary costs. Fixed costs, such as depreciation of machinery, rent, insurance and interest, stay the same whichever crops you grow, so they are left out of the gross margin and taken off later for the whole farm.

MAIZE, TWO HECTARES, WHOLE SEASON

Grain sold — 7.2 tonnes at 210 per tonne = 1,512

Seed — 160

Fertiliser — 480

Crop protection — 70

Hired labour — 360

Fuel and machine hire for the maize — 190

Total variable costs — 1,260

Gross margin — 1,512 − 1,260 = 252, or 126 per hectare

DAIRY, SAME SEASON

Milk sold — 6,600

Calves sold — 600

Feed bought — 2,280

Veterinary and breeding — 410

Other dairy variable costs — 350

Total variable costs — 3,040

Gross margin — 7,200 − 3,040 = 4,160

The whole farm's total gross margin is 252 + 4,160 = 4,412. Take away the whole-farm fixed costs, such as depreciation, rent, insurance, interest, and diesel and repairs not traced to one enterprise, and what is left is net farm income: the return to the family's labour, land, capital and management.

In this made-up example, the cash book reveals something a farmer might not have guessed: the maize barely covered its own variable costs, while the dairy carried the farm. That does not mean the maize should stop. It may feed the cows, break disease cycles or use land the cows cannot. But it is now a decision made with numbers, and the obvious next questions are clear: was the yield low, the price low, or the fertiliser bill high?

Comparing with yourself

The manual describes three comparisons: a farm against its own past, against its budget, and against similar farms. The first is the easiest and often the most useful. Keep the same cash book for three years and you will know your real yield, your real cost per hectare and your real price, and you will see the effect of every change you make.

Two simple ratios help. The gross ratio is total expenses divided by gross income: below 1 is profitable, and lower is better. And cost per unit, such as cost per tonne of grain or per litre of milk, tells you the lowest price at which you can sell without losing money.

The yearly inventory

Once a year, ideally when stocks are low and work is light, make a list of everything the farm owns and owes on that date: land, buildings, machinery, animals by class and age, stored crops, feed, seed and chemicals, cash, money owed to you, and loans and unpaid bills. The manual calls this the farm inventory. Compare it with last year's and you see whether the farm's net

worth, what it owns minus what it owes, has grown or shrunk. A farm can have a good cash year while its machinery wears out and its herd ages; the inventory catches that.

TEN MINUTES A WEEK: A ROUTINE THAT WORKS

1. Keep every receipt and payment slip in one envelope or box.
2. Once a week, write each one into the cash book and mark its enterprise.
3. At the end of each month, add up the columns.
4. At the end of the season, sort the lines by enterprise and work out each gross margin.
5. Once a year, take the inventory.

What usually goes wrong

Writing nothing for the small amounts, which add up. Mixing household money with farm money, so neither can be read. Forgetting produce the family ate or fed to its own animals, which has a value even though no cash moved. Leaving out family labour entirely, which makes a labour-hungry enterprise look better than it is. And keeping records for a month and stopping, which wastes the effort, because records become valuable when there are several seasons to compare.

A cash book does not make a farm profitable. It shows you where the profit is, and where it is leaking away.

Laisha's free tools can help with the arithmetic around a cash book: the Area Calculator for the hectares, and the Stack Calculator for what is in store at inventory time.

SOURCES

- Laisha degree manual: Farm Management, chapters on farm records, accounts and inventory; cost concepts; measures of farm efficiency; and partial and enterprise budgeting, with gross margins.
- All figures in the worked example are illustrative and invented for this article; they describe no real farm, price or country.

Read the full manual
laisha.ai/degrees/agribusiness/farm-management

Farm Management: records, costs, budgets and farm planning.

FREE IN LAISHA · TOOLS

The tools that cost nothing

Land unit conversions, bags in a stack, a farm diary, libraries of guides and pests, and a few questions a day to Ask Laisha: the parts of Laisha that are free, and stay free.

A lot of farming arithmetic is small, and it is needed at awkward moments: at a counter with a form half filled in, in a godown with a torch, at the edge of a field with one bar of signal. Laisha has paid tools, but a good part of it costs nothing at all, needs no account, and in several cases does not even need the internet. This is a tour of the free part, written from the tools themselves rather than from a brochure.

Area Calculator: fourteen units, one honest warning

Land is measured in units that do not agree with each other. A bank form wants hectares, a seed bag is printed for acres, a neighbour talks in bigha, and an agronomy recommendation is per square metre. The Area Calculator converts between fourteen of them in both directions: square metre, are, hectare, acre, square kilometre, square foot, square yard and square inch, and the regional units cent, decimal, guntha, bigha, kanal and marla. One tap shows the same figure in every unit at once.

Its most useful feature is a warning. Guntha, kanal and marla have fixed legal sizes, but the bigha does not: it varies from region to region, roughly from 1,340 to 3,025 square metres. The calculator says so on screen and tells you its bigha figure is an approximation, not a legal standard. If the number is going on a lease or a sale, check the local size first. The arithmetic runs on your own phone, so it works with no connection and no sign-in.

