Trainers manual
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Photo: SysCom India

Improved Irrigation in Cotton Production

Photo: SysCom India

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Content

There are various methods applied worldwide to optimize the irrigation of crops. Learn in this manual why, when and how cotton should be irrigated.

Image source: www.kj1bcdn.b-cdn.net

1. Introduction

How to use this manual

- This manual is meant for farmers and trainers.
- It provides an overview of different irrigation systems and suggests how and when crops, especially cotton, should be irrigated.

Why improved irrigation is important

- 80% of rainfall in India occurs during the monsoon period. Monsoon rainfall is very uncertain, and irrigation is important to supply water to plants.
- Farmers should have a reliable water supply. Irrigation systems must be planned and designed to maximise efficiency and minimise water loss.
- The various sources of water for irrigation are wells, ponds, lakes, canals, tube wells and dams.
- Through technologies and innovations, the efficiency of our irrigation system can be improved. By doing so, we can maximise crop yields and minimise water waste.

In places with no rain during dry periods, irrigation will be key to achieving high yields in many crop cultures.
Image source: https://fdp.com.pk/wp-content/uploads/2018/11/irrigation-services-in-arizona-southwest-irrigation.jpg

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2. Irrigation systems

There are three main irrigation systems that are followed in India:

Drip irrigation: Well and tube well

Flood irrigation: Well, tube well, canal, ponds etc.

Sprinkler irrigation: Well and tube well

Drip irrigation

What is the best irrigation system?

Drip irrigation is among the most sustainable and efficient agricultural watering systems to date and presents several attractive benefits.

Flood irrigation

Its positive impact on water efficiency and crop growth promotes maximised crop yield while saving time and money.

Sprinkler irrigation

Benefits of drip irrigation

- Cost-effective
- Environmentally friendly
- Minimised chance of disease spread
- Adjustable water flow
- Encourages high crop yield and profitability
- Minimises soil erosion
- Improved crop quality
- Enhanced nutrient control

Image sources: Drip irrigation: SysCom India, Flood irrigation: https://3.bp.blogspot.com, Sprinkler irrigation: https://image.shutterstock.com/

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Comparison of different irrigation systems

Particulars	Irrigation System		
	Flood	Drip	Sprinkler
Water use	High	Low	This system is not used in the Nimar region/ in Khargone.
Weed	High	Low	
Time and labor investment	High	Low	
Crop condition	Crop condition is often worse, there are more problems	Crop condition is generally better	
Cost (Rs/acre) for infrastructure	No extra cost	10 thousand	
Yield	Comparatively lower	Comparatively higher	
Fertigation with irrigation water	Not possible	Possible	
Power Consumption	High	Low	

Source information in table: TNAU AGRITECH PORTAL

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3. When is irrigation necessary?

The approaches to determine the right time to irrigate can be broadly classified into following groups:

A) Soil moisture regime approaches

Soil moisture is the temporary storage of water within a shallow layer of earth's upper surface. Soil moisture plays a key role in water stress detection and irrigation management. Information of soil moisture can be also used as an indicator for the prediction of natural disasters, such as drought and flooding and for environmental changes, such as dust storms and erosion.

Soil moisture can be estimated by feeling it and by its appearance: take a small handful of soil and squeeze it to observe its behaviour. If it forms a ball that holds its shape but crumbles easily, it has adequate moisture, while dry soil won't bind and overly wet soil will feel sticky.

Sandy soil has a low water holding capacity (WHC) and needs frequent irrigation, while clay soil has a high WHC and needs less frequent irrigation.

Visual observations of the field: Do you see any cracks in the soil? This is caused by the lack of water, so this field should be irrigated.
Photo: SysCom India

B) Plant indicators

Water-deficit stress has a significant effect on cotton's growth and development. The effects of water stress depend on the severity and duration of the stress, the growth stage at which stress is imposed, and the genotype of the plant. The cotton crop is sensitive to water shortage at all growth stages, but particularly reproductive development is the most sensitive period to drought stress following seed germination and seedling establishment. In cotton, water sensitivity during flowering and boll development has been well established. Crops can be observed to see if they need irrigation. If a plant is under water stress, the color might change, from a bright green to a dull, darker color. The leaves can also begin to curl and eventually wilt. The growth of the crops decreases or even stops.
Source:https://www.fao.org/4/t7202e/t7202e06.htm

Signs of water stress: Observing the plant to see if irrigation is needed.
Photo: www.s3.ap-southeast-1.amazonaws.com

