BENEFIT

Boosting Innovation in Education and Research of Precision Agriculture in Palestine

Course name: Design of Irrigation and Drainage

Module one: Precision Technology in Irrigation Scheduling

Disclaimer

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Irrigation Systems

Water is applied to the plant using several methods. These methods are classified mainly in two categories:

1) Gravitational methods and mainly surface irrigation in which water is conveyed and stored by the soil under the force of gravity.

2) Pressurized irrigation: Where water is distributed using pipes under pressure as in sprinkler and trickle irrigation systems.

Selection of the type of an irrigation system

Factors to be taken into account in selecting the type of an irrigation system:

1) Water source and value of water
2) Cost of pumping and whether pumping is available or not.
3) Available cost of the system (the available capital).
4) Type of soil and its topography.
5) Type of crops.

Sprinkler Irrigation Systems

Conditions favoring sprinkler irrigation:

1) Soil too porous for good distribution of water (sandy soils).
2) Topography as in hilly areas where the use of surface irrigation will result in erosion and low efficiency.
3) Irrigation stream too small to use surface systems.
4) Labor is no experienced with surface irrigation.
5) Spacing between crops is too small which will require a lot of drip lines.

Uses of sprinkler irrigation other than supplying irrigation water:

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1) Frost protection

2) Application of fertilizers, pesticides and soil amendments.

3) Crop cooling.

Classification of sprinkler systems:

1) Solid set systems: These are the most commonly sprinkler methods used around the West Bank and Gaza. The sprinklers are installed all over the farm and are not moved during the season. The disadvantage of this type is its high cost as we need too many sprinklers to irrigate the whole farm.

2) Move stop system: The sprinklers are moved from a location to another in the farm. The cost of these systems is lower but they require a high operational cost to move the sprinklers during irrigation.

3) Continuous move systems: These systems move continuously in the farm to irrigate it while moving. They include:

a) Center pivot systems: A lateral line with sprinklers on it rotates around the field. During its rotation, water is applied. Center pivots form circles and thus the corners are not irrigated. They should be used at lands with slopes less than 1%.

b) Linear move systems: A lateral moves linearly across the field. This is utilized especially when the source of water is an open ditch and a pump is connected to the lateral and moves with it.

c) Big gun systems: These are big sprinklers which irrigate large areas and moved by tractors along the field.

Sprinkler irrigation equipment:

The sprinkler head

The distribution piping

Flow regulators

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Controllers

Filters and injectors

Pumps

Pressure heads:

The pressure heads used in sprinkler irrigation range from 3.5 to 70 m. According to these heads, sprinkler systems are classified as:

a) Low pressure systems with pressure heads from 3.5 to 10 m.

b) Medium pressure systems with pressure heads from 10 to 20 m.

c) Intermediate pressure systems with pressure heads from 20 to 40 m.

d) High pressure systems with pressure heads from 40 to 70 m.

Trickle Irrigation

Trickle or drip irrigation is the slow and frequent application of water on, above, or beneath the soil. Water is applied as discrete or continuous drops, tiny streams, or miniature spray through emitters or emission points placed along a water delivery line near the plant. Using delivery lines to deliver water to plants decreases deep percolation and eliminates runoff. Deep percolation can be minimized by good hydraulic design and proper management of each application. Controlling deep percolation and eliminating runoff increases the application efficiency of drip irrigation. The wetted area is reduced, so a significant reduction in evaporation from the soil is observed. Therefore, water savings are obtained in trickle irrigation.

Trickle irrigation has many advantages. Besides saving water, it operates at low pressures. Through low pressures and saving water, energy costs are reduced. The weed growth is reduced and becomes more controlled. Frequent or daily application of small amounts of water is possible, so plant stress can be reduced. Reducing plant stress improves plant growth and increases yields. Possible disadvantages of frequent application of water include restricted soil aeration and plant disease.

Water of higher salinity can be used with trickle irrigation without greatly reducing crop yields. Minimizing salinity hazards to plants irrigated by trickle irrigation can be attributed to moving salts beyond the active plant root zone. Irrigating more frequently keeps salts in the soil water more diluted. In addition to these advantages, trickle irrigation can improve fertilizer and chemical applications. It is easy to automate and requires less labor.

Disadvantages of trickle irrigation are mainly related to its high initial cost, persistent maintenance requirements, salt accumulation near plants and restricted plant root development. In order to achieve high application efficiency, the uniformity should be high. The uniformity of a trickle irrigation unit is governed by the range and distribution of discharge rates of emitters in the unit. As the range of emitter discharge rates increases, the operation time must be increased to satisfy the crop water requirements at lower discharging emitters. Increasing the operation time causes an increase in energy costs and an excess application at higher discharging emitters. Systems of high uniformities can apply the required amount of water at low variation, therefore their energy and water costs will be less.

Crop Consumptive Use

Crop consumptive use is all the water required for the plant in its plant processes. Plant processes which require water include:

1. Digestion

2. Photosynthesis,

3. Transport of minerals and photosynthesis,

4. Structural support,

5. Growth, and

6. Transpiration.

Water is primarily used for transpiration. More than 99% of water added to the plant is lost through transpiration. Transpiration is the transfer of water from its liquid or solid phase to vapor through the plant leafs.

In addition to the loss of water through plant surfaces, water is lost from soil surfaces through direct evaporation. However, evaporation and transpiration can't be separated easily. Therefore, they are usually combined and called evapotranspiration (ET).

The total amount of water lost through direct evaporation from soil surface and through transpiration from plant surfaces forms more than 99% of the water required by the plant. This makes evapotranspiration the primary use of water by crops. Therefore, crop consumptive use is primarily evapotranspiration. This makes some people refer to crop consumptive use as evapotranspiration.

Factors affecting evapotranspiration:

Evapotranspiration from any crop is affected by the following factors:

1. Climatic factors: Such as temperature, solar radiation, wind speed, humidity, precipitation.

2. Crop type.

3. Crop growth stage,

4. Available water in the soil, if the available water is low then evapotranspiration will be reduced as more energy is required to extract water from the soil.

A General Introduction to Precision Agriculture

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Precision Agriculture (PA) is no longer a new term in global agriculture. Since the first substantial PA workshop was held in Minneapolis in 1992, it has become the subject of numerous conferences worldwide. An Australasian symposium on PA has held annually from 1997. Its acceptance in the United States of America has been formally recognized by the drafting of a bill on PA by the US Congress in 1997. However, where did the term and concept of PA come from?

The impetus for the current concept of Precision Agriculture in cropping systems emerged in the late 1980's with the matching of grid-based sampling of soil chemical properties with newly developed **variable-rate application (VRA)** equipment for fertilizer's. Using a compass and dead-reckoning principles, fertilizers were applied at rates designed to complement changes in soil fertility maps that had created. Crop yield monitoring technologies were still in the research phase at this stage.

Around 1990, the NAVSTAR **Global Positioning System (GPS)** became available in a limited capacity for civilian use and the opportunity for rapid and 'accurate' vehicle location and navigation sparked a flurry of activity. Electronic controllers for VRA were built to handle this new positioning information and crop yield monitors began to hit the commercial market. By 1993, the GPS was operational and a number of crop yield monitoring systems were allowing the fine-scale monitoring and mapping of yield variation within fields. The linking of yield variability data at this scale with maps of soil nutrient changes across a field marked the true beginning of PA in broad acre cropping.

As yield-monitoring systems were improved, it became evident that methods other than grid sampling for collaborative information would need to be developed. In many instances, grid sampling at the intensity required to correctly characterize variability in soil and crop parameters proved cost prohibitive and, by the late 1990's,

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a "zonal" management approach had become a real option for management. This approach subdivides existing fields into zones of similar crop response and helps account for current limitations in data resolution while trying to maximize the benefits of PA for crop management.

New systems for measuring or inferring soil and crop parameters on a more continuous basis continue to be developed using both proximal (i.e. on ground-based platforms) and remote (i.e. aerial and satellite) platforms. Examples of these are soil ECa measuring instruments, crop reflectance imaging and crop quality sensors.

The success and potential for further success, observed in the grains industry prompted other farming industries, particularly viticulturally and horticultural crops, to adopt precision agriculture. Since the late 1990's more and more research has been carried out in non-grain crops. In addition, more emphasis is being placed on the environmental auditing capabilities of PA technology and the potential for product traceability. Advances in **Global Navigation Satellite System (GNSS)** technology since 1999 have also opened the door for machinery guidance, auto-steering and **controlled-traffic farming (CTF)**. CTF has provided sustainability benefits (such as minimization of soil compaction), economic benefits (by minimizing input overlap and improving timeliness of operations) and social benefits (such as reducing driver fatigue). As a result, this form of PA technology has been showing swift adoption rates in the first decade of the 21st century.

What is precision Agriculture?

- Precision Ag is managing each crop production input (fertilizer, limestone, herbicide, seed, insecticide, etc.) on a site-specific basis to reduce waste, increase profit and maintain the quality of the environment.

- Precision Ag is carefully tailoring soil and crop management to fit the different conditions found in each field.

PRECISION FARMING (PF)

Precision farming or precision agriculture is about doing the right thing, in the right place, in the right way, at the right time. Managing crop production inputs such as water, seed, fertilizer etc to increase yield, quality, profit, reduce waste and becomes eco-friendly. The intent of precision farming is to match agricultural inputs and practices as per crop and agro-climatic conditions to improve the accuracy of their applications.

Precision farming (PF) has emerged as a management practice with the potential to increase profits by utilizing more precise information about agricultural resources. In row-crop production, this means the management of input variables, such as application rates, cultivar selections, tillage practices and irrigation scheduling. PF management became feasible from a large-scale perspective through the development of new technologies. The technology has now been developed so that field information (such as yield and application rates) can be controlled and monitored about every 3 feet in the field at a reasonable cost to the farmer. Pesticides can applied in areas of pest infestation, reducing the amount of pesticide applied and reducing the amount of pesticide, which may potentially affect the environment.

Fertilizer and lime can applied only where needed. Plant population can chosen to optimize soil nutrients, and plant variety selection can chosen to take advantage of the field conditions. Crop yield can also be monitored to create maps that show the high and low production areas of a field for improved management decisions.

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Why Precision Farming?

1. To enhance productivity in agriculture with respect to profit.
2. Prevents soil degradation in cultivable land.
3. Reduction of chemical use in crop production
4. Efficient use of water resources
5. Dissemination of modern farm practices to improve quality, quantity & reduced cost of production in agricultural crops

Advantages:

- **Agronomical perspective:** Use agronomical practices by looking at specific requirements of crop.
- **Technical perspective:** allows efficient time management
- **Environmental perspective:** eco-friendly practices in crop
- **Economical perspective**: increases crop yield, quality and reduces cost of production by efficient use of farm inputs, labor, water etc

Precision agriculture calls for a more precise application of inputs based on the localized management of variations in yield in a given area. In contrast, in traditional agriculture, inputs are applied on the basis of average values. The use of precision agriculture technologies can be divided into three stages **(Figure 1)**

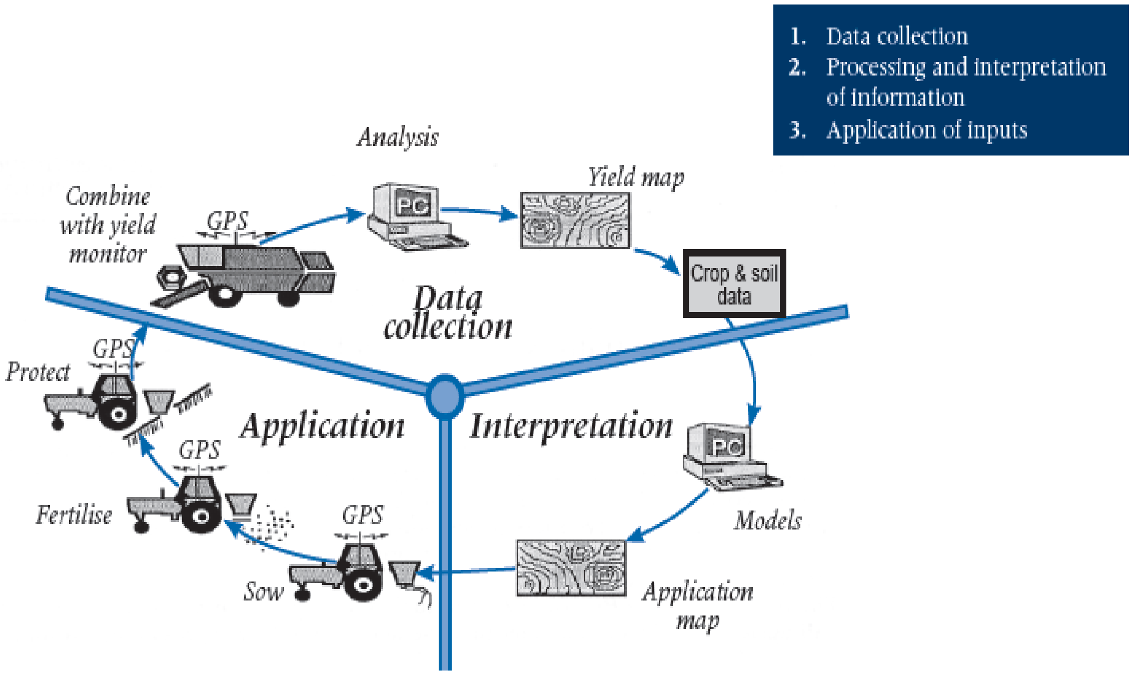

Figure 1. The three stages of precision agriculture

Disadvantageous of Precision Agriculture:

- Too much information
- Generate more questions than answers
- Forcing too many decision on producers
- Still too complicated for most farmers
- Need multidisciplinary cooperation

Precision Farming Technologies

There are five major components of technology used for PF management practices. They are Geographical Information Systems (GIS), Global Positioning Systems (GPS), sensors, variable rate technology (VRT) and yield monitoring (YM). A brief description of the individual technologies is provided in the following paragraphs **figure 2**.