Stack Calculator: bags and tonnes in a godown

How many bags are in that stack, and what do they weigh? Type the bags per row, the number of rows, the number of layers and the weight of one bag, and the Stack Calculator gives the count and the tonnage. You can name a stack, save it, and keep going down the godown one stack at a time; the saved stacks stay on the device and can be totalled at the end. It is free and needs no account.

Daily Diary: the farm's memory in one place

A farm runs on a list of phone numbers and a list of things that must happen today. Daily Diary keeps a task list, a contact book, a calendar and a clock together. Everything is stored on the device itself, so it opens instantly and keeps working without a signal. It is honest about what it is: it reminds, it does not act. It sends no messages and books nothing on anyone's behalf.

Libraries you can read without signing in

The biggest free part of Laisha is reading:

- **Grow Guides**: 210 crops from choosing land to harvest and storage, free to read with no account. This issue's oat story comes from one of them.
- **The pest and disease encyclopedia**: 172 crop pests, diseases, weeds and disorders, each with what it looks like and how it is managed. The fall armyworm page is the one behind our crop health story.
- **Degree notes**: the manuals behind this magazine's library articles, in veterinary science, sustainability, agricultural engineering and more, free to read here with no account.
- **Laisha Kids**: illustrated books for children to read aloud together, starting with Class 1's *What Is a Plant?*
- **Country Fun**: a page for each happy country this magazine visits. Finland, from this issue, is the newest.

Ask Laisha, five questions a day

Ask Laisha answers farming questions in plain words, from Laisha's own library first. With a free account you can ask five questions a day,

every day. When the five are used, it tells you plainly, and five more are there the next day. Nothing is charged for them.

Laisha Run, still free

The farm runner from Issue 1 opens in any browser, with nothing to install and no account. Your best score is kept on your own device. It was free in October and it is free now.

WHERE THE MONEY COMES IN

Some tools cost real money to run every time they are used, such as reading a photograph of a sick crop, building a season plan for your own field from the live forecast, or turning a lab report into a fertiliser plan. Those are part of Laisha Smarter, at US$10 a month, one price worldwide. Everything in this article stays free, and you can use it for as long as you like without ever subscribing.

Three habits that make free tools more useful

1. **Write down the unit with the number.** "Twelve" means nothing a year later; "12 bigha (local size 1,600 m^2)" still means something.
2. **Save the stack or field under a name you will recognise**, such as "North godown, stack 3" or "River field", so next season starts from a record rather than a memory.
3. **Check one figure by hand the first time.** A tool you have tested once on a sum you already know is a tool you can trust in a hurry.

Free should mean free: no account to browse, no card to read, and no trick at the end of the page.

All of these are listed, with what each one does and does not do, at laisha.ai/tools.

SOURCES

- Checked against the tools themselves on 18 November 2026: the Area Calculator's list of units and its bigha note, the Stack Calculator, Daily Diary, and the free daily limit of five Ask Laisha questions.
- The tool pages at laisha.ai/tools, which say what each tool does and does not do.
- Page counts from the laisha.ai sitemaps on the same day: 210 grow guides and 172 pest and disease pages.
- Laisha Smarter's price, US$10 a month, one price worldwide, as listed on laisha.ai/tools.

See every Laisha tool Each tool explained: what it does, and what it will not do.
laisha.ai/tools/

Finland: forests, lakes and the midnight sun

A northern land of almost 188,000 lakes, wild berries anyone may pick, reindeer and a short, bright farming summer. Say "Hei!" to this issue's happy country.

Say "Hei!" to Finland, a country of forests, lakes, berries and long summer days in the far north of Europe. In March 2026 the World Happiness Report placed Finland first in the world for a record ninth year in a row. And like every happy country in this magazine, Finland loves its plants.

A land of trees and water

Look down on Finland from a plane and you see two colours: the dark green of forest and the shining blue of lakes. Forestry land covers 86 per cent of Finland's land, according to the Natural Resources Institute Finland, and most of that is real forest of pine, spruce and birch. Finland is often called the land of a thousand lakes, but that is far too few. The country's environment institute counts almost 188,000 lakes bigger than 500 square metres, about the size of two tennis courts.

Everyone's forest

Finland has a wonderful rule called everyman's rights. Anyone may walk in the forests and pick wild berries and mushrooms, as long as the plants are not protected, and they do not need the landowner's permission. So in late summer families head into the woods with buckets. The most picked berry for selling is the red lingonberry: about four million kilos were picked for sale in 2024, according to the Finnish Food Authority. Blue bilberries come next, and the golden cloudberry, which grows on wet bogs in the north, is rare and treasured.

Farming at the top of the world

Finland's farmers work with a short summer. The Finnish Meteorological Institute says the growing season lasts about 180 days in the mild south-west islands, 140 to 175 days elsewhere in southern and central Finland, and only 100 to 140 days in Lapland. What the summer lacks in length it makes up for in light. In the far north the sun does not set at all for 73 days, the midnight sun, and even in the south summer nights are short and bright.