C) Climatological approaches

Using weather forecast information can help to plan irrigation ahead. Nowadays, a wide range of weather forecast websites (Google, www.weather-forecast.com) are available. During particularly hot and dry periods, the plants and soil lose a lot of water, so irrigation is important. If rain is predicted, irrigation might not be necessary, and the intervals between irrigations in the schedule can be elongated.
Source:https://www.fao.org/4/t7202e/t7202e06.htm)

Climatological approaches: Rainfall is getting late
Photo: SysCom India

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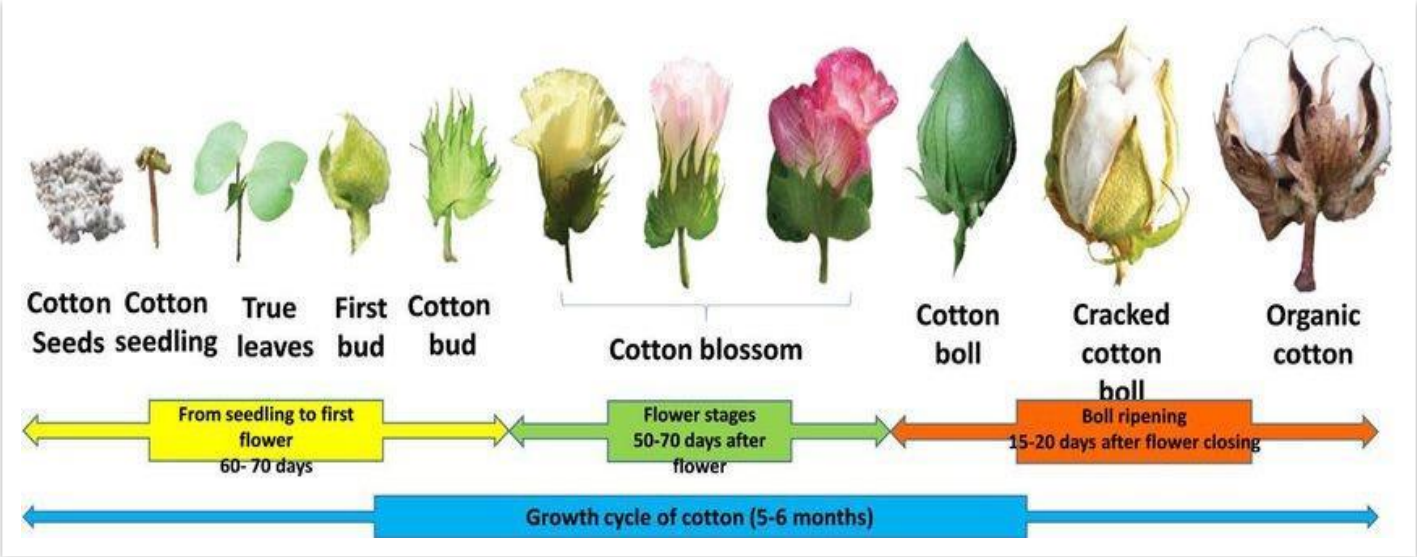
4. Water deficiency in different growth states in cotton

The benefits of irrigation vary depending on the stage of the growth stage. See the different growth stages in the image below:



A plant has different levels of sensitivities throughout its growth stages. It is most sensitive during early blooming and in the very beginning (cotton seedling until first buds are visible).

Growth Stage	Sensitivity to water deficit	Benefits of irrigation	Disadvantages of irrigation
From seedling to first flower	Slight – moderate	Hydrates germinating plants, builds plant size, brings fertilizers into solution, termite control	Seedling disease if cool, creates soil crust, more weeds, shallow root system,
Early bloom	Moderate – high	Retains bolls, new fruit and leaves, maintains fibre quality, control the nematodes	Few
Late bloom	Moderate	Retains bolls, healthy leaves, maintains fiber	Few
Cutout	Slight	Healthy leaves	Delayed maturity
Opening	None	Few	Boll rot, delayed harvest

Source image on top: https://www.seminolesentinel.com

Source information in table: https://www.cropscience.bayer.us

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General recommendations on irrigation during different growth stages for cotton

Germination Stage (from sowing up to 1-15 days)

- Irrigate once immediately after sowing and on every 3rd day.

Vegetative Stage (16-44 days)

- For light soil: Irrigate on the 20th or 21st day after sowing, three days after weeding and hoeing. Irrigate again on the 35th or 36th day after sowing.