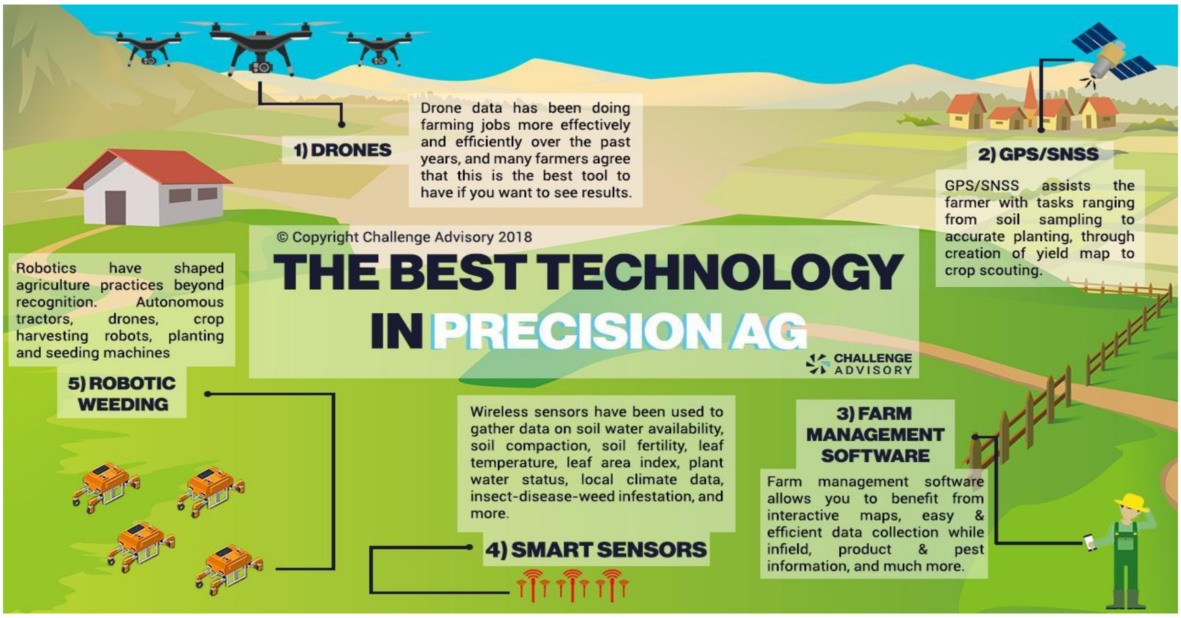

Figure 2. The best quality in precision agriculture

Tools and equipment for precision agriculture

- GPS, GIS
- Yield monitoring and mapping
- Soil testing
- Variable rate fertilizer application
- Crop scouting/ Ground trothing

- Environment sensing

Precision Farming is a combination of application of different technologies. All these combinations are mutually inter related and responsible for developments. The same are discussed below:

1. Global Positioning System (GPS): It is a set of 24 satellites in the Earth orbit. It sends out radio signals that can processed by a ground receiver to determine the geographic position on earth. It has a 95% probability that the given position on the earth will be within 10-15 meters of the actual position. GPS allows precise mapping of the farms and together with appropriate software informs the farmer about the status of his crop and which part of the farm requires what input such as water or fertilizer and/or pesticides etc.

Global Positioning System satellites broadcast signals that allow GPS receivers to calculate their position. This information is provided in real time, meaning that continuous position information is provided while in motion. Having precise location information at any time allows soil and crop measurements to be mapped. GPS receivers, either carried to the field or mounted on implements allow users to return to specific locations to sample or treat those areas **figure 3**.

Uncorrected GPS signals have an accuracy of about 300 feet. To be useful in agriculture, the uncorrected GPS signals must compared to a land- based or satellite-based signal that provides a position correction called a differential correction. The corrected position accuracy is typically ±3-10 feet. In Missouri, the Coast Guard provides differential correction beacons that are available most areas free of charge. When purchasing a GPS receiver, the type of differential correction and its coverage relative to use area should considered.

Figure 3. Global positioning system (GPS) and working

Global positioning system is used to determine position. It is operated and maintained by Department of Defense (DOD). It was announced fully operational capability on April 27, 1995.

Type of GPS:

- Land based
- Satellite based (GLONASS, GPS, Galileo, GNSS (Global Navigation Satellite system)

GPS has three segments:

- Space segment
- Control segment
- User segment

Space Segment

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There are 24 active NAVSTAR (NAVigation by Satelite Timing And Ranging) satellites, 8 spare satellites (Space vehicles). They orbit at 20200 km above ground on 6 orbital paths with 4 satellites in each path and 1 revolution per 12 hours. It is guaranteed that at least 4 Space vehicles (SVs) to be viewed by GPS receiver anytime and anywhere. The NAVSTAR satellites broadcast radio signals at 1200-1500 MHz and is equipped with atomic clocks **figure 4**.

Control segment

The control segment receives and transmits information to SV. There are 5 monitoring station around the world. The control segment task is to ensure accuracy of SV positions and clocks and also to compute exact orbits of SV and update their navigation signals.

User segment

This includes the GPS receivers. They track SV and use SV signals to calculate positioning, velocity and time. For a GPS to track a location in 2-D space there need to be 3 reference points. For 3-D position determination, there should be 4 reference points.

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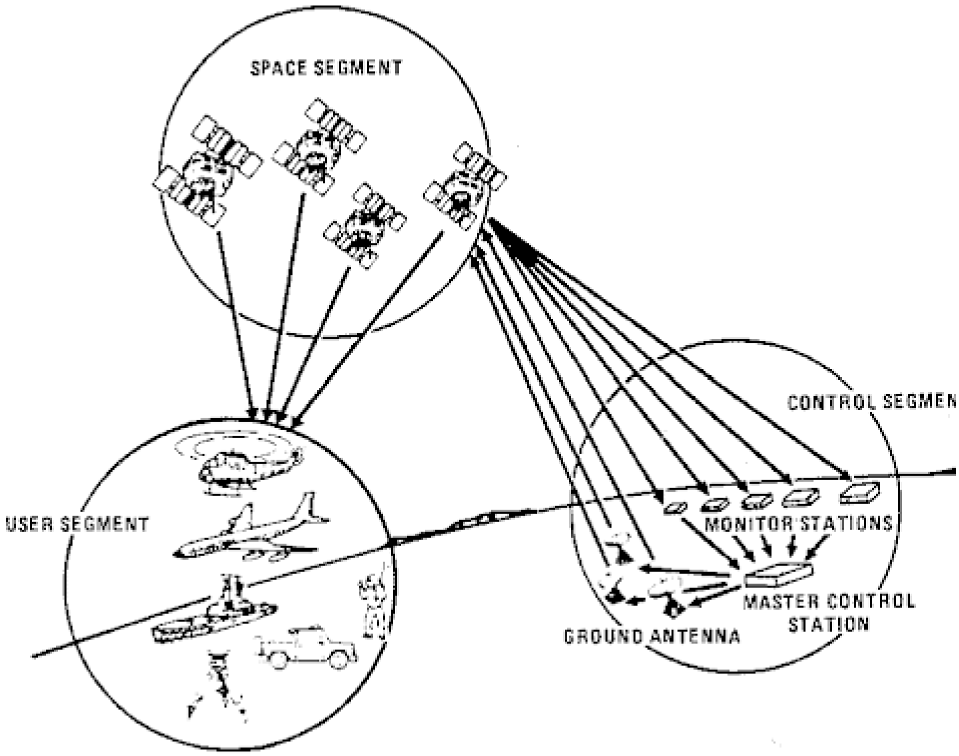

Figure 4. All about GPS: the three segments of GPS systems

Smart Irrigation in Agriculture

Wise use of irrigation water is a top priority for California growers, and many different practices and technologies can help improve on-farm water-use efficiency. Efficient irrigation systems, such as drip and micro-sprinklers, are one component. However, even these technologies do not ensure increased water-use efficiency—watering too often or for too long can lead to unproductive water use (water lost to evaporation, runoff, deep percolation, or weed growth). On the other hand, irrigating too little can cause water stress and reduce yields or crop quality. Irrigation needs vary based on a complex set of variables such as crop type, plant age, micro-climate, stored water, and soil type. Irrigation scheduling—deciding how often and for how long to irrigate—is a critical component of how efficiently water is used. Therefore, increasing the amount and quality of information available to growers is an essential first step in efficient irrigation.

Smart irrigation scheduling refers to technologies that help growers determine more precisely when crops need to be watered and how much water they require. With smart irrigation scheduling, growers are able to use their water more efficiently, either by reducing or by keeping constant the amount of applied water, while maintaining or improving yields. Having more precise knowledge of soil moisture levels also has a number of peripheral benefits, such as pest control.

The benefits of a smart irrigation system

The advantages of smart irrigation are far-reaching. By monitoring soil moisture levels, a smart water irrigation system allows farmers to automate their irrigation processes and reduce water use. In addition to more efficient consumption of resources, other benefits include:

- Cost savings due to minimized water waste
- Reduced human efforts
- A unified view of soil characteristics, including moisture and nutrient contents
- Smart notifications in case of abnormalities
- Better long-term landscape health
- IoT ecosystem for smart irrigation

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To achieve these advantages, smart water irrigation systems make extensive use of IoT sensors. These sensors, placed in the field, send real-time data to a central gateway that then automatically switches on a water pump whenever moisture or temperature values are outside the predetermined range.Wireless low-power networks like LoRa are used to empower IoT sensors and make it possible for information to flow in real time to and from the central gateway. The entire smart irrigation system can be managed by an end user through a custom cloud-based platform or mobile application.

Types of IoT sensors for smart irrigation of farmlands

Depending on the type of data to be captured, soil, weather, and plant IoT sensors can be used in a smart irrigation solution.

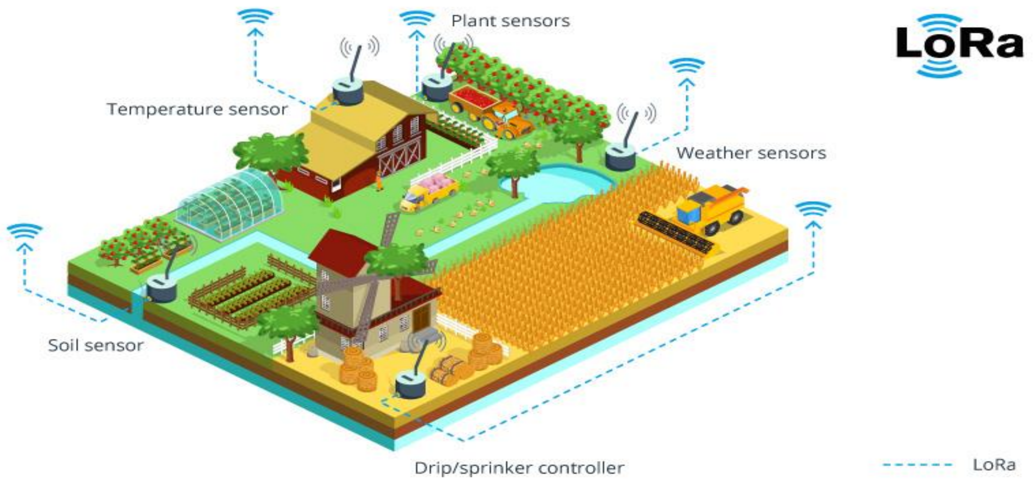

Figure 5. Smart irrigation solution

Soil moisture and temperature sensors

Soil-based sensors gather relevant data about volumetric water content, salinity, electrical conductivity, and other crucial parameters. Located at key points across the field, these sensors send data to a smart water irrigation system to help farmers gain quick insights into the soil's state and predict irrigation needs

Soil Moisture Sensor

Soil moisture sensor is one kind of sensor used to detect the soil moisture content. This sensor has two outputs like the analog output as well as the digital output. The digital o/p is permanent and the analog o/p threshold can be changed. The working principle of soil moisture sensor is open & short circuit concept. Here the LED gives an indication when the output is high or low.

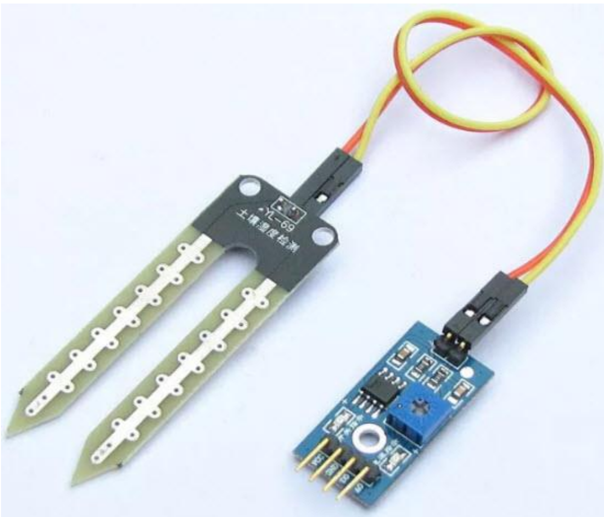

Figure 6. Soil moisture sensor

When the condition of the soil is dried up, the flow of current will not flow through it. So it works like an open circuit. Therefore the o/p will be maximized. When the soil condition is soaked, the flow of current pass from one terminal to the other. So it works like a closed circuit. Therefore the o/p will be zero.

Temperature sensors

Figure 7. Temperature sensor

Weather sensors

Also called evapotranspiration (ET) sensors, weather sensors measure ultra-local environmental conditions like water evaporation from the soil surface and plant transpiration. Combined with data provided by a GIS-based solution, these sensors can help generate more accurate water predictions.

Weather monitoring

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One way to do that is to incorporate satellite data and weather reports from weather stations to better schedule your irrigation activities. Knowing that rain is forecasted, the system can wait and automatically recalculate the amount of required water based on actual precipitation received.

How technology reinforces each type of irrigation system

Based on how water is distributed throughout the field, you can choose from different types of irrigation systems that can be enhanced with smart irrigation software. The most common are flood, sprinkler, center pivot, drip, and micro-irrigation systems. Let’s see how technological solutions for smart irrigation can improve the efficiency of each type.

Sprinkler irrigation

In a sprinkler irrigation system, water is pumped through pipes and then distributed via high-pressure overhead sprinklers. These sprinklers can be set in a central location in the field or can be located on a moving platform.

Role of software: Thermal and acoustic rain sensors recognize rainfall and measure its intensity to schedule the next irrigation after rain stops. A smart irrigation system analyzes data and calculates the water budget for the next month. Sprinklers get automated notifications to prevent extensive water use and overwatering due to rain.

Center pivot irrigation

This is the most popular form of sprinkler irrigation and is also known as water-wheel and circle irrigation. A typical center pivot system consists of a long irrigating pipeline attached to a central tower and moves slowly over the field in a circular pattern, irrigating plants with sprayers.

Role of software: The system that controls circle irrigation sprinklers obtains data insights from in-field sensors to adjust the water stream or angle of flow. This helps to reach plants that are far from the water source and save those nearest from overwatering. By analyzing weather data and soil moisture, the system plans irrigation and calculates potential yield and harvest times.

Drip irrigation

In this type of irrigation, water is distributed directly to the roots of plants through pipes with small openings called drippers. This allows farmers to significantly reduce evaporation and runoff.