In 2025 Finland had 39,825 farms and horticultural businesses, with an average of 57 hectares of farmland each. About three in four farms mainly grow crops. Cereals cover about one million of Finland's nearly two million hectares of arable land:

QUICK FACTS: FINLAND'S FIELDS IN 2025

Grass for forage — 789,000 hectares, for cows and cattle

Barley — 369,000 hectares

Oats — 320,000 hectares, see this issue's crop story

Spring wheat — 162,000 hectares

Autumn-sown wheat — 73,000 hectares

Rye — 21,000 hectares

Most grain is sown in spring, as soon as the snow has gone and the soil can be worked, and harvested in late summer or early autumn. That is one reason oats grow so well here: they like a cool summer.

Reindeer of the north

In Lapland, reindeer roam the forests and fells. The reindeer herding area covers almost 123,000 square kilometres, 36 per cent of Finland. For the Sámi, the Indigenous people of the far north, reindeer herding is part of an old way of life.

When the sun takes a holiday

In December, northern Finland has the opposite of the midnight sun. Above the Arctic Circle there are days when the sun does not rise at all. This is called kaamos, the polar night. In the northernmost parts it lasts about 51 days, from late November into January. It is not completely

black: at midday the sky glows blue and pink, the snow reflects every bit of light, and on clear nights the northern lights may dance overhead.

Food from the fields and forests

In a national vote organised in 2016 with the Ministry of Agriculture and Forestry, Finns chose rye bread, ruisleipä, as Finland's national food. It is dark, sour and filling. Another favourite is the Karelian pie, karjalanpiirakka: a thin rye crust folded around rice porridge. Its name is protected across the European Union as a traditional speciality, so only pies made the traditional way may use it.

WORDS TO KNOW

Hei / Moi — Hello (Finnish)

Kiitos — Thank you (Finnish)

metsä — forest

pelto — field

marja — berry

lehmä — cow

Hej — Hello (Swedish)

Finland has two national languages, Finnish and Swedish, so you will see signs in both.

MINI-QUIZ

1. How many lakes larger than 500 square metres does Finland have? a) About 1,000 · b) Almost 188,000 · c) Exactly 10
2. What may anyone pick in Finland's forests under everyman's rights? a) Only flowers · b) Nothing · c) Wild berries and mushrooms
3. Which berry was picked most for selling in 2024? a) Lingonberry · b) Strawberry · c) Banana
4. What is kaamos? a) A dance · b) The polar night, when the sun does not rise · c) A kind of bread
5. What did Finns vote their national food? a) Rye bread · b) Pizza · c) Rice

Answers: 1 b · 2 c · 3 a · 4 b · 5 a

SOURCES

- World Happiness Report 2026 news release: Finland first for a ninth year in a row. worldhappiness.report
- Natural Resources Institute Finland (Luke): forest resources; structure of agricultural and horticultural enterprises 2025; utilised agricultural area 2025 (preliminary). luke.fi
- Finnish Environment Institute (SYKE): lakes larger than 500 m^2. ymparisto.fi
- Metsähallitus, Everyman's rights. luontoon.fi
- Finnish Food Authority: wild berries picked for sale in 2024; Karelian pasty registered as an EU traditional speciality (TSG, 2003). ruokavirasto.fi
- Finnish Meteorological Institute, Seasons in Finland: growing season, midnight sun and polar night. en.ilmatieteenlaitos.fi
- Reindeer Herders' Association: the reindeer herding area. paliskunnat.fi
- ELO Foundation: rye bread chosen as Finland's national food (2017). elo-saatio.fi
- Institute for the Languages of Finland (Kotus): Finnish and Swedish are the national languages. kotus.fi

More Country Fun
laisha.ai/countries/finland

Finland on laisha.ai: more facts, words and a longer quiz.

STUDENTS · PRACTICE QUESTIONS

Test yourself: 33 exam-style questions

Water, animals, pollinators, soil and grain: practice questions from Laisha's question banks on the topics in this issue, with answers and explanations.

Every year, agriculture, veterinary and engineering students around the world sit entrance, licensing and university exams that test the same ideas this issue has been about: how much water a crop uses, how an animal loses heat, why pollinators matter, what a soil test means and how grain is dried. This section gives you 33 practice questions to test yourself, drawn from Laisha's own question banks, the same banks behind the practice papers on laisha.ai.

Try each question before you look at the answers. The answers come after the last question, each with a short explanation of why the right answer is right and, just as useful, why the wrong ones are tempting. Where a question needs a calculation, write it out: examiners award marks for the method, and the method is what you will use in a field or a clinic.

HOW TO USE THIS PAGE

- Cover the answers and give yourself 45 minutes for all 33 questions.
- Mark each one you guessed, even if you got it right. Those are the topics to revise.
- For every calculation you got wrong, find the step where it went wrong: a unit, a percentage entered as a fraction, a wet-basis figure treated as dry-basis.
- Then read the article in this issue that covers the topic, and the full manual on laisha.ai.