- For heavy soil: Irrigate on the 20th or 21st day after sowing, three days after weeding and hoeing. Irrigate again on the 40th day after sowing if necessary.

Flowering Stage: (45-100 days)

- For light soil: Irrigate on the 48th day, 60th day, 72nd day, 84th day, and 96th day.

- For heavy soil: Irrigate on the 55th day, 70th day, 85th day, and 100th day.

Maturity Stage: (more than 100 days)

- For light soil: Irrigate on the 108th day, 120th day, 130th day, and 144th day, and stop irrigation after the 150th day.

- For heavy soil: Irrigate on the 115th day and 130th day, and stop irrigation after the 150th day.

Source: www.agritech.tnau.ac.in/agriculture/agri_irrigationmgt_criticalstage.html

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5. Growth stages and irrigation in cotton and other crops

Every crop has a critical stage of irrigation for getting better yield.

Crops	Critical Stages
Barley	Boot stage, dough stage
Berseem	After each cutting.
Cotton	Emergence, Pre squaring, squaring, Early bloom, late bloom.
Gram	Pre flowering and flowering.
Maize	Early vegetative, tasselling and silking stage.
Peas	Pre bloom stage.
Pigeon pea	Flower initiation, pod filling.
Pulses	Flowering and podding.
Sorghum	Initial seedling, pre flowering, flowering, grain formation.
Wheat	Most critical stage: Crown root initiation, tillering, jointing, booting, flowering, milk and dough stages

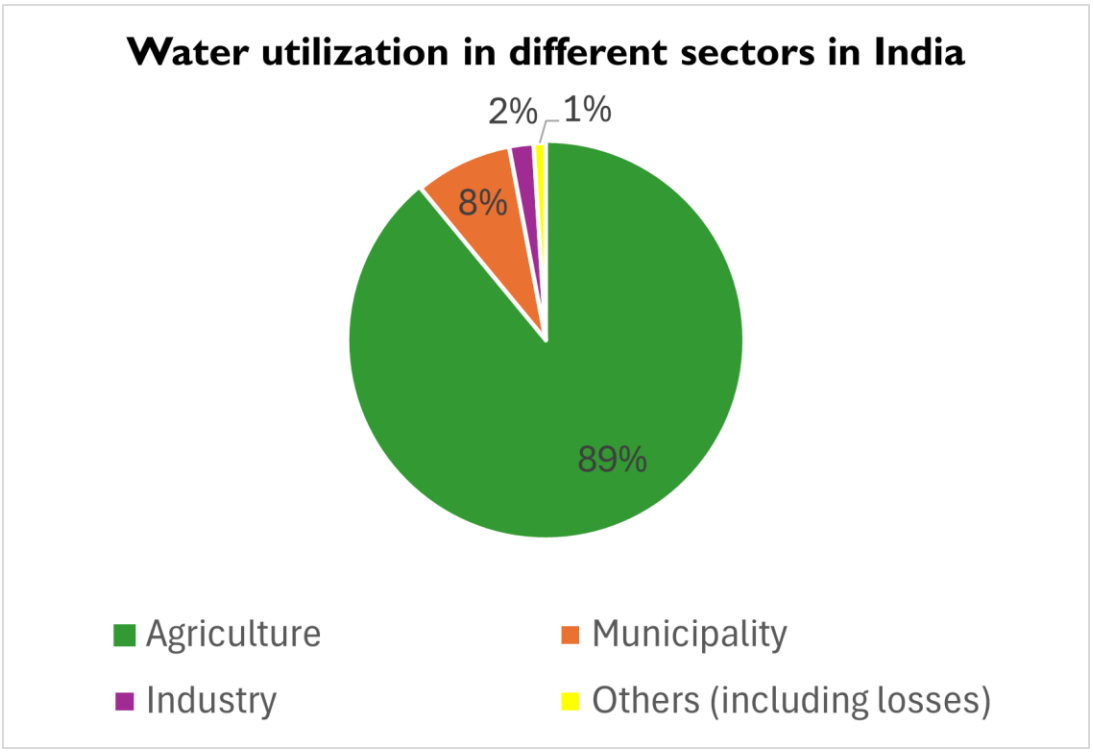
Source: www.agritech.tnau.ac.in/agriculture/agri_irrigationmgt_criticalstage.html

6. Current challenges with irrigation

A) Decreasing groundwater levels

Ground water levels in some parts of the country are declining because of continuous withdrawal necessitated by increased demand of fresh water for various uses, vagaries of rainfall, increased population, industrialization & urbanization etc. Agriculture, with its large water demand for irrigation, plays the most important role in this. For this reason, irrigating in a water-saving way and coordinating water use is essential.