Role of software: For this type of irrigation, the main challenge is the visibility of the watering process. The system notifies the user through an app about starting and finishing irrigation. It also measures soil parameters before and after irrigation.

Micro-irrigation

Micro-irrigation is a low-pressure, low-volume system that offers precise control over watering. The system applies water directly to the plant's roots, improving irrigation efficiency and ensuring uniform distribution.

Role of software: The system can plan the exact dosage for each plant as the amount of water is precisely controlled. AI algorithms can be applied to recognize plants and adjust watering appropriately.

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In-field Monitoring and Irrigation Scheduling Systems

Increasingly, growers are using in-field monitoring systems to inform their irrigation decisions. These systems typically combine in-field measuring devices, including soil probes, plant moisture sensors, and weather stations, paired with software that allows the grower to easily access and interpret the measurements collected. Many provide near real-time data, which can be accessed from anywhere with an internet connection, and may have additional features such as email or cell phone alerts and remote control or automation of the irrigation system.

These types of systems greatly increase the amount and precision of information available to growers on key parameters such as soil moisture. For example, many systems allow the grower to monitor soil moisture at various depths, and in various field locations.

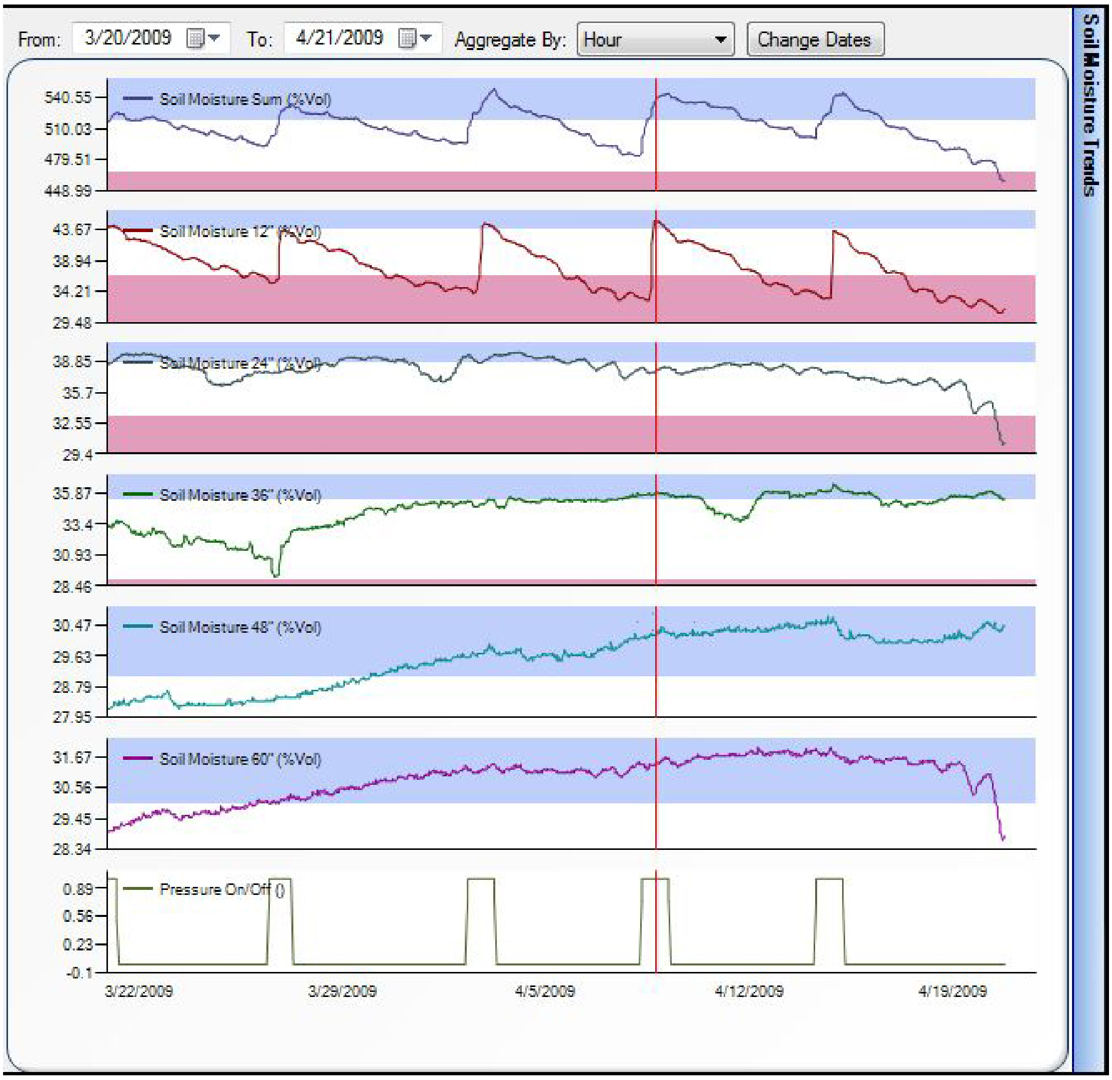

Figure 8. Graph created by PureSense software showing soil moisture over time by depth

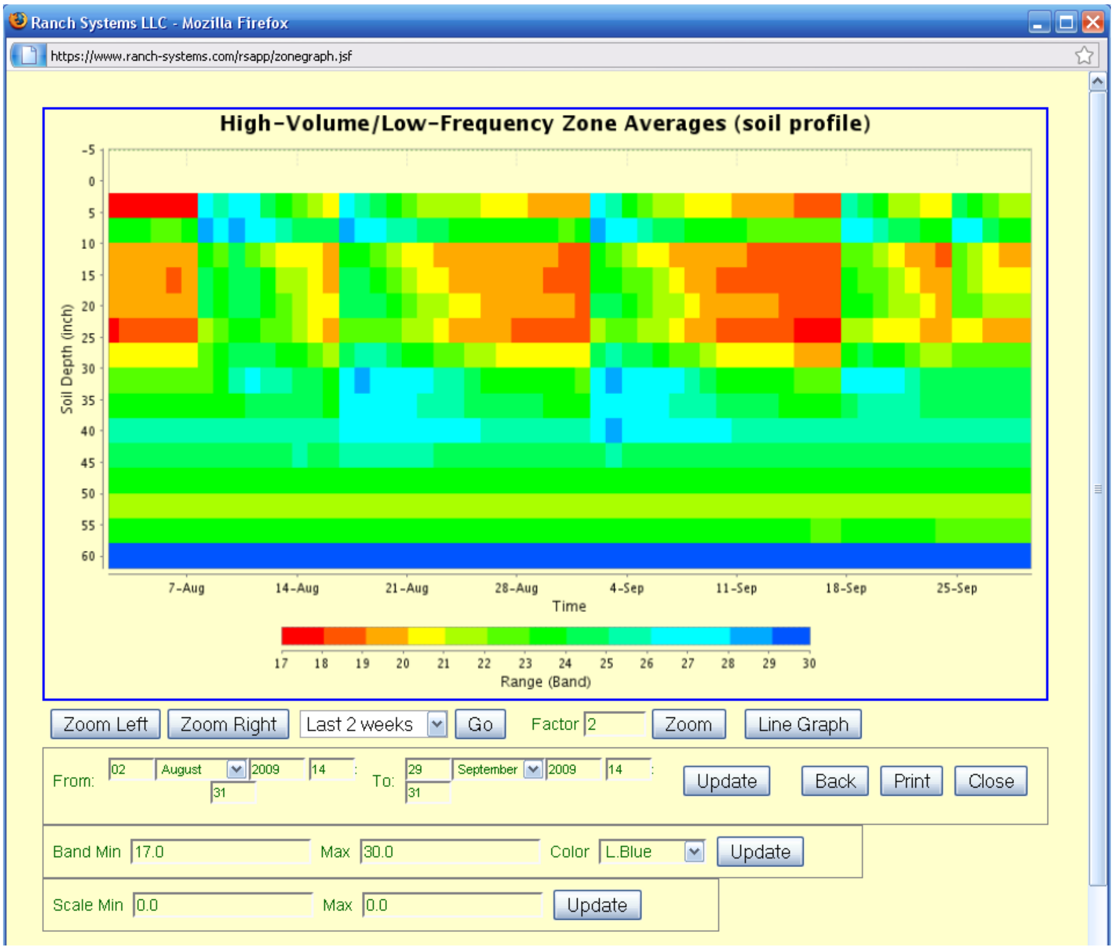

Figure 9. Graph created by Ranch Systems LLC software showing soil moisture by depth, over time

Note: Different colors indicate different soil moisture levels; thresholds for different colors can be set by the user

Some of these systems create an irrigation schedule for the grower, taking into account the specifics of the irrigation system, soil moisture and other measurements, and pre-determined plant water needs (see screenshot of PureSense irrigation scheduler, Figure 5 below). These programs can help the grower to plan for water needs throughout various growth stages. By combining the schedule provided by the

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software, graphs of their actual soil moisture at various depths, and knowledge of plant water requirements, growers can irrigate to match crop water needs.

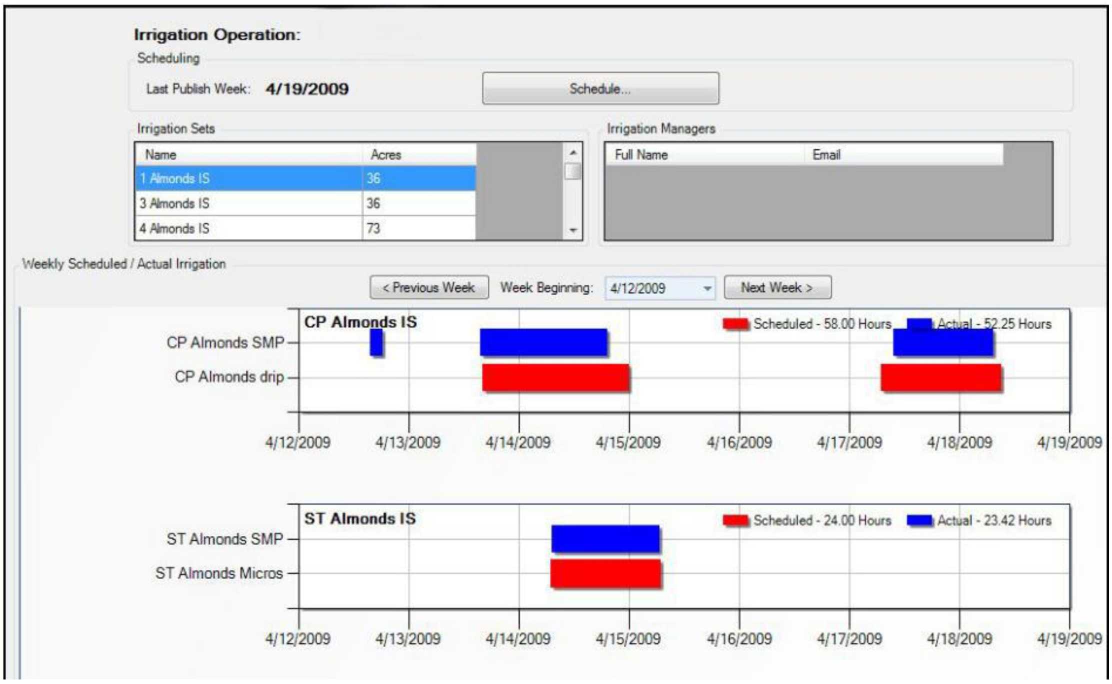

Figure 10. Screenshot of PureSense irrigation scheduling software

IoT-Enabled Sensors for Moisture Determination

In order to acquire more precision in water utilization (IoT) solution, involves special ground-based sensors for data recording and processing, are narrowing the gaps between the computer application and applied science. IoT based smart irrigation system helpful to simulate the irrigation needs of the crop and field with sensing of edaphic factors like soil temperature, moisture and evaporation rate, and temperature air humidity and can predict future water requirement of the crop linking with the weather forecast from the Internet in specific a region. The structure of this system relies on an algorithm, which detects sensors data and integrating with weather elements e.g. rainfall, humidity, temperature, and UV for future prediction. This improved technology has the potential to increase judicious water application and use according to crop stage and requirement **Figure 11**.

Additionally, SDI can be linked with fertigation (irrigation water plus fertilizer), that not only increase irrigation efficiency (20–305) but also decrease fertilizer especially nitrogen losses (20–40%) as well as increase crop yield (10–20%) depending upon soil, crop and environmental conditions.

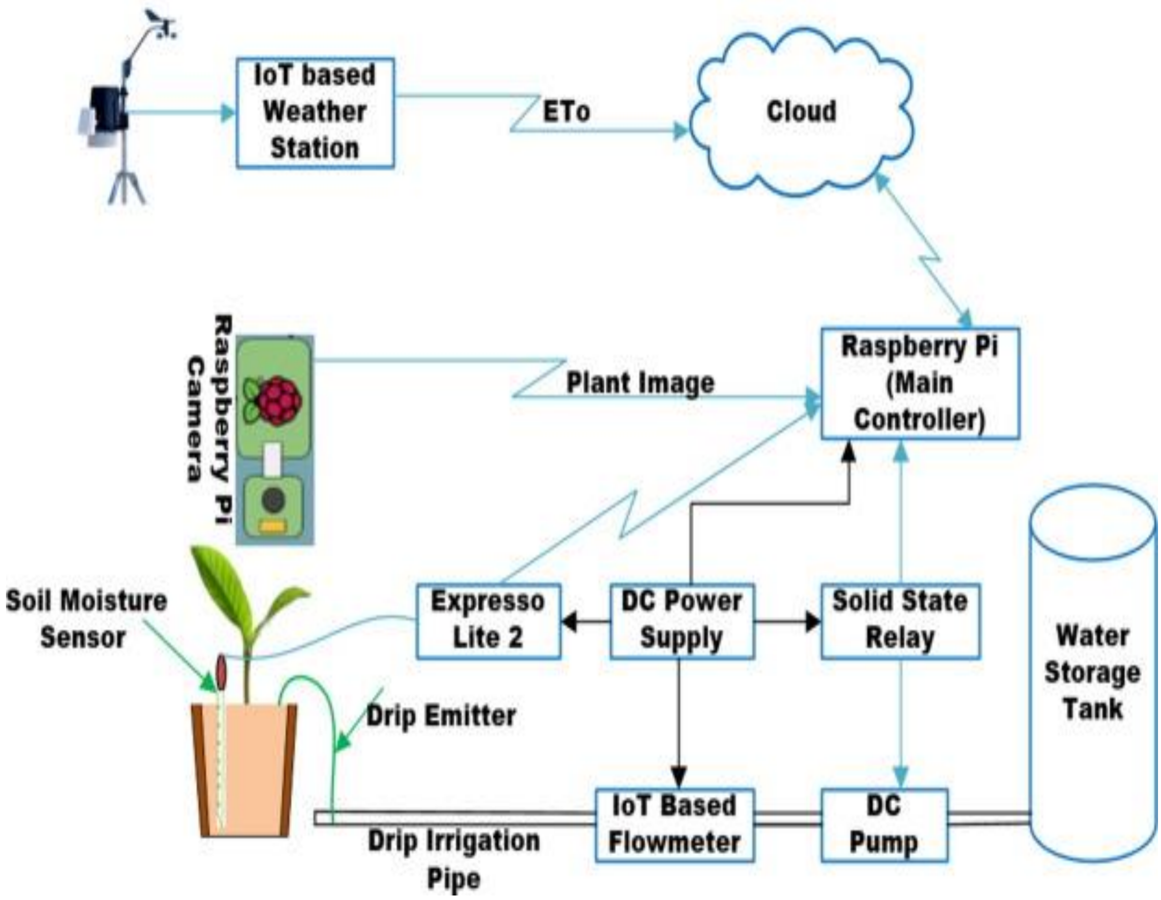

Figure 11. IOT- based monitoring and data driven modelling of drip irrigation system

Benefits of Smart Irrigation Scheduling

Smart irrigation scheduling has a number of benefits to the grower derived from the ability to closely monitor stress to plants, including deficit irrigation, which itself has a number of benefits including increased quality in some crops and disease and pest management, as well as a number of peripheral benefits

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Increased water-use efficiency

Increasing water-use efficiency benefits growers by increasing yields and/or decreasing the costs associated with irrigation, including the cost of water and energy needed to pump water. Smart irrigation scheduling may result in a decrease or an increase in water applied, but has been shown to consistently increase water-use efficiency. Here, we define water use efficiency to mean the ratio of outputs to inputs, where outputs are yield and crop value, and inputs are irrigation water.