Water and irrigation

1. Which set describes the FAO-56 hypothetical reference crop?

- a) Grass 0.12 m tall, surface resistance 0 s/m, albedo 0.05
- b) Grass 0.12 m tall, resistance 70 s/m, albedo 0.23
- c) Alfalfa 0.5 m tall, surface resistance 45 s/m, albedo 0.23
- d) Open water surface, no surface resistance, albedo 0.08

2. In the FAO-56 single crop coefficient curve, in which order do the growth stages occur?

- a) Crop development, initial, mid-season, late season
- b) Initial, mid-season, crop development, late season
- c) Initial, late season, crop development, mid-season
- d) Initial, crop development, mid-season, late season

3. During a 30-day mid-season stage, reference ET averages 5.0 mm/day and Kc mid is 1.15. What is the crop water use for the stage?

- a) 17.25 mm
- b) 172.5 mm
- c) 150.0 mm
- d) 130.4 mm

4. A clay loam has volumetric field capacity 0.32 and wilting point 0.14. With a 1.2 m root zone and a management allowed depletion of 50 %, what is the readily available water?

- a) 192 mm
- b) 84 mm
- c) 216 mm
- d) 108 mm

5. Total available water in the root zone is 150 mm, MAD is 40 % and peak ETc is 6 mm/day. What is the irrigation interval at peak?

- a) 25 days
- b) 6 days
- c) 15 days
- d) 10 days

6. Class A pan evaporation is 8.0 mm/day, the pan coefficient is 0.70 and the crop coefficient is 1.10. What is the crop evapotranspiration?

- a) 12.57 mm/day
- b) 5.60 mm/day
- c) 6.16 mm/day
- d) 8.80 mm/day

7. Seasonal ETc of a crop is 480 mm, effective rainfall 120 mm and useful stored soil water at sowing 40 mm. There is no groundwater contribution. With a field application efficiency of 64 %, what is the gross irrigation requirement?

- a) 500 mm
- b) 204.8 mm
- c) 562.5 mm
- d) 750 mm

8. Where should tensiometers be installed to schedule a deep-rooted row crop?

- a) In the furrow bottom, where water stands longest, with both instruments at the same shallow depth so that their readings can be averaged
- b) One in the upper root zone to trigger irrigation and one near its bottom to check that water reached it without excess drainage
- c) Only just below the soil surface, at 2–3 cm
- d) Only below the root zone

Animals and their environment

9. The range of environmental temperature within which an animal maintains body temperature with minimal metabolic effort is the:

- a) Lethal temperature range
- b) Thermoneutral zone
- c) Zone of hyperthermia
- d) Upper critical temperature

10. As air temperature approaches skin temperature, the main route by which a cow can still lose heat is:

- a) Conduction to the floor
- b) Evaporation from skin and respiratory tract
- c) Convection to moving air
- d) Radiation to the surroundings

11. Using the NRC (1971) THI formula with T in °C and RH in %, what is the THI at 25 °C and 50% relative humidity?

- a) About 66.6
- b) About 71.8
- c) About 64.6
- d) About 77.0

12. Which single intervention gives the largest, cheapest reduction in heat load for cattle kept outdoors in the tropics?

- a) Providing shade
- b) Adding an ionophore to the ration
- c) Reducing the drinking-water allowance
- d) Increasing dietary crude protein

13. In a humid tropical region, a dairy uses sprinklers that wet the cows' backs in the holding pen, followed by strong fans. Why does this work better there than evaporative pads that cool incoming air?

- a) Wet hair reflects solar radiation more than dry hair does
- b) Sprinklers raise the relative humidity of the pen, which itself lowers heat stress
- c) Fans remove ammonia, and ammonia is the main cause of heat stress in cows
- d) Water evaporates directly from the wetted coat using body heat, even when the air is humid

14. Laying hens in a heat wave produce eggs with thin shells. The main physiological reason is:

- a) Panting causes respiratory alkalosis, reducing carbonate available for shell formation
- b) High temperature raises calcium intake beyond what the shell gland is able to use
- c) Heat destroys the vitamin D in the feed before the hens are able to absorb any of it
- d) Heat directly dissolves calcium carbonate already laid down in the shell

15. Several cattle are found dead near the downwind shore of a farm dam in late summer, with a green scum on the water. The most likely cause is:

- a) Fluoride dissolved from the rock under the dam
- b) Nitrate leached from fertilised fields into the dam
- c) Heavy metals settling slowly out of the dam sediment
- d) Cyanobacterial toxins concentrated in wind-blown blooms

16. Which organism is the preferred indicator of recent faecal contamination of drinking water?

- a) Total heterotrophic bacteria
- b) Escherichia coli
- c) Staphylococcus aureus
- d) Pseudomonas aeruginosa

Pollinators and natural pest control

17. According to Klein and colleagues (2007), how many of the 115 leading global food crops benefit from animal pollination?