Decreasing ground water levels
Photo: SysCom India



Agriculture is the sector that consumes the most water.
Source of information for graph: Water Footprint, A Tool for Sustainable Development of Indian Dairy Industry, Thakur, Ankaj et al. 2018 (Data Adapted from Grail Research, 2009)

B) Over-irrigation affecting the soil quality

Over-watering increases the moisture in the crops' active root zone over the field capacity. Field capacity refers to the amount of water crops can hold. Any additional moisture over this limit starts draining out of the crops' root zone, depriving the crops of water and extracting valuable nitrogen.

One of the most damaging repercussions of over-irrigation is the increase in the soil's salinity. Naturally, most crops don't favour salty conditions, which can adversely affect growth.

An important factor in determining the scale of the damage is the soil type. In particular, if the soil doesn't have proper drainage, the excess water can result in saturated or low-oxygen conditions. Additionally, the nutrient and water uptake is slowed down, depending on how badly waterlogged the crops are. If the waterlogging persists for over two days in the middle of the growing season, the moisture will kill some roots.

Over-irrigated cotton field
Photo: SysCom India

Too much irrigation will result in increased vegetative growth and reduced fruiting, here for example in chickpeas.
Photo: SysCom India

C) Repercussions of over-irrigation

Too much irrigation or more rainfall in the crops with poor drainage systems causes waterlogging and salinity in the soil.

Waterlogging and salinisation harm plant growth and production by making the plant roots shallow.

- **Waterlogging** affects plant growth by reducing soil aeration around the root zone.
- Very salty soil (**salinisation**) makes it harder for plants to take up water, so the crops do not grow well.
- The damage to plant growth and yield is more serious when these processes occur simultaneously.

Waterlogging situations in cotton crop due to the excess rain or poor drainage.
Source image: https://th-i.thgim.com/

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7. Keep moisture in the soil

A) Mulching

- Mulching means covering soil with a layer of organic (e.g. plant residues) or inorganic (e.g. polyethylene covers) material to conserve moisture, regulate temperature, and suppress weed growth.
- Mulching helps maintain soil integrity and protects valuable topsoil from erosion caused by wind and water.
- By reducing the impact of raindrops, mulching decreases soil compaction, slows down water runoff, and promotes the infiltration of water into the ground.
- In doing so, it conserves precious soil resources and prevents the loss of vital nutrients carried away by runoff.

Different materials can be used as mulch.
Source image: www.mdpi.com

Benefits of mulching in the crop

- Moisture conservation
- Weed suppression
- Soil temperature Regulation
- Soil health and fertility

B) Low tillage and no tillage

- No-till or reduced tillage practices are also saving the moisture in the soil and allow you to spend less time in the field.

C) Further erosion and runoff prevention

- **Don't leave the soil bare.**
- **Adapt tillage practices:** To prevent water runoff, ploughing and crop sowing should be in the opposite direction of the slope. This will increase water holding and reduce soil erosion.
- **Watch out for overgrazing.** Cattle overgrazing in the field also increases moisture loss.
- **Consider terracing steep slopes:** If there are more slopes, adopt terracing farming to increase the water-holding capacity and stop soil erosion.

Heavy water runoff on bare soil after heavy rainfall.
Source: www.gettyimages.in

Severe case of erosion due to leaking overgrown soil.
Source: https://theagrotechdaily.com/

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8. Conclusion

- Use **drip irrigation** systems instead of flood irrigation systems to increase irrigation efficiency and increase production.
- Use traditional approaches, like **soil moisture estimation by hand**, as well as modern internet technologies, like weather forecasting (www.weather-forecast.com), for determining the right time to irrigate the crops. Also, farmers can use Google weather information.
- Learn more about the water requirements of the various crops in order to irrigate them according to their water requirements.
- Optimise plant production through optimal use of irrigation water and other moisture-saving ideas.
- Use **mulching** in the field to save water, suppress weeds, increase soil fertility, stop soil erosion, solve labour problems, and save electricity.
- **Low till or no-till saves moisture**, can improve soil fertility and decrease carbon emissions.
- Through all the above activities, we can achieve **the highest crop production**, while having lower costs of cultivation, improving the soil fertility and saving a lot of water, which is ultimately good for the environment..

Text: Ishwar Patidar (bioRe), Julia Hauri (SysCom)
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