Crop quality

Irrigation scheduling can also be an important tool in improving crop quality. For example, studies suggest that regulated deficit irrigation, or intentionally imposing water stress during drought-tolerant growth stages, can improve crop quality Irrigation scheduling can help growers safely implement regulated deficit irrigation, avoiding long-term damage to the plants.

Pest and disease management

Too much or too little water can cause plant stress, which can lead to disease and vulnerability to pests.

Frost protection

Frost protection is another benefit of many in-field monitoring and irrigation scheduling systems. Some systems can be programmed to alert the grower, through email or cell phone, to conditions which may cause frost damage; other systems can automatically turn on fans or sprinklers when frost damage may occur.

Environmental benefits

Reducing the amount of applied water, and therefore runoff and deep percolation, can have environmental benefits by decreasing the amount of pesticides and fertilizers

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entering waterways and groundwater. In parts of California where the soil contains high levels of selenium, which can be toxic to wildlife, irrigation scheduling can help to reduce drainage and therefore decrease inputs of selenium to local waterways.

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Annex 1

Quiz

Question 1: Select the correct answer and fill it in the table below:

1) The selection of irrigation system depends on the following:

a) Water sources and value of water

b) Crop type

c) Area of the land

d) a and b

2) IoT sensors for smart irrigation of farmlands include one of the following

a) Soil moisture sensor

b) Soil texture sensors

c) Soil porosity sensors

d) All the above mentioned are true

3) Medium pressure systems in sprinkle irrigation has a pressure heads ranges from

a) Pressure heads from 20 to 40 m

b) Pressure heads from 40 to 70 m

c) Pressure heads from 3.5 to 10 m

d) Pressure heads from 80 to 90 m

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4) Uses of sprinkler irrigation other than supplying irrigation water are

a) Frost protection

b) Application of fertilizers and pesticides

c) Crop cooling

d) All the above mentioned are true

NO	1	6	8	11
Answer	d	a	a	d

Question 2: Choose True or False and fill it in the table below:

1) Center pivot system is the most commonly sprinkler method used around the West Bank and Gaza ( ).

2) Global Positioning System (GPS) is a set of 24 satellites in the Earth orbit used to determine the geographic position on earth ( )

3) Soil moisture sensor has two outputs like the analog output as well as the digital output ( )

4) Irrigation scheduling can be an important tool in improving crop quality ( )

5) In gravitational irrigation methods, water is distributed using pipes under pressure as in sprinkler and trickle irrigation systems ( )

NO	1	2	3	4	5
Answer	F	T	T	T	F

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Annex 2

Exam

Question 1: Select the correct answer and fill it in the table below:

1) One of the following conditions is suitable for selecting the sprinkler irrigation system

a) Spacing between crops is too small

b) Soil permeability is very low

c) Spacing between crops is too large

d) All the above mentioned are true

2) Evapotranspiration from a given crop is affected by:

a) Climatic factors

b) Crop type

c) Crop growth stage

d) All the above mentioned are true

3) One of the following considered a disadvantageous of precision agriculture

a) Decreases crop yield and quality

b) Generate more questions than answers

c) Allows efficient time management

d) Eco-friendly practices in crop

4) Tools and equipment for precision agriculture

a) GPS and GIS

b) Yield monitoring and mapping

c) Soil testing

d) All the above mentioned are true

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5) Low pressure systems in sprinkle irrigation has a pressure heads ranges from

a) Pressure heads from 20 to 40 m

b) Pressure heads from 40 to 70 m

c) Pressure heads from 3.5 to 10 m

d) Pressure heads from 80 to 90 m

6) High pressure systems in sprinkle irrigation has a pressure heads ranges from

a) Pressure heads from 20 to 40 m

b) Pressure heads from 40 to 70 m

c) Pressure heads from 3.5 to 10 m

d) Pressure heads from 80 to 90 m

7) One of the following considered an advantageous of precision agriculture

a) Increases crop yield and quality

b) Too much information

c) Forcing too many decision on producers

d) Need multidisciplinary cooperation

8) One of the followings sprinkler irrigation considered a continuous move system

a) Solid set systems

b) Center pivot systems

c) Big gun systems

d) b and c

9) Plant processes which require water include:

a) Photosynthesis

b) Transport of minerals

c) Transpiration

d) All the above mentioned are true

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10) Why precision farming is applied worldwide:

a) To enhance crop productivity

b) Prevents soil degradation

c) Efficient use of water resources

d) All the above mentioned are true

11) The segment that calculate positioning, velocity and time in Global positioning system (GPS) is

a) Space Segment

b) Control segment

c) User segment

d) All the above mentioned are true

NO	1	2	3	4	5	6	7	8	9	10	11
Answer	a	d	b	d	c	b	a	d	d	d	c

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Question 2: Choose True or False and fill it in the table below:

1) Big gun systems are big sprinklers which irrigate large areas and moved by tractors along the field ( ).

2) High pressure sprinkler irrigation systems have a pressure heads from 10 to 20 m ( ).

3) Precision agriculture is carefully tailoring soil and crop management to fit the different conditions found in each field ( ).

4) Space Segment in GPS used to receive and transmits information to space vehicles ( )

5) User segment in GPS used to calculate positioning, velocity and time ( )

6) Micro-irrigation system is a low-pressure, low-volume system that cannot offers precise control over irrigation ( ).

7) Smart irrigation scheduling has a number of benefits to the grower derived from the ability to closely monitor stress to plants ( )

8) In solid set sprinkler systems the sprinklers are moved from a location to another in the farm ( )

9) the main disadvantages of trickle irrigation are mainly related to its high initial cost, persistent maintenance requirements ( )

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10) Precision farming or precision agriculture means doing the right thing, in the right place, in the right way at the right time ( )

NO	1	2	3	4	5	6	7	8	9	10
Answer	T	F	T	F	T	F	T	F	T	T

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Boosting Innovation in Education and Research of Precision Agriculture in Palestine

Course Name: Fertilizers and soil fertility

Module 2: Precision Technology in Fertilizers Management

Disclaimer

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General definitions

Soil fertility: the status of a soil in respect to its ability to supply the nutrients essential to plant growth.

Soil productivity: the capacity of a soil in its normal environment, fort producing a specified plant or sequence of plant under a specified system of management.

The following factors may limit the productivity of a fertile soil:

1- Poor drainage, compaction, poor aeration.

2- Salinity problem

3- Sodicity problem

4- Drought

5- Soil acidity or alaklinity

Thus, we must study fertility and factors which limit or support productivity. Maintaining and improving soil fertility is very important and crucial to improve productivity of soil and consequently increase food production. Intensification of agriculture production can be achieved by:

1. Adopting new varieties.
2. Irrigation of dry lands
3. Weed control
4. Use of fertilizers

Among these means, fertilizer use will play a vital role because of the following factors:

1. Uses of highly productive cultivars which require more nutrients.
2. Planting more than one crop/season intensification.
3. Adapting new technology in irrigation.
4. Cultivation of fertile soils.

However, intensification of farming unfortunately resulted in

1. Declining soil productivity (low organic matter, erosion, salinity)
2. Deteriorating environmental quality
3. Reduces profitability and threats to human health.

Plant nutrients

There are 16-20 elements up to this date found to be essential to the growth of plants.

C,H,O, N, P, K, Ca, Mg, S, B, Fe, Mn, Cu, Zn, Mo, Cl, Co, V, Na, Si

- CHO = from air + water (mainly), all other from soil (mineral elements).
- N P K = major elements
- S Ca Mg = secondary elements
- B Fe Mn Cu Zn Mo Cl and Co V Na Si = micronutrients.

All macro and micro are essential to plant growth regardless of the amount of each need to plant.

All 16-20 elements are essential to plant growth. Not all are required by all plants but all are necessary to some.

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Classification of nutrients

A. Plant nutrients can be divided into two main groups:

1- Non-mineral nutrients:

* Carbon, Oxygen, and Hydrogen (C H O):

* Found in the atmosphere and water and used in photosynthesis in this manner.

$$6CO_2 + 12H_2O = 6CH_2O + 6H_2O + 6O_2$$

Product of photosynthesis (carbohydrates) used for plant growth and development.

2- Mineral nutrients:

Coming from the soil (all others).

B. Plant nutrients can also be divided into:

1- Macronutrients: essential nutrients needed in relatively higher amounts.

2. Micronutrients: essential nutrients needed in small amounts.

Macro: 0.2-5% on dry matter basis (C N H O S Mg Ca P K).

Micro: exist at low concentrations: essential nutrients needed in smaller amount.

ppm = mg nutrients / kg dry matter wt. (1% = 10000 ppm).

These two classifications:

1. Not informative

2. Give little information on how important a nutrient is.

- Therefore, classification according to the biochemical and physiological function is more appropriate.

Effect of nutrient on crop growth and development:

Nitrogen- for building plant tissue, growth of sprouts, leaves, branches and stem.

Phosphorous- necessary for conveying energy used in building plants products in photosynthesis and respiration.

Potassium- helps in increase the resistance against diseases and in making plants yield quality products, improves taste of fruit.

Boron- helps in the transfer of organic substances and plays a role of synthesis of proteins, helps the flow of sugars into the fruits.

Cobalt- plays a vital role in the nitrogen fixation processes of the rhizobium present in the nodules of the roots of leguminous plants such as beans .

Copper- a vital substance for the photosynthesis of plants, stimulates some types of enzymes.

Iron- a vital substance for the photosynthesis of plants, synthesis of chlorophyll.

Manganese- plays an auxiliary role in photosynthesis and an indispensable part of the enzyme system.

Molybdenum- helps plants utilize the absorbed nitrogen in building amino acids and protein.

Sulfur- necessary for the synthesis of protein and enzymes.

Zinc- plays a role in building hormones and enzymes for the plants, chlorophyll and starch formation.

Movement of nutrients from soil to roots

1-root interception and contact exchange

- As roots grow they push through soil and intercept and come in contact with nutrients retained at soil surfaces. As a result a contact exchange is a accomplished and nutrients are absorbed by roots.
- Absorption of nutrients by this mechanism is enhanced by enhancing root growth and by mychorrhizal infection which result in exploring soil volume.

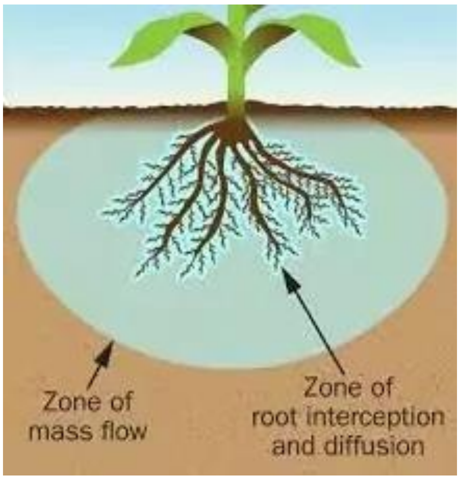

Figure1: Zone of mass flow

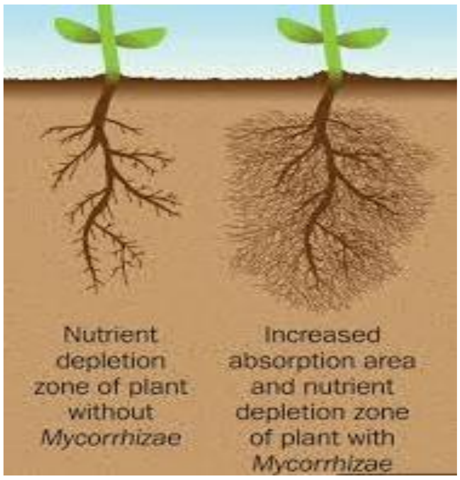

Figure 2: Mycorrhiza infiction

2- Mass flow:

- Movement of nutrients dissolved in the soil solution with water as it moves to the plant root. It is a convective process, occurs when solutes (nutrients and other dissolved substances) are transported with the flow water from the soil to plant roots that result from transpirational water uptake by the plant.

3- Diffusion:

- Movement of nutrients through the soil solution in response to a concentration gradient.
- Diffusion occurs when ion moves from a higher to a lower concentration by random thermal motion.
- As root absorb nutrient from the surrounding soil solution they create a depletion zone and a diffusion gradient is set up. The roots thus create sink to which nutrient diffuse.
- Nutrients will diffuse from higher to lower concentration.

Notes: Diffusion is important mainly for immobile nutrients like P and K.

Mass flow is the major means of supplying mobile nutrients to roots.