- a) 87
- b) 15
- c) 50
- d) 115

18. Which crop is largely wind-pollinated and does not depend on animal pollinators?

- a) Apple
- b) Mustard
- c) Wheat
- d) Cucumber

19. Which parasitic mite is a major cause of honey bee colony losses worldwide?

- a) Tetranychus urticae
- b) Sarcoptes scabiei
- c) Varroa destructor
- d) Demodex folliculorum

20. Which practice best protects bees when insecticides must be used on a flowering crop?

- a) Spraying outside bee foraging hours with less toxic products
- b) Spraying at midday when most bees are foraging
- c) Spraying the field margins and flower strips first
- d) Using the most persistent systemic product available

21. In the push-pull system developed in East Africa, what does Desmodium do?

- a) Attracts stemborer moths into the trap-grass border of the field
- b) Repels stemborer moths and suppresses the parasitic Striga weed
- c) Pollinates maize flowers to increase grain set
- d) Produces an insecticide sprayed on maize leaves

22. Releasing mass-reared Trichogramma wasps against lepidopteran pests is which form of biological control?

- a) Augmentative
- b) Classical
- c) Conservation
- d) Chemical

23. Bees can be exposed to neonicotinoid seed treatments through:

- a) Only direct spraying of the open flowers in the crop
- b) Dust at sowing and residues in pollen and nectar
- c) Only drinking rainwater far from fields
- d) Feeding on the treated seed itself

Soil

24. Which practice is correct when collecting a soil sample for testing a field?

- a) Take one core from the wettest corner
- b) Sample only near manure heaps
- c) Composite many cores from a zig-zag pattern, avoiding unusual spots
- d) Mix soil from several different farms into a single bag to save on laboratory cost

25. A soil with CEC 25 cmol(+)/kg holds Ca 12, Mg 4, K 1 and Na 1 cmol(+)/kg. What is its base saturation?

- a) 72%
- b) 139%
- c) 64%
- d) 28%

26. A soil has exchangeable Na of 6 cmol(+)/kg and CEC 20 cmol(+)/kg. What is its ESP?

- a) 30
- b) 333
- c) 0.30
- d) 70

27. A soil with ECe 6 dS/m, ESP 8 and pH 8.0 is classified as:

- a) Sodic
- b) Saline-sodic
- c) Saline
- d) Normal

28. Why does the lime requirement of a clay soil exceed that of a sand at the same pH?

- a) Sands are always more acidic
- b) Lime does not dissolve in sandy soils, so it has no effect on their pH
- c) Clay soils contain no calcium at all
- d) The clay has higher buffer capacity from more exchangeable acidity

Grain after harvest, and pest control decisions

29. Grain has a moisture content of 20% on a wet basis. What is its moisture content on a dry basis?

- a) 25%
- b) 20%
- c) 80%
- d) 16.7%

30. 1,000 kg of paddy is dried from 22% to 14% moisture (wet basis). How much water is removed?

- a) 72.6 kg
- b) 102.6 kg
- c) 80.0 kg
- d) 93.0 kg

31. At constant relative humidity, as air temperature increases the equilibrium moisture content of grain

- a) decreases
- b) stays the same
- c) first increases then decreases
- d) increases steadily

32. The pest density at which control should be applied to prevent economic damage is the:

- a) Economic injury level
- b) Economic threshold
- c) General equilibrium position
- d) Maximum residue limit

33. Rotating insecticides between different IRAC mode-of-action groups mainly:

- a) Slows the evolution of resistance
- b) Raises residues in the harvested crop
- c) Increases toxicity to natural enemies
- d) Removes the need for pest monitoring

Answers and explanations

1. b) FAO-56 defines the reference as hypothetical grass, 0.12 m tall, rs = 70 s/m, albedo 0.23. The alfalfa option describes a tall reference (ASCE), and the others describe open water or an unrealistic surface.

2. d) The season runs initial (to about 10 % ground cover), development (to effective full cover), mid-season (full cover to start of maturity) and late season (to harvest). Kc is flat in the initial and mid stages and changes linearly in the other two.

3. b) ETc = 1.15 × 5.0 = 5.75 mm/day; × 30 days = 172.5 mm. 150 mm ignores Kc; 130.4 mm divides by Kc; 17.25 is a mm–cm slip.

4. d) TAW = 1000 × (0.32 − 0.14) × 1.2 = 216 mm. RAW = 0.5 × 216 = 108 mm. 216 mm is TAW, not RAW; 192 mm applies MAD to field capacity alone; 84 mm applies it to the wilting point water, which is unavailable.

5. d) Allowable depletion = 0.40 × 150 = 60 mm; interval = 60/6 = 10 days. 25 days uses the full TAW; 15 days uses MAD = 0.6; 6 days confuses ETc with the interval.

6. c) ET_o = Kp × Epan = 0.70 × 8.0 = 5.60 mm/day; ETc = Kc × ET_o = 1.10 × 5.60 = 6.16 mm/day. 5.60 stops at ET_o; 8.80 skips the pan coefficient; 12.57 divides by Kp instead of multiplying.

7. a) NIR = 480 − 120 − 40 = 320 mm; gross = 320 / 0.64 = 500 mm. 750 mm ignores rain and stored water; 562.5 mm forgets the stored soil water; 204.8 mm multiplies by efficiency instead of dividing.

8. b) Most extraction is in the upper root zone, so the trigger sensor goes there; a deeper sensor shows whether the irrigation refilled the lower zone or drained past it. Surface readings fluctuate with evaporation, and sensors below the roots do not see crop use.