Soil and fertilizer nitrogen

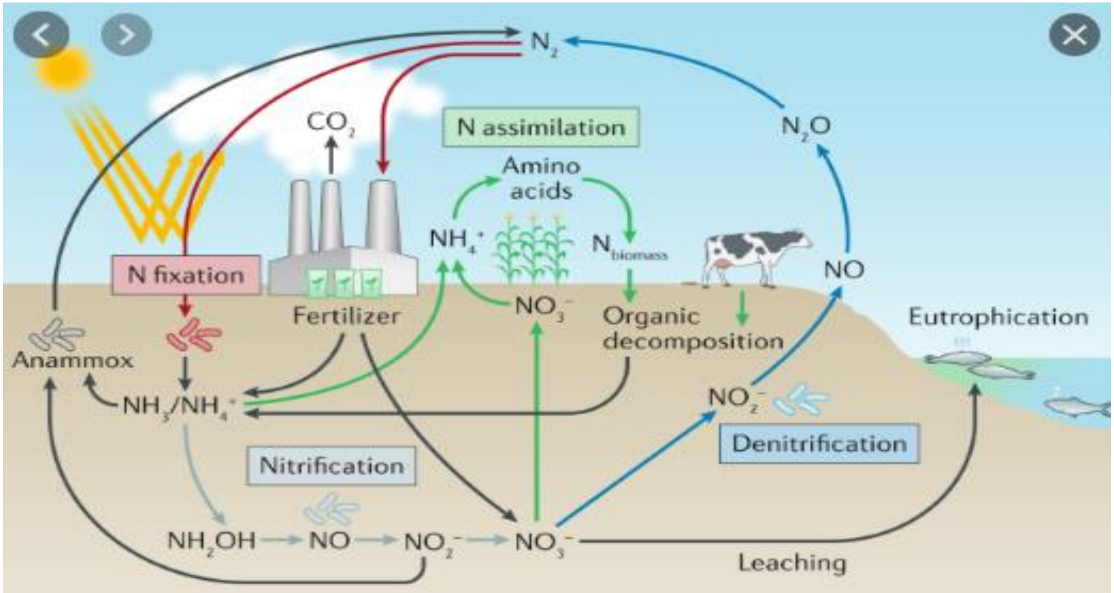

Figure 3: Nitrogen cycle

Impact of N on plant growth

Nitrogen stimulate vegetative growth, however, excess nitrogen can:

1) Prolong the growing period and delay crop maturity.
2) Stimulate vegetative growth and cause logging of the grain crops
3) Stimulate vegetative growth early and deplete soil moisture
4) Cause excessive succulence thus enhances lodging and fungal diseases.
5) Reduce sugar in sugar beets.

Inadequate nitrogen supply will cause:

1) Carbohydrate will be deposited in vegetative cells (less protein is formed from the carbohydrates) which will cause them to thicken.
2) Stunted and yellow.

3) Yellowing (chlorosis) appears first on lower leaves
4) The upper leaves remain green. This evidence of the mobility of N in the plant. Nitrogen compound in the older leaves will under go lyses. The protein N thus is converted to a soluble from translocated to the active meristimatic regions and reused in the synthesis of new protoplasm.
5) Severe N shortage cause the leaves to turn brown and die.

Nitrogen transformation

Fixation: Conversion of atmospheric N into available form.

Mineralization: Conversion of organic N into inorganic N.

Immobolization: Conversion of inorganic N into organic N.

Volatilization: Conversion of NH4 into NH3 gas lost to atmosphere.

Nitrification: Biological oxidation of NH4 to NO3.

Denitrification: conversion of NO3 into N gases of N2 and N2O.

Leaching: Down movement of NO3 toward the ground water.

Nitrogen fixation

Nitrogen can be converted to available nitrogen

- ❖ Chemical fixation: - fertilizer manufacture
- ▪ Industrial N fixation: Haber-Bosch process.
- ❖ Chemical fixation: Lightning
- ▪ Atmospheric electrical discharge from N oxide

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❖ Biological fixation: - legumes

- Rhizobia – N fixing bacteria
- Symbiotic relationship between legume plant and rhizobia
- Used by the legume plus significant amount left in soil.

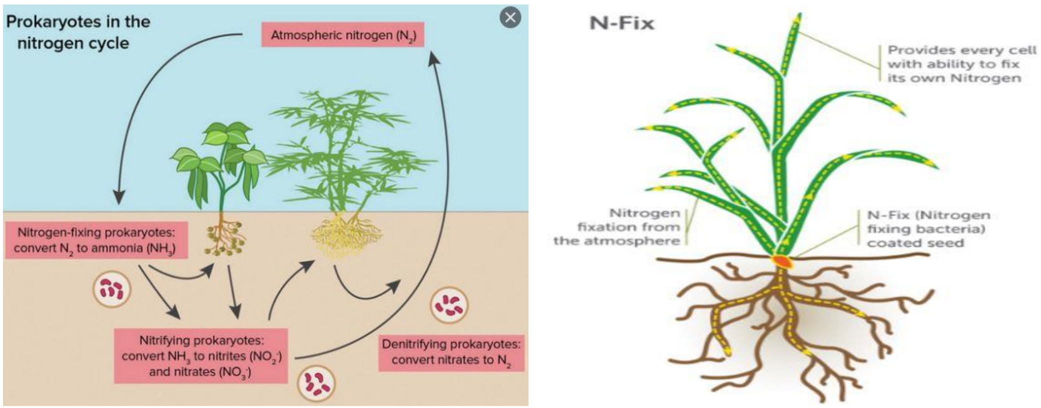


Figure 4: N-Fixation

Mineralization

Mineralization: decomposition of soil organic matter by soil microbes releasing mineral nitrogen in the process.

Mineralization of soil N depends on many factors but mainly on:

1) C:N ratio of the organic material added to the soil

- Net immobilization @ C:N of >30
- Net mineralization @ C:N of >20
- No net effect @ C:N between 20-30

2) Soil moisture

Optimum @ field capacity

3) Temperature: Max. 40-50 C

Min. 5-10 C

4) Aeration: most mineralizing bacteria are aerobic

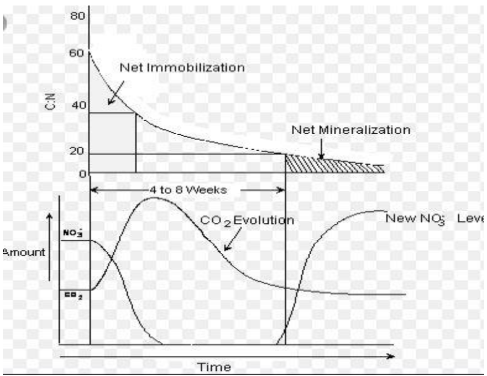
5) pH: microbes can be sensitive to pH.

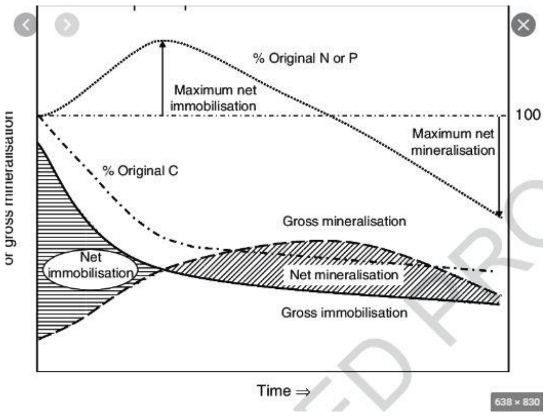
Reaction of ammonium into the soil

1. Rapidly converted into nitrate
2. Can be absorbed by plant directly
3. Can be utilized by microorganisms
4. Can be fixed by clay minerals in a form nonexchangeable
5. Can be volatilized as ammonia in high pH
6. Exchangeable at colloidal particles

Immobilization

- ☐ Immobilization: conversion of mineral N to organic N by microbes
- ☐ Organisms that decompose organic matter as source of energy require nitrogen.
- ☐ Organic material with a low N content can not supply the needs of these organisms thus thy use soil N. Therefore, they compete with the crop.
- ☐ Freshly immobilized N = 5-15% of soil N
- ☐ Immobilization can result in N deficient crops
- ☐ Immobilization can tie up excess N reducing losses
- ☐ Immobilization is temporary.





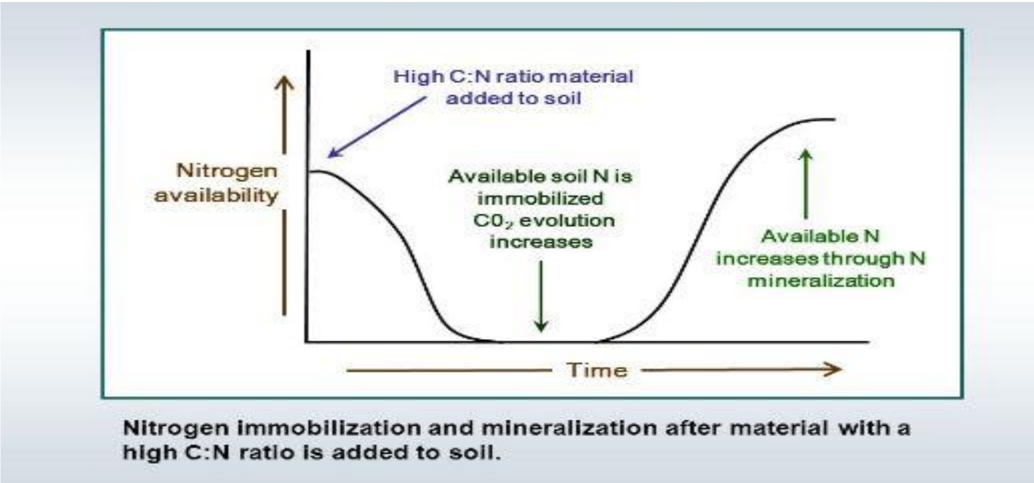


Figure 5: relation between mineralization and immobilization

Nitrification

- ☐ **Nitrification: biological oxidation of ammonia to nitrate**
- ☐ It is a two step process by autotrophic bacteria

- ➢ Nitrification of ammonium nitrogen

$2NH_4 + 4O_2 = 2NO_3 + 4H + 2H_2O$

- ➢ Nitrification carried out by obligate autotrophs
- ➢ Nitrification is fairly rapid under favorable conditions

- ☐ Nitrification is a two step process:

$2NH_4 + 3O_2 = 2NO_2 + 4H + 2H_2O$ (nitrosomonas)

$2NO_2 + O_2 = 2NO_3$ (Nitrobactor)

Factors affecting nitrification

1. Moisture level: optimum at field capacity

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2. Temperature: optimum : 25-35 C (75-95 F)
3. Aeration: O2 necessary for nitrification
4. pH

- Nitrification bacteria sensitive to soil pH
- Nitrification will be slower at low pH
- At high pH free NH_3 is toxic to nitrobacter which may result in buildup of toxic levels of NO_2

Volatilization

- Reaction of NH_4 with OH in the soil

$NH_4 + OH = NH_3 + H_2O$

High pH gas

- Require very high pH (at pH 7, 50% N as NH_3, while at 8 and 9 are 5 and 35%, respectively).
- Reaction of Urea in the soil

$CO(NH_2)_2 + 2H_2O = 2NH_4 + CO_3^{-2}$

$CO_3 + H_2O = HCO_3 + OH$

$NH_4 + OH = NH_3 + H_2O$

Denitrification

- Denitrification is the process of conversion of NO_3 into N gases of N_2 and N_2O.
- Factors affecting denitrification:

- Population of denitrifying bacteria
- Level of nitrate nitrogen
- No oxygen- wet soil
- Energy source for bacteria-organic matter
- Temperature:

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* rate of denitrification increase with the increase from 2 to 25 C

- Favored by higher pH

* Max. at pH 8-8.6. denitrifies are snensitive to low pH

Note to be consider

- Dnitrification losses can be very high
- Denitrification occurs very rapidly once soil is saturated with water
- Very little denitrification once nitrate is in the groundwater because no energy source for microbes.
- Growing plant can increase denitrification when organic materials such as manure are applied.
- Increase potential for denitrification in conservation tillage systems.
- Avoid denitrification losses by not applying N prior to the wet period of the year.
- Denitrification used in wetlands to remove NO3 from water.

Soil conditions that reduce availability of N

1. Excess irrigation causes leaching
2. Bad drainage causes denitrification
3. High soil pH causes volitalization
4. Addition of organic matter high in C:N ratio causes immobilization
5. Soil compaction causes denitrification
6. Frequent summer following causes denitrification

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Phosphorous in soil

- ☐ Total soil P = 0.04% = 2000 kg P2O5/ha
- ☐ Mineral P = 50%
- ☐ Organic P = 50% (15-80%)
- ☐ Soluble soil P = 0.03 ppm = 15 kg P2O5/ha
- ☐ Organic soil P:
- ☐ Insoluble phosphates 10-50%
- ☐ Phospholipids 1-15%
- ☐ Nucleic acid 0.2 -2.5%
- ☐ Balance by unknown forms
- ☐ Organic matter must be mineralized to release P into available forms

Soil P summary

- ☐ Availabe forms are ortho phosphate (HPO4 and H2PO4)
- ☐ Most of the P is in unavailable forms
- ☐ Insoluble mineral (Ca and Mg phosphate)
- ☐ Adsorbed on oxides
- ☐ Stable organic matter
- ☐ Sensitive to soil pH
- ☐ Organic P release by mineralization
- ☐ Little leaching no volatile form
- ☐ Mainly lost by erosion of soil containing P
- ☐ Some soluble loss in runoff from high P soil.

Factors affecting P retention in the soil

- ☐ Al and Fe oxides: as AL and Fe oxides increase retention increase
- ☐ Soil pH: maximum availability at neutral pH

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- ☐ Clay content: as clay increase retention increase
- ☐ Organic matter: as organic matter increase retention decrease

Phosphorous in the environment

1. P is an essential element for plant and animals
2. High P is generally non-toxic to plant or animals
3. P causes accelerated autrophication

- Excessive growth of algae and aquatic plants
- Limits use of water for drinking, fishing

Management of soil phosphorous

1. Addition of organic matter
2. Addition of N-P fertilizers
3. Alteration of soil pH using suitable fertilizer

Potassium

- ☐ Average potassium in soil = 0.83% = 16600 kg/ha.
- ☐ 6 times more than N and 13 times more than P.

Forms of K in the soil:

1. Structural (mineral) K:

- ➢ In the structure of primary minerals (feldspar and mica)
- ➢ In the structure of clay mineral (mica)

2. Non-exchangeable K
3. Exchangeable K: 2- 5% saturation of the CEC

4. Solution K: 2 – 6 mg/l in solution.

Precision agriculture to improve soil fertility

Precision agriculture technologies have potential to improve soil fertility management and on-farm research or demonstrations. Two major projects are being developed. One project focuses on the field-scale study of relationships between the phosphorus (P) and potassium (K) contents of soils and plants with grain yields and on the evaluation of soil sampling methods. No treatments are applied to the fields in this project. It is designed to address the expectation of many producers and agronomists in that grid sampling will adequately describe soil nutrient supplies better than the traditional "sampling by soil type" method and that variation in nutrient levels will explain much of the yield variability within a field. The other project focuses on the evaluation of variable-rate fertilization and on adapting new technologies to traditional on-farm strip trials. In this project, treatments are applied to long strips replicated several times across the fields. Intensive grid soil sampling is conducted before and after applying the treatments. The treatments compared vary between fields and include fertilizer placements (starter, deep-banding), interactions of herbicides and fertilization, variable-rate fertilization or manuring, and others. In both projects, yields are measured with calibrated yield monitors and, in some strip trials, the yield monitors are checked by weighing the yield of each strip.

Soil sampling for precision agriculture

The results of sampling many fields show that the spatial variability of P and K and other nutrients in soils is complex and that variability patterns differ markedly among fields. The causes for variability on a large scale are different from the causes of variability on a smaller scale. Soil types, landscape characteristics, previous crops, or proximity to feeding lots usually create variation over a scale of several acres.

Practices such as tillage, fertilization, and manure application also create large variability on a scale of a few feet or even inches. Although in some fields the spatial variations of P, K, and pH tend to follow the distribution of soil types or other landscape characteristics, the variability of P or K (and sometimes of pH) usually do not follow the distribution of soil types and the patterns differ among fields. In many fields, the variability over many acres often is similar to that over a few hundred square feet.

Attempts to find an optimum soil sampling scheme valid across all fields have been largely unsuccessful. The maps in Fig. 1 show examples of the different answers a producer may get when different sampling schemes are used. The maps show assessments of soil P for three fields using three sampling methods. The data show that no general rule applies, and similar results have been observed for soil K and pH. Sometimes, intensive grid sampling results in a useful description of nutrient supplies. Often, however, sampling by soil type was as useful and it should make more economic sense. Data from most fields suggest that sampling of large cells three to four acres in size does not represent soil nutrient levels appropriately in many fields because the variation within those areas is as large as the variation over the entire field and cell borders usually do not follow soil mapping units or landscape. Sampling of large areas often overestimates nutrient levels and pH of significant areas of the fields. Increasing the number of soil cores collected for each composite sample will not solve this problem. Reducing the cell area or increasing the number of points sampled may not be economically viable, however. It is likely that a targeted grid sampling scheme that considers landscape characteristics or other field information is the most economical alternative. This procedure is flexible enough to adapt to different field characteristics and different intensities of sampling. Digitized soil maps, soil test data, yield maps, and aerial photographs (of bare soil and crop canopy) can be used to plan an efficient sampling scheme.

The observation that economically feasible soil sampling procedures may not describe the variation in soil nutrients with as much detail as agronomists want is not new. Even traditionally recommended soil sampling methods have always compromised detail for economic feasibility. In spite of deficiencies, however, soil testing for P and K has proved successful as a method in which to base fertilizer recommendations. This is not different for grid soil sampling.

Soil sampling and variable-rate fertilization

The impact of grid sampling and variable-rate fertilization on soil fertility management and the profitability of crop production depends on several factors. Some include the nutrient levels found in relation to crop needs, the nutrient variability patterns, the fertilizer recommendations used, the expected responses to fertilization, and the additional costs. Results of four trials with corn and soybean in fields that tested optimum or high on average showed no major yield advantage of variable-rate P fertilization (or of uniform fertilization) in most fields because there was little response to P. This should not be surprising because surveys show that more than half of Iowa fields test optimum or above in P and K. High variability in a field with predominantly optimum or high values is likely to be irrelevant because the probability of yield responses in soils testing optimum or above is small and the proportion of low-testing areas is also small. Given the likelihood of small responsive areas in many Iowa fields, the most likely benefit of intensive grid sampling and variable-rate fertilization will be accomplished through savings in maintenance fertilization. Producers who will also benefit from these practices are those who realize that most parts of their fields test above-optimum and do not need maintenance fertilization until levels decreased to the optimum range. These outcomes will also be beneficial from environmental and sustainability perspectives. Without grid sampling, uncertainty usually leads producers to apply a uniform high maintenance rate over the field when it may not be needed.

Interpretation of soil-test and yield maps

Many producers believe that variation in nutrient levels will explain much of the yield variability within a field and that much can be learned from comparisons of several layers of information. Statistical analyses and visual observations of maps of soil-test values, soil types, and yields showed that only part of the yield variability in each field could be explained by the fertility measurements. This result could be expected because crop yields are influenced by a variety of factors. The field measurements that were related to yields varied among fields and high nutrient variation not necessarily explained highly variable yields. Although in a few instances low yields could be reasonably explained by the soil-test or soil type maps, use of tests and data management methods that cannot normally be used by producers showed that apparent correlations often were misleading and would lead to wrong conclusions. Questions concerning what nutrients limit yields cannot be answered with certainty unless treatments with and without fertilization are used. This concept lead to efforts in developing better methods for comparing management practices on a field scale.

On-farm comparison of management practices

Results of many on-farm comparisons show that precision agriculture technologies can be successfully adapted to on-farm, field-scale evaluations of alternative management practices. A commonly used method of on-farm research is based on the applications of treatments to long strips replicated across the field and on weighing large loads of grain. Use of grid sampling, differential global positioning systems (DGPS), yield monitors, and data management with geographical information systems (GIS) computer software allow for a more detailed evaluation of treatment differences for different parts of a field and for estimating interactions between response to fertilization and other growth factors.

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Finding solutions through innovation

There are many tools and technologies available to assist farmers to correctly apply plant nutrients, for instance: 1) Soil testing (using wet chemistry or sensors); 2)Field mapping, data management and Global Positioning System (GPS), useful for precision farming; 3) Tools for monitoring crops' nutrient status, ranging from a simple leaf colour chart to sophisticated remote sensing technologies; 4) Decision support tools; 5) Slow- and controlled- release or stabilized fertilizers with polymer coatings or additives, such as nitrification inhibitors, have shown significant results in successfully delaying nutrient release or microbial conversions to forms subject to losses, thereby reducing the amount transferred to the atmosphere or to water; 6) Foliar fertilization allows to apply small amounts of nutrients (typically micronutrients) when and where needed without being influenced by soil-nutrient interactions; 7) Precision farming techniques like "micro-dosing" of small quantities of fertilizer to improve productivity on depleted soils – a method that has shown significant results in Africa.

N-Sensor - to variably apply nitrogen

The Yara N-Sensor is a real time variable rate nitrogen sensor that allows farmers to measure crop nitrogen requirement as the fertiliser spreader passes across the field and variably adjusts the fertiliser application rate accordingly.

N-Sensor ensures that the right and optimal rate of fertiliser is applied at each individual part of the field. It has become the benchmark technology for precision agriculture.

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N-Sensor: tractor-mounted remote sensing

Site-specific fertilisation is one of the main objectives in precision agriculture. Variable rate application requires accurate and efficient tools to determine the actual nutrient demand. Remote sensing techniques offer the opportunity to deliver this information quickly, precisely and cost-efficiently. The N-Sensor has been developed to determine the crop nitrogen status by measuring the light reflectance properties of crop canopies and to enable variable rate fertilisation "on-the-go".

N-Sensor use advantages

- Bring the optimal fertiliser rate in every part of the field
- Enhance the crop potential all over the field
- Increase fertiliser efficiency
- Decrease nitrogen residues in soils post harvest
- Increase yield
- Quality is more homogeneous
- Reduce harvesting time and cost
- Reduce risk of nitrogen losses to the environment

How does N-Sensor work?

The N-Sensor determines a nitrogen demand by measuring the crop's light reflectance covering a total area of approximately 50m2. Measurements are taken every second with the system designed to operate at normal working speeds and all bout widths. Sensing technology applied to agriculture is based on the typical light reflectance curve for vegetation. N-Sensor measures light reflectance at specific wave bands related to the crop's chlorophyll content and biomass. It calculates the actual N-uptake of the crop. Optimum application rates are derived from the N-uptake data and sent to the controller of the variable rate spreader or sprayer, which will adjust fertiliser rates accordingly.

The whole process of determining the crop's nitrogen requirement and application of the correct fertiliser rate happens instantaneously, with no time delay. This enables "real time agronomy" to be possible.

N-Sensor development

Following development coordinated by Yara's Research and Development Centre, Hanninghof in Germany, the first N-Sensor (Classic) was introduced in 1999 for use on cereals.

Work to develop the N-Sensor to keep up with changes in cereal production as well as for use on a wider range of crops and has been a continuous part of Yara's R&D Programme. More than 250 trials have been carried out between 1997 and 2010 to refine its performance and add new programs such as the Absolute-N calibrations for oilseed rape.

N-Sensor and N-Sensor ALS - two systems, one philosophy

In 2006, Yara launched the new N-Sensor ALS (Active Light Source), which works in a similar way to the classic N-Sensor to determine a crop's nitrogen demand by measuring the crop's light reflectance. Both systems make use of the same field trial based agronomic algorithms for optimum site-specific fertilisation and both are connected to a vehicle terminal where crop and GPS data is stored for processing.

The major difference between the two N-Sensors is that the ALS Sensor has its own built in light source. Instead of using daylight for the measurement the N-Sensor ALS is constantly beaming its own source of light at the crop, using Xenon flash lamps, and recording the reflectance. This enables N-Sensor ALS operation independent from ambient light conditions, even at night.

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Installation of precision agriculture (Agrilive) at PTUK farm

One of the most important output of this project for PTUK concerning for purchasing and installation of advanced devices (soil moisture and temperature sensors, nitrogen soil sensors, phosphorus soil sensors, and potassium soil sensors) that will be used on the university farm to enhance students and researchers to increase their knowledge and science, as these sensors will serve students and researchers in carrying out advanced research to help farmers solve their problem.

AgriLive is a smart solution designed within a platform to serve the agricultural fields, their main job is to monitor and control things over internet connection.

AgriLive System Components:

- **Gateway (AgriLive Gateway) :** the brains of the system which is tasked with collecting data and relaying actions between our servers and the nodes through redundant and reliable internet connections.
  1- High secure connection.
  2- High local storage up to 3 years.
  3- Long rang wireless connectivity with the Nodes (Sensors) or over 3G/4G.
  4- Supported with real-time Dashboards using Website & Mobile APP.
  5- Multi users' authentication levels (User, Admin, and Super Admin).
  6- Ability to connect multi nodes.

- **Node (AgriLive Node):** tasked with collecting data from the field and environment then relaying it back to the gateway via long range radio connection.

Humidity and temperature sensors, nitrogen soil sensor, phosphorus soil sensors, and potassium soil sensors were installed at the PTUK farm.

Agrilive system which installed at PTUK farm consist of

25 sensors soil moisture

25 N soil sensors

25 P soil sensors

25K soil sensor

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25 soil temperature sensor

One light sensor

One gate way for data collection

10 nodes for reading from sensors (solar node)

Features:

1- Wide range of sensors that related to the Hydrological field (soil content N-P-K sensors, soil moisture sensor, soil temperature sensor, solar radiation sensor).
2- Powered by solar energy, Low power consumption.
3- Long rang wireless data transferring between AgriLive Gateway & AgriLive Node.

System benefits:

1- Graphical data history through website.
2- Ability to create notifications and alerts over any sensor value.

The benefit of installation of these sensors at PTUK farm

1- Nitrogen ,phosphorus and potassium soil sensors (also called soil NPK sensor) are suitable for detecting the content of nitrogen, phosphorus, and potassium in the soil, and judging the fertility of the soil by detecting the content of nitrogen, phosphorus, and potassium in the soil, thereby facilitating the

systematic assessment of soil fertility subsequent impact on crop

2-Good knowledge and timely prediction of the soil surface temperature and moisture status are useful for understanding factors that affect crop development, crop root condition and many physical and biological processes influencing crop growth and development within the soil Modeling of soil temperature and moisture can play a significant role in irrigation and other farm operations.

3-Accurate measure of soil temperature and moisture is thus important for planning farm operation, drought monitoring and crop emergence prediction.

4- Estimates of these parameters can be used to determine the best possible period for field operations.

Figure 6: Smart system for measuring N-P-K in the greenhouse

Figure 7: Smart system for measuring N-P-K in the open orchards field

Figure 7: Fixation testing of the smart system

Figure 8: Insulation of sensors in the soil

Figure9: Data monitoring through mobile system

Annex

Quiz

Question 1 : Select the correct meaning and fill out the table bellow:

Plant nutrient	**Correct number**	**Effect on plant growth**
Nitrogen		1. Plays a vital role in the nitrogen fixation process of the rhizobium at roots of leguminous plants.
Soil productivity		2. A vital substance for the photosynthesis of plants, synthesis of chlorophyll
Potassium		3. Necessary for conveying energy used in building plants products in photosynthesis and respiration.
Soil fertility		4. For building plant tissue, growth of sports, leaves, branches and stems
Iron		5. Helps increasing the resistance against disease and improving plant yield quality
Cobalt		6. The status of soil in respect to its ability to supply the essential elements to plant growth
Phosphorous		7. The capacity of a soil in its normal environment, fort producing a specified plant or sequence of plant under a specified system of management

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Key answer

Plant nutrient	Correct number
Nitrogen	4
Soil productivity	7
Potassium	5
Soil fertility	6
Iron	2
Cobalt	1
Phosphorous	3

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Annex 2

Exam

Question 1: Chick (√) in front of the correct sentence and (x) in front of the wrong sentence, and fill it into the table below.

1. Poor drainage, compaction and poor aeration may limit productivity of fertile soil (   ).
2. Carbon, Oxygen and Hydrogen are classified as mineral nutrients (   ).
3. Mass flow is the movement of nutrients through the soil solution in response to concentration gradients (   ).
4. Diffusion is the movement of nutrients dissolved in the soil solution with water as it moves to the plant root (   ).
5. Precision agriculture technologies have potential to improve soil fertility management ( ).
6. The advantages N-Sensor are to bring the optimal fertilizer rate in every part of the field and to increase fertilizer efficiency (   ).

Number	1	2	3	4	5	6
Answer	T	F	F	F	T	T

Question 1: Chick (√) in front of the correct sentence and (x) in front of the wrong sentence, and fill it into the table below.