9. b) The thermoneutral zone lies between the lower and upper critical temperatures. The upper critical temperature is one boundary of the zone, not the zone itself.

10. b) Radiation, conduction and convection all depend on a temperature gradient, which shrinks as air temperature nears skin temperature; evaporation (sweating and panting) then carries most of the heat load, and it falls as humidity rises.

11. b) 1.8 × 25 + 32 = 77; 0.55 − 0.0055 × 50 = 0.275; 1.8 × 25 − 26 = 19; THI = 77 − 0.275 × 19 = 71.8. 77.0 is simply the temperature in °F; 66.6 comes from

entering RH as 0.5 instead of 50; dropping the − 26 (77 − 0.275 × 45) gives 64.6.

12. a) Solar radiation adds a large heat load; shade removes much of it at low cost. Extra protein increases metabolic heat, and restricting water is harmful because evaporative cooling and intake depend on water. Ionophores do not cool animals.

13. d) Soaking the coat and then blowing air over it removes heat from the cow's skin as water evaporates, so it remains effective when ambient humidity limits evaporative cooling of the air itself. Higher humidity worsens heat stress by reducing evaporative loss. Ammonia is an air-quality problem, not a cause of hyperthermia. Wet hair does not reflect more radiation; cooling comes from evaporation and convection, not reflection.

14. a) Panting blows off CO2, causing respiratory alkalosis and lowering blood bicarbonate and ionised calcium available to the shell gland; reduced feed intake adds to the shortfall. Feed intake (and so calcium intake) falls in heat rather than rises.

15. d) Warm, still, nutrient-rich water grows cyanobacteria; wind concentrates scums on one shore where animals drink, and hepatotoxins (microcystins) or neurotoxins (anatoxins) can kill within hours. Fluoride and settled metals act chronically, and nitrate does not produce a visible scum.

16. b) E. coli lives in the gut of warm-blooded animals and does not usually multiply in water, so its presence signals recent faecal contamination. Heterotrophic counts describe general bacterial load and biofilm, not faecal origin; Pseudomonas and Staphylococcus are not faecal indicators.

17. a) 87 of 115 (about 75 %) benefit to some degree, though they account for about a third of production volume because staple cereals are wind- or self-pollinated.

18. c) Wheat is self- and wind-pollinated; apple, mustard and cucumber benefit from insect pollination.

19. c) Varroa jumped from the Asian honey bee to the western honey bee and spreads viruses. The others are a plant spider mite and mites of mammals.

20. a) IPM-based timing (evening or early morning), product choice and protecting margins reduce exposure. Midday spraying, treating flower strips and persistent systemics increase harm.

21. b) Desmodium intercropped with maize repels ('pushes') moths, suppresses Striga and fixes nitrogen; the border grass (Napier or Brachiaria) attracts ('pulls') moths. Maize is wind-pollinated; Desmodium is not sprayed.

22. a) Augmentative control releases reared natural enemies; classical introduces enemies from a pest's native range; conservation supports enemies already present.

23. b) Systemic uptake into pollen, nectar and guttation, plus sowing dust.

24. c) Representative composite sampling is the main source of reliable results.

25. a) BS = (12+4+1+1)/25 = 72%. The last value is the acid saturation.

26. a) ESP = 100 x Na/CEC = 30 (> 15: sodic range).

27. c) ECe > 4 and ESP < 15 with pH < 8.5 = saline.

28. d) More CEC and organic matter hold more reserve acidity.

29. a) M_db = M_wb/(1 − M_wb) = 0.20/0.80 = 0.25, i.e. 25% db. 16.7% is what you get by applying the reverse formula M_wb = M_db/(1 + M_db) to 0.20 by mistake; dry-basis moisture is always higher than wet-basis for the same grain. 20% leaves the value unconverted; 80% is the dry-matter fraction.

30. d) Dry matter is constant: 1000 × 0.78 = 780 kg. Final mass = 780/0.86 = 907.0 kg, so water removed = 1000 − 907.0 = 93.0 kg (equivalently 1000 × 0.08/0.86). 80 kg is the classic error of subtracting wet-basis percentages; dividing by (1 − 0.22) instead of (1 − 0.14) uses the wrong final mass. 102.6 kg is 1000 × 0.08/0.78; 72.6 kg applies 0.08/0.86 to the 780 kg of dry matter instead of the 1000 kg.

31. a) Higher temperature raises the vapour pressure of water in the grain, so less water is held at equilibrium with air of the same RH. This is why warm air dries better and why cooling stored grain raises its EMC.

32. b) The economic (action) threshold is set below the economic injury level.

33. a) Alternating modes of action reduces selection pressure.