1- The conversion of inorganic nitrogen to organic nitrogen called:

a) Mineralization   b) Volatilization

c) Nitrification   d) Immobolization

2- The conversion of NH4 into NH3 gas called:

a) Nitrification   b) Volatalization

c) Leaching   d) Fixation

3) One of the following elements important in vegetative growth stage

a) Nitrogen   b) Calcium

c) Magnesium   d) Cobalt

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4) Elemental nitrogen (N2) can be converted to available nitrogen under the following reactions:

a) Mineralization
b) Denitrification
c) Biological fixation
d) Nitrification

5) One of the following soil potassium forms is uptake by plants:

a) KOH
b) K2O2
c) K2+
d) K+

6) One of the following soil nitrogen forms is uptake by plants:

a) NH4+
b) NO2-
c) NO
d) N2O

7) The present of mineral phosphorous in the soil is about:

a) 20%
b) 15%
c) 70%
d) 50%

8) The present of organic phosphorous in the soil is about:

a) 50%
b) 20%
c) 70%
d) 10%

9) One of the following soil phosphorous forms is uptake by plants:

a) $CaPO4^-$
b) H_2PO4^-
c) $MgPO4^-$
d) H_3PO4^-

10) The advantage of installing Nitrogen sensors is

a) Increase yield
b) Improve fruit quality
c) Reduce harvesting time and cost
d) all the above mentioned are true

Number	1	2	3	4	5	6	7	8	9	10
Answer	D	b	a	c	d	a	d	a	b	d

****

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Boosting Innovation in Education and Research of Precision Agriculture in Palestine

Course: Agriculture Economic

Module 3: Big Data management and Analysis

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Introduction:

Once you've identified a big data issue to analyze, how do you collect, store and organize your data using Big Data solutions? In this course, you will experience various data genres and management tools appropriate for each. You will be able to describe the reasons behind the evolving plethora of new big data platforms from the perspective of big data management systems and analytical tools. Through guided hands-on tutorials, you will become familiar with techniques using real-time and semi-structured data examples. This chapter provides techniques to extract value from existing untapped data sources and discovering new data sources.

Information management is a combination of the foundation and the plumbing in a house. Who wants to think about information management? Not many. But just like a house, if the foundation isn't solid, you'll have all sorts of structural problems that can cause it to come crashing down. Or, at least, you'll experience annoying problems that limit your abilities to live comfortably. Just like when you contract to have a house built, you want to invest in experienced builders who know how to build the foundation to meet today's needs and anticipate future needs so you'll have the ability to easily expand.

The Big Data Foundation

Just like the house analogy, the Big Data foundation is composed of two major systems. The first stores the data and the second processes it.

Big Data storage is often synonymously interchanged with the Hadoop File System (HDFS), but traditional data warehouses can also house Big Data. HDFS is distributed data storage that has become the de facto standard because you can store any type of data without limitations on the type or amount of data. One of the reasons HDFS has become so popular is that you don't have to do any "set up" to store the data. In traditional databases, you need to do quite a bit of "set up" in order to store data. You have to understand the data that will be housed in the database and set up the database by creating a schema. The schema is the blueprint for how you'll place data into tables with columns.

This chapter is for those new to data science. Completion of Intro to Big Data is recommended. No prior programming experience is needed, although the ability to install applications and utilize a virtual machine is necessary to complete the hands-on assignments. Refer to the specialization technical requirements for complete hardware and software specifications. Hardware Requirements: How to find your hardware information: (Windows): Open System by clicking the Start button, right-clicking Computer, and then clicking Properties; (Mac): Open Overview by clicking on the Apple menu and clicking "About This Mac." Most computers with 8 GB RAM purchased in the last 3 years will meet the minimum requirements. You will need a high speed internet connection because you will be downloading files up to 4 Gb in size. Software Requirements: This course relies on several open-source software tools, including Apache Hadoop. All required software can be downloaded and installed free of charge (except for data charges from your internet provider). Software requirements include:

What is big data?

Big data is a broad term that encompasses the policies, processes, and technologies used for information management and storage. Perhaps, the most common application of big data is in the IT industry.

Various IT companies use large databases to help with the collection of relevant information from diverse sources. These organizations store their data on various storage media, such as the Internet, CD-ROMs, memory sticks, mobile devices, and even file cabinets.

Enterprises may apply the information gathered in different applications, such as:

- Information technology architecture (ITA)
- IT infrastructure
- Data warehousing
- Business process management (BPM)
- Big data analytics
- Machine learning or artificial intelligence (AI)

But, gathering big data is only part of the solution for business success. Organizations need to use applications that allow them to pull information quickly, lest they waste valuable time and effort.

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To help you with this, you can **use The Cloud Tutorial**. You can customize your business's knowledge base, and pull necessary information on-the-fly. This application, along with other similar software, allows staff members to check various data without spending seemingly countless hours looking for a specific document or file.
Note that big data help improve business processes by providing companies with **data valuation reports** and valuable data on various areas of interest, such as marketing, manufacturing, service, and research. Use the information to make informed and beneficial decisions to all employees, regardless of in-house rank.

Summary: Big data and agriculture is virtually a blank canvas, in particular, from the legal point of view. Issues regarding Smart Farming and related matters are still new items on the agenda, in contrast to discussions concerning self-driving or Connected Cars. Therefore, the legislators have the opportunity to effectively regulate a new phenomenon from the very start to provide a safe environment for innovation and investments as efficiently as possible.

What is knowledge management?

Knowledge management is the process of managing information, hoping to improve and **grow business performance**. If used correctly, it can become effective in achieving an organization's objectives.
For example, the human resources department of a large manufacturing company uses knowledge management to ensure that it has the most effective and efficient workforce in the industry. Another example is when an IT department in a technology-based company uses knowledge management to ensure that its systems and applications are functional and flexible.

At the organizational level, knowledge management is usable for organizing resources to develop and promote technologies and improve business effectiveness by improving the business's knowledge base.

Knowledge management takes into consideration several things to help enterprises achieve various goals. For example, the management team should look at the current processes of the manufacturing department to identify their strengths and weaknesses.

Staff members can then use the data gathered to evaluate how those strengths and weaknesses can improve the company's manufacturing strategy.

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In-house knowledge management teams should also examine the current and future technology changes that could affect the company's business strategies. In doing so, the firm may develop actionable long-term solutions for the benefit of both in-house staff and the business's clientele.

How to secure big data

Placing big data on the Internet may help various organizations capture and retrieve information efficiently. But, always keep in mind the risks of **security breaches**. Remember, the benefits of securing big data are as follows:

- Improved business performances
- Reduced organizational errors and risks
- Increased sales
- Improved profitability
- Enhanced customer service
- Improved safety measures
- Updated inventory controls
- Enhanced management protocols

However, all these benefits will be for nothing if hackers breach into your digital databanks. Many companies usually face several challenges in securing their data online. If you want to protect your valuable data, you should consider how to secure big data.

It would be best if you always considered the importance of storing data safely. A big data security system must ensure that information stays protected from all possible threats, such as human error, natural calamities, or external threats.

This is why you need to look for a company that specializes in information security. By hiring a company that has the appropriate skills, you'll find it easier to protect your data.

If you're going to hire a third-party IT company to handle your big data, ensure that the service provider is trustworthy. The last thing you'd want is for a data security firm to be the culprit that steals your organization's valuable data.

How to manage and organize your business data

If you want to take advantage of your business's data efficiently, you need to implement a system wherein you and other staff members can access information quickly.

One way to organize business data is to manage your business's physical storages. Ask yourself the following question, "Do your employees waste valuable time rummaging through file cabinets, trying to search for a specific file or folder?"

If they do, you need to form a system that allows the staff to find documents within, at most, a few minutes. Perhaps, you can label each cabinet and folder to indicate what files are in those containers.

But, if you're going to secure your company's data in a digital platform, consider organizing and securing the passwords for the databanks. Note that there's nothing wrong with having one password for your organization's apps. However, ensure that the master passcode you use isn't as simple as something like '1234.'

Instead, have different passwords for each data center, like **4D Data Centres**. That way, if a hacker breaches a databank, you can still recover some or all of those files if you have backups located in another digital container. However, that cyber attacker can capture all organizational data if you only have one password for all databanks in your business.
Having different passwords also forces you and your employees to maintain proper data management. Otherwise, failing to follow correct data management protocols might lead to information loss.

Quiz 1: What's the benefits of securing big data

Big data and knowledge management are important in every business

Big data and knowledge management are integral factors in maintaining and improving various business performance and practices. Always keep in mind to secure the sensitive company information, or they fall into the hands of cyber attackers.

Practice discipline and diligence in handling organizational data, and your business might be one step closer to achieving its goals.

Fig.1 Analysis of 10 Vs of data

The 10 Vs of big data:

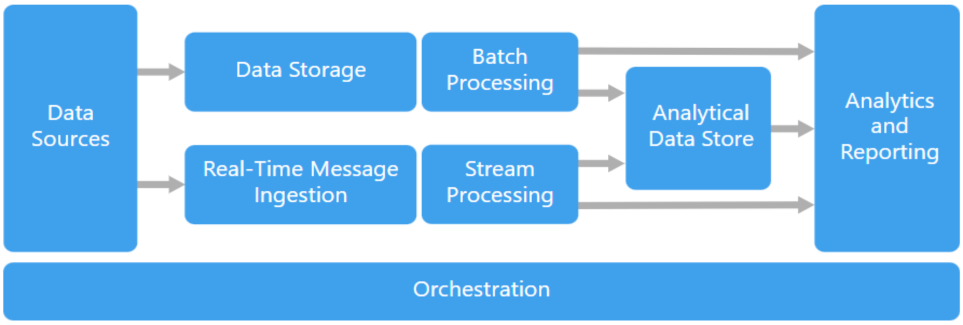
Volume	There is a large amount of data is generated from various sources.
Variety	Data has complex structures, different data types, and formats depending on the data sources.
Velocity	In real time processing, the rate of data flowing into and out of the systems is high.
Veracity	Due to the different data sources are often of many different origins data quality is not all verifiable.
Validity	Validity is based on veracity, the data should have quality, governance, master data management (MDM) on massive, diverse, distributed and heterogeneous.
Value	To derive significant value from high volumes of data with a low value density is not straight forward.
Variability	The data source should be dynamic, evolving, spatio-temporal data, time series, seasonal, and any other type of non-static behavior, customers, objects of study, etc.
Venue	Data sources are distributed, heterogeneous data from multiple platforms, from different owners' systems, with different access and formatting requirements, private vs. public cloud.
Vocabulary	It relates new concepts, schema, data models, semantics, ontologies, taxonomies, and other content- and context-based metadata that describe the data's structure, syntax, content, and provenance.
Vagueness	It relates to the confusion over the meaning of big data and overall developments around big data.

Source:https://learn.microsoft.com/en-us/azure/architecture/guide/architecture-styles/big-data

Big data architecture style

Data Lake Analytics | IoT

A big data architecture is designed to handle the ingestion, processing, and analysis of data that is too large or complex for traditional database systems.



Source:https://learn.microsoft.com/en-us/azure/architecture/guide/architecture-styles/big-data

Often, big data is referred to as a singular entity. It is not! In reality, big data is much more a capability than a thing. It is the capability to extract information and insights where previously it was economically, if not technically, possible to do so. Advances across several technologies are fueling the growing big data capability. These include, but are not limited to computation, data storage, communications, and sensing. The growing ability of analysts and managers to exploit the information provided by the big data capability is equally important. Only recently have numerous attempts been made to define big data. For example:

1. The phrase "big data" refers to large, diverse, complex, longitudinal, and/or distributed data sets generated from instruments, sensors, Internet transactions, e-mail, video, click streams, and/or all other digital sources available today and in the future (The National Science Foundation 2012).

2. Big data shall mean the datasets that could not be perceived, acquired, managed and processed by traditional IT and software/hardware tools within a tolerable time (Chen et al. 2014).

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3. Big data is where the data volume, acquisition velocity, or data representation [variety] limits the ability to perform effective analysis using traditional relational approaches or requires the use of significant horizontal scaling for efficient processing (Cooper and Mell 2012).

4. Big data is high-volume, -velocity, and -variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making (Gartner IT Glossary 2012).

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Big Data Technologies and Tools

Recent technological development led to automation of several processes in various domains like agriculture, health care, fraud detection, etc., which in turn led to the generation of humungous data. McKinsey & Co. (Manyika et al., 2011) foresees that the society is now facing a tremendous wave of innovation, productivity, and growth as well as new modes of competition and value capture - all driven by Big Data.

The term Big Data is mainly used to describe massive, often unstructured, and heterogeneous digital content which is difficult to store and process using traditional data management tools and techniques (Talia, 2013), (Stephen Kaisler et al.,2015), (Rob Lokers et al., 2016). Once these started gaining attention, the data analyst developed it further and currently big data can be described using the 10V model. (Borne, 2014) has listed the V's as challenges in deploying Big Data into any application. These V-based characterizations represent ten different challenges associated with the main tasks involving big data like- capture, cleaning, curation, integration, storage, processing, indexing, search, sharing, transfer, mining, analysis, and visualization.

Big data can be described by the following 10 characteristics which are illustrated in Figure 1 and Table 1. These covered most of the challenges in big data including collecting, storing, transferring, analyzing, and visualizing. Big data is primarily defined by the volume of a data set. The data sets are generally huge measuring tens of terabytes and some cases crossing the petabytes. The term big data was preceded by very large databases which were managed using database management systems. Currently, big data falls under three categories of data sets namely structured, unstructured and semi-structured. The structured data sets comprise of data which can be used in its original form to derive results.

The unstructured data sets comprise of data are without proper formatting and alignment (Khan et al., 2014). Semi-Structured data sets are a combination of both structured and unstructured data. Big data processing requires a particular setup of physical and virtual machines to derive results. The processing is done simultaneously to achieve results as quickly as possible.

Dimensions of Big Data Three dimensions (Figure 1) often are employed to describe the big data phenomenon: volume, velocity, and variety (Manyika et al. 2011). Each dimension presents both challenges for data management and opportunities to advance agribusiness decision-making. These three dimensions' focus on the nature of data. However, just having data isn't sufficient. Analytics is the hidden, "secret sauce" of big data. Analytics (discussed later), refers to the increasingly sophisticated means by which useful insights can be fashioned from available data. Volume: According to (IBM, 2012) 90% of the data in the world today has been created in the last two years alone. In recent years, statements similar to IBM's observation and its emphasis on volume of data have become increasingly more common.

The volume dimension of big data is not defined in specific quantitative terms. Rather, big data refers to datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyze. This definition is intentionally subjective; with no single standard of how big a dataset needs to be to be considered big—and that standard can vary between industries and applications. Velocity: The velocity dimension refers to the capability of understanding and responding to events as they occur. Sometimes it's not enough just to know what's happened; rather we want to know what's happening. For example, applications like Google Maps provide real time traffic information at our fingertips. Google Maps provides live traffic information by analyzing the speed of phones using the Google Maps app on the road (Barth 2009). Based on the changing traffic status and extensive analysis of factors that affect congestion, Google Maps can suggest alternative routes in real-time to ensure a faster and smoother drive. Variety: As a dimension of big data, variety may be the most novel and intriguing.