SOURCES

All 33 questions are from Laisha's question banks, which are checked against standard texts and official guidance and used for the practice papers on laisha.ai. Bank and question numbers:

- Irrigation Engineering (Soil-Water-Plant, Conveyance, Surface Methods): questions 11, 20, 21, 3, 37, 13, 26, 44
- Environment & Environmental Hygiene: questions 35, 33, 29, 34, 124, 32, 17, 1
- Ecosystem Services & Pollinators in Agricultural Landscapes: questions 25, 86, 29, 35, 39, 37
- Pesticides in the Environment: Fate, Risk & Reduction: questions 53
- Soil Science & Soil Health: questions 93, 32, 38, 36, 44
- Post-Harvest Engineering of Cereals, Pulses & Oilseeds: questions 1, 3, 11
- Pesticides in the Environment: Fate, Risk & Reduction: questions 83, 88
- The banks' own references include FAO Irrigation and Drainage Paper 56, the US National Research Council (1971) temperature-humidity index, WHO Guidelines for Drinking-water Quality, IPBES (2016), Klein and colleagues (2007), and standard irrigation, post-harvest and soil science texts.

More practice questions
laisha.ai/tools/exam_prep

Exam practice for agriculture, veterinary and engineering examinations worldwide.

REFERENCE · GLOSSARY

Words in this issue

From avenin to the winter cluster: the technical terms in Issue 2, explained in plain language, with the article each one comes from.

Every subject has its own words, and farming has more than most, because it borrows from biology, chemistry, engineering, economics and the weather. This glossary collects the technical terms used in Issue 2, explained in plain language, so a student, a farmer or a curious reader can look one up without leaving the magazine. Each entry says which article it comes from, so you can read the term in context.

Where a word has a stricter scientific definition than the one given here, the article and the Laisha degree manual behind it give the full version. Words in *italics* are scientific names.

Water and soil

ETo, reference evapotranspiration — the water a standard, well-watered grass field would lose in a day through evaporation and transpiration, in millimetres. It depends only on the weather. (When to water)

ETc, crop evapotranspiration — the crop's own daily water use: ETo multiplied by the crop coefficient. (When to water)

Kc, crop coefficient — the number that converts ETo into a particular crop's water use at a particular stage. Low for young crops, highest at full canopy. (When to water)

FAO-56 — FAO Irrigation and Drainage Paper 56 (1998), the standard method for working out crop water needs. (When to water)

Field capacity — how much water a soil holds after a thorough wetting, once free water has drained away. (When to water)

Wilting point — the soil water content at which roots can no longer take up water and plants wilt. (When to water)

TAW, total available water — the water between field capacity and wilting point over the depth of the roots. (When to water)

RAW, readily available water — the part of TAW a crop can use without stress: p × TAW. (When to water)

Depletion fraction, p — the share of TAW a crop can use before it suffers. About 0.5 for many crops; lower for sensitive ones. (When to water)

Effective rainfall — the part of the rain that stays in the root zone, after runoff and losses. (When to water)

Water balance — a running total of crop water use, rain and irrigation, used to decide when to irrigate. (When to water)

Tensiometer — an instrument in the soil that shows how hard roots must pull to get water. (When to water)

Leaching requirement — the extra water needed now and then to wash salts below the root zone. (When to water)

Salinity, EC — the amount of dissolved salt in soil or water, measured as electrical conductivity. (Soil testing)

Crops and pests

Panicle — the open, branched flower and grain head of oats and some other grasses. (Oats)

Lodging — when a crop falls over, from weak stems, wind, rain or too much nitrogen. (Oats)

Screenings — small, thin or broken grains sieved out of a sample; too many lower its value. (Oats)

Specific weight — the weight of a fixed volume of grain, in kilograms per hectolitre; a quality measure. (Oats)

Kernel content — the share of an oat grain that is the inner groat once the husk is removed. (Oats)

Crown rust — a fungal disease of oats with orange pustules, caused by *Puccinia coronata* f. sp. *avenae*. (Oats)

Alternate host — a second, different plant a pathogen needs to complete its life cycle; buckthorn, for crown rust. (Oats)

Barley yellow dwarf virus — a virus of cereals spread by aphids; infected oat leaves turn red. (Oats)

Avenin — a protein in oats similar to gluten. (Oats)

Beta-glucan — a soluble fibre found in oats and barley. (Oats)

Instar — one of the growth stages of a caterpillar between moults; fall armyworm has six. (Fall armyworm)

Frass — insect droppings; for fall armyworm, like moist sawdust in the maize funnel. (Fall armyworm)

Whorl — the funnel of young, rolled leaves at the centre of a maize plant. (Fall armyworm)

Windowpane — a clear patch where a young caterpillar has eaten the leaf surface but left the thin membrane. (Fall armyworm)

Action threshold — the level of pest damage at which acting pays for itself. (Fall armyworm)

Scouting — walking a field in a set pattern to count pest damage; for fall armyworm, a W with five stops of ten plants. (Fall armyworm)

Natural enemies — predators, parasites and diseases that kill pests, such as ants, earwigs, wasps and fungi. (Fall armyworm)

Biopesticide — a pest control product based on a living organism or natural substance, such as Bt, a virus or a fungus. (Fall armyworm)

Push-pull — a system in which a repellent intercrop pushes pests away from maize and an attractive border grass pulls them out. (Fall armyworm)

Mode of action — the way a pesticide kills; rotating between different modes slows resistance. (Fall armyworm)

Germination — when a seed wakes up and begins to grow. (Seeds and sprouts)

Radicle — the first root to come out of a seed. (Seeds and sprouts)

Cotyledon, seed leaf — the store of food in a seed, which in beans makes up its two halves. (Seeds and sprouts)

Embryo — the baby plant inside a seed. (Seeds and sprouts)

Animals

Thermoneutral zone — the range of temperature in which an animal keeps warm or cool with little effort. (Animals)

Lower critical temperature — the temperature below which an animal needs extra feed to keep warm. (Animals)

Upper critical temperature — the temperature above which an animal must work to lose heat, and eats and produces less. (Animals)

THI, temperature-humidity index — one number combining temperature and humidity, used to judge heat stress. (Animals)

Heat stress — the effects of more heat than an animal can lose: panting, less feed, less milk, poorer fertility. (Animals)

Colostrum — the first milk after birth, rich in antibodies a newborn needs in its first hours. (Animals)

Oestrus — the period when a female animal will accept mating, also called heat. (Animals)

Brooding — keeping young chicks warm until they can control their own temperature. (Animals)

Creep area — a warm, covered space in a farrowing pen that piglets can enter and the sow cannot. (Animals)

Fly-strike — an attack by fly maggots on a sheep's skin, most common in warm, humid weather. (Animals)

Bees and pollination

Pollination — moving pollen from the male to the female part of a flower, so seed and fruit can form. (Honey bee)

Winter cluster — the tight ball honey bees form in cold weather to keep the colony warm. (Honey bee)

Swarm — part of a honey bee colony leaving with a queen to start a new colony, usually in spring and early summer. (Honey bee)

Varroa — *Varroa destructor*, a mite that feeds on honey bees and spreads viruses between them. (Honey bee)

Nectar flow — the period when many plants are in flower and bees bring in nectar fast. (Honey bee)

Ecosystem services — the benefits farms and people get from nature, such as pollination, pest control and clean water. (Honey bee)

IPBES — the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (Honey bee)

Money and records

Cash book — a simple record of every sum of money in and out of the farm, with date and enterprise. (Farm cash book)

Enterprise — one part of the farm business, such as a crop or a group of animals, whose results are counted separately. (Farm cash book)

Variable costs — costs that rise and fall with the size of an enterprise: seed, fertiliser, feed, sprays, hired labour. (Farm cash book)

Fixed costs — costs that stay the same whatever is grown: rent, depreciation, insurance, interest. (Farm cash book)

Gross margin — the value of an enterprise's output minus its variable costs. (Farm cash book)

Net farm income — total gross margin minus whole-farm fixed costs. (Farm cash book)

Depreciation — the yearly loss in value of a machine or building through use and age. (Farm cash book)

Inventory — a dated list of everything the farm owns and owes. (Farm cash book)

Net worth — what the farm owns minus what it owes. (Farm cash book)

Gross ratio — total expenses divided by gross income; below 1 is profitable. (Farm cash book)

Weather, places and people

Hemisphere — one half of the Earth; north and south of the equator, the seasons are reversed. (Editor's note)

Kaamos — the polar night in northern Finland, when the sun does not rise. (Finland)

Midnight sun — the summer weeks in the far north when the sun does not set. (Finland)

Everyman's rights — in Finland, the right to walk in the countryside and pick wild berries and mushrooms on others' land. (Finland)

Sámi — the Indigenous people of the far north of Finland, Sweden, Norway and Russia. (Finland)

TSG — the European Union's traditional speciality registration, which protects the name of a traditional food. (Finland)

Extension service — the advisers, often from universities or ministries, who bring research to farmers. (several articles)

If a word in this issue is missing here, write and tell us. The best glossaries are built by their readers.

SOURCES

- The definitions follow the articles in this issue and the Laisha degree manuals they draw on: Irrigation Engineering; Environment & Environmental Hygiene; Ecosystem Services & Pollinators in Agricultural Landscapes; Farm Management; and Laisha's grow guide on oats and pest encyclopedia entry on fall armyworm.
- FAO Irrigation and Drainage Paper 56 (1998), for the irrigation terms.

BACK PAGE

The Issue 2 quiz

Five questions, one from each corner of this issue.

1. **Which part of a sprouting seed comes out first?**
   a) The leaves
   b) The root
   c) The flower

2. **In the FAO-56 method, a crop's water use is ETc = Kc × ...**
   a) ET_0, the reference evapotranspiration
   b) The rainfall last month
   c) The field's area

3. **Where is the fall armyworm native to?**
   a) Africa
   b) The Americas
   c) Australia

4. **When are oats harvested in southern Australia?**
   a) Late spring and early summer
   b) Midwinter
   c) They are never harvested

5. **What may anyone pick in Finland's forests under everyman's rights?**
   a) Wild berries and mushrooms
   b) Only pine cones
   c) Nothing at all

Answers: 1 b · 2 a · 3 b · 4 a · 5 a

Tell us what to write next

Which article did you read to the end, and which did you skip? Which crop, pest or question from your country should we explain next? Write to us: every message is read, and the best ideas become articles.

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COMING NEXT ISSUE

Laisha Kids
Another story for young readers, with something to grow or make at home or at school.

A new happy country
Another of the world's happiest countries, and the plants its people love. Can you guess which?