Data refers to numbers meaningfully arranged in rows and columns. For big data, the reality of "what is data" is wildly expanding. For example, the movement of your eyes as you read this text could be captured and employed as data. Suddenly (at least in agricultural measurement terms), the "what is data" question—the variety dimension of big data—has new answers. Figure 2 provides a visual illustration of the change. In its upper left hand corner, we see data as we are used to it – rows and columns of nicely organized numbers.

The picture in the upper right hand corner is of a pasture in New Zealand. Pastures are the primary source of nutrition for dairy cows in that country and supplemental fertilization is a necessary economic practice. The uneven pattern of the forage in that field is measured by a sensor on the fertilizer spreader to regulate how much fertilizer is applied—as the spreader goes across the field. In this situation, uneven forage growth is now data. (This also is an example of velocity where the measurement activity is directly linked to action based upon the measurement.)

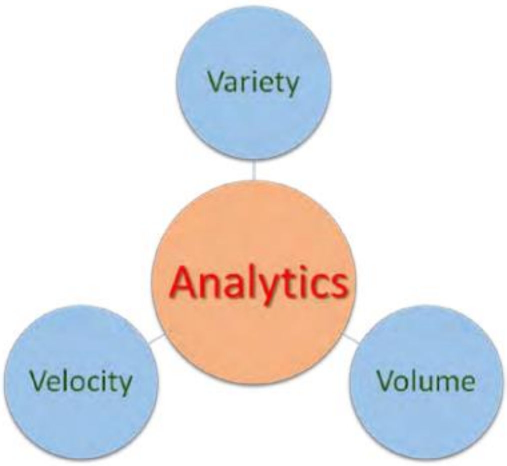


Fig.2 Analysis of data impacts.

Summary: The volume dimension of big data is not defined in specific quantitative terms. Rather, big data refers to datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyze. This definition is intentionally subjective; with no single standard of how big a dataset needs to be to be considered big and that standard can vary between industries and applications

How Might Big Data Impact Industry Structure and Enhance Margins?

How might big data impact the agricultural sector and food industry? The impacts on the structure of the industry and the profit margins of individual businesses are numerous, but two critical impacts are: 1) improvements in supply chain linkages to enhance efficiency and effectiveness of the food production and distribution industry; and 2) improvements in on farm production practices. This commentary provides a brief synopsis of these two impacts. Supply Chain Linkages Consumers, particularly those in the developed economics, are becoming increasingly demanding in terms of the attributes and characteristics of the products they consume. Traditional attributes of plant and animal protein products such as nutritional content, taste, texture, affordability, and safety are still mainstays of consumer's expectations, but their expectations of predictability and reliability have increased. With a specific focus on food safety and quality, it is argued that a whole chain traceability system can reduce exposure to hazardous foods and reduce quality deterioration across the chain from producer to consumer. Big data driven quality/safety/traceability systems provide the capabilities to respond to these increased consumer expectations. Such systems have significant benefits in terms of disease control and management of food contamination as argued by Adam et al. (2016) in this issue.

Other attributes have become more important in shaping consumer buying behavior as well as society's expectations from the food industry—attributes that economists call "credence" attributes are generally harder to measure and often a function of how the product is produced and processed along the entire value chain from breeding/genetics, to retail outlets (traditional grocery stores, restaurants, food service providers, and on-line vendors such as Amazon.com). Such attributes include: additive or antibiotic free, organic production systems, locally and/or family-farmer grown, animal treatment/welfare production practices, sustainable production/processing/distribution systems, etc. Given that many credence attributes are not characteristics of the final product but instead processes and activities that do or do not occur across the value or supply chain, documentation and certification often can only occur through systems of whole-chain tracking and tracing. As a consequence, data and information systems are required that monitor and measure these processes and activities at each stage of the supply chain. Equally important, this data and information must be tagged or linked to the physical product (boxes of cereal, cuts of meat, etc.) that flows along that supply chain so that the final product can be credibly marketed and certified as having the attributes that consumer's desire. Some have argued that the incentives of enhancing food safety, product quality, and traceability to guarantee credence attributes and responsiveness to consumer demands and societal expectations of the food production /processing /distribution system may be more important than production efficiencies at the producer level in incanting adoption of big data technologies/systems in the food industry (Sonka, 2016). But are consumers willing to pay for "credence" attributes that require different and costlier production processes as well as unique and costly (tracking/tracing, segregation, storage and handling, and inventory) management processes along the supply chain from producers to consumers? Numerous studies indicate that at least a segment of meat and animal protein consumers are willing to pay for unique attributes. For example, Olynk, Tonsor and Wolf (2010) estimate that consumers would pay a $1.74 per pound premium for pork chops that are USDA – PVP verified that individual crates and stalls are not permitted in the production process. (Olynk, 2012) also found that consumers are willing to pay for pasture access, non-antibiotic use and non-use of crates and stalls in dairy production. Wolf, Tonsor and (Olynk, 2011) found that consumers were generally willing to pay substantial premiums for milk produced without the use of rbST, on local family farms, with assured food safety enhancement, when claims are verified by the U.S. Department of Agriculture. In addition, more systematic alignment along the supply chain from input supplier and manufacturing to food retailer has the potential to increase efficiency through better inventory management and product flow scheduling in both differentiated products and commodity supply chains. This alignment will be facilitated by big data technologies and information systems. For example, the logistics and inventory management challenges across all stages (from grain and livestock production through processing and distribution) have the potential for costly stock-outs as well as excess inventories and (waste/spoilage/ quality) deterioration unless the system is well coordinated. Information and communication systems that facilitate alignment and improve the ability to fulfill current product flows and more accurately predict future shortages, bottlenecks, or excess stock will be increasingly driven by big data analytical programs and systems. While the verification discussion is primarily relevant in developed countries, extended supply chains are increasingly important in developing country agriculture where urbanization is rapidly redefining how food reaches consumers. Coordination of delivery of inputs to farmers and the collection, distribution, and transformation of agricultural products

into food is relatively ineffective and inefficient in the developing compared to developed economies. The phenomenal increase in availability and adoption of cell phones, however, offers a means by which communication and coordination capabilities can be greatly strengthened. Distribution and logistics systems are improving with increased investment in logistics/transportation infrastructure, storage and handling, and cold chain distribution systems. Coupled with big data analytics, systematic improvements in supply chain performance are now potentially available. On-Farm Production Practices How might big data technologies/systems enhance the ability of producers of agricultural products to be more precise in their production practices and thus improve efficiency and profitability? This concept of precision farming—using information technology to add exactness to the quantity, quality, timing and location of the application and utilization of inputs in crop and livestock production and to produce specific attribute products/outputs— has been discussed and debated for years. But after more than two decades of innovation in this area, our ability to capitalize on this concept has fallen far short of the potential. For example, agricultural retailers in the US estimated in 2015 that 41% of the acres in their market area utilize grid or zone soil sampling procedures. While this is up from 12% in 2000, it's still well below full-adoption levels. Furthermore, agricultural retailers estimated in 2015 that, on average, 32% of acres in their market area utilized variable rate technologies for multiple-nutrient fertilizer applications. While this is up from 3% in 2001, technology adoption has been slow (Erickson and Widmar, 2015).

Will big data driven technologies/systems have the ability to cost effectively provide the prescriptions that precision farming requires? Recent advances in measuring / monitoring / sensing technology combined with continued improvement in nutritional and biological technology and process control input application technology make more precise input application and measurement of physical output possible. But do we have adequate precision and accuracy to fulfill the promise? More specifically do we have the scientific and numerical evidence based answers to the following questions?

1. What are the fundamental drivers/determinants/constraints of plant/animal growth and what are the specific structure and parameters of the underlying growth model?

2. What technologies are available to accurately real-time measure/sense/monitor the growth process?

3. How regularly and in real-time can growth conditions, drivers, determinants, and constraints on growth be measured?

4. What are the accuracy and measurement errors in measuring outputs (yield, production) and inputs (seed, nutrition, location/spatial, etc.) in biological growth processes?

5. What are the characteristics of the output distributions (i.e. normal, skewed, etc.)?

6. What are the alternative (application/process) control technologies that can be used in real-time to manage and intervene in order to enhance and control biological growth process?

7. What are the errors/accuracy in "application" technology (seed and fertilizer placement, spray patterns and dosage, tank or batch composition and concentration, etc.)?

8. What data aggregation and sharing is needed to obtain essential insights at the appropriate level of granularity given the long cycle-time in biological manufacturing?

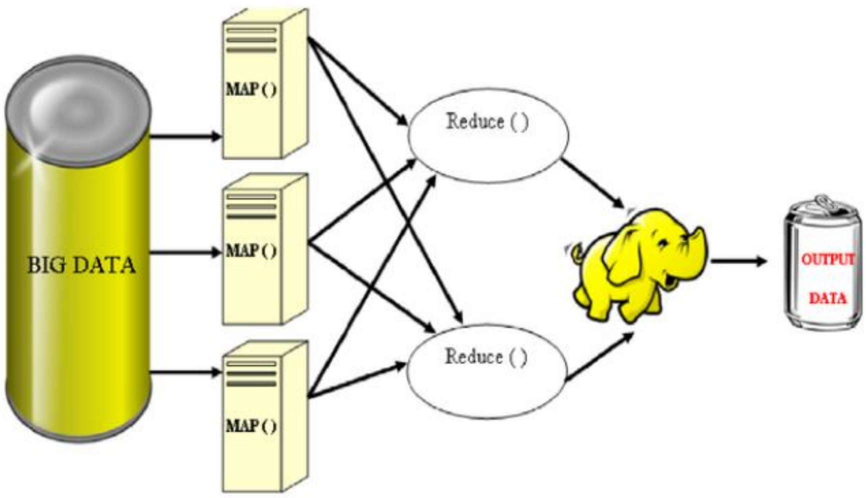
9. What information insights are essential to supply chain partners (buyers and suppliers) to increase producer efficiency and profitability while reducing their risk?

10. How might Bayesian/stochastic/systems dynamics with feedback numerical decision models and "options" modeling concepts that focus on the "tails" of the output distributions be used to assess risks and rewards and obtain insights for improved decisions? The more accurate and positive the answers we find to these questions, the higher the prospects that big data driven technologies and systems will enhance farmer's profit margins and thus be more widely adopted.

<u>Quiz 2: Explain How Might Big Data Impact Industry Structure and Enhance Margins</u>

Inquiry

Data obtained from high throughput screening is usually not a qualified one and therefore additional detection of reactive false positives is required. Data management consists of two parts: data process and analysis, which refers to the experimental results transmission, data storage and diverse analysis methods (including dose-response analysis, structure analysis, clustering, *etc*.). The aim of processing and analysis of the raw data is to get the most valuable information and therefore identify the most potential lead compounds with sufficient activity.



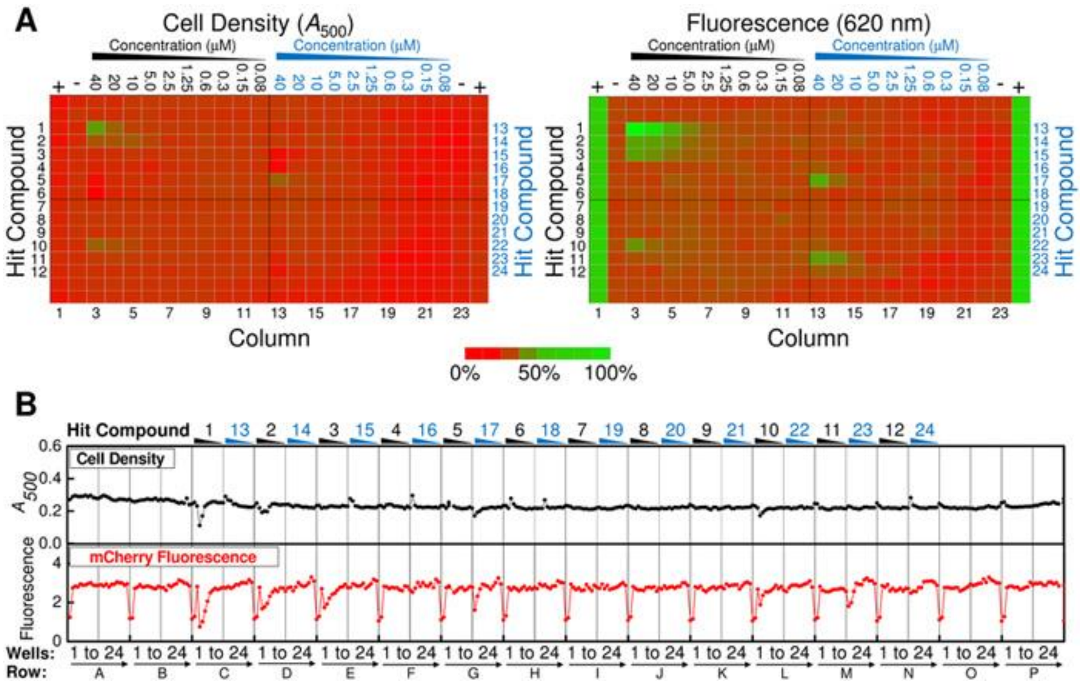


Fig.3 Analysis of dose response data for hits from the local HTS.

Big Data Services includes:

- **Data screening**

Plate-level data visualization is completed in just a few moments by our teams. We are capable of providing integrated stack view which displays all plates of a series in one graphic and this interactive plate views allow us a rapid and easy detection of false positives.

- **Quality management**

Several statistical parameters, such as Z’ and CV are useful in quality control of experimental data. We design interactive charts to track problematic data sets and conduct processing in time utilizing our statistics knowledge.

- **Dose-response analysis**

We check if the IC50 or EC50 values have a reasonable slope and whether they are unaffected by incubation time through performing non-linear regression of dose-response data. Our team can also provide a rapid assessment and help to remove the outlier data points.

- **Undesirable structures pick-up**

It is necessary to remove compounds obtained from HTS with undesirable properties. Herein we introduce substructure searching and similarity searching to filter false positives.
Substructure searching: Since some of the substructure might represent functional groups such as some kind of important pharmacophore. We therefore select molecules of your interest and conduct a set of substructure searching to identify compounds with the same substructure.
Similarity searching: BOC Sciences has developed a database with a large number of molecular fingerprints created based on the presence or absence of structural features. Our scientists select potential chemical molecules and perform searching operations for the compounds with similarities. We are experienced in identifying a common structure with our multiple expertise including clustering techniques, recursive partitioning methods and selecting from singletons.

- **Real-time analysis**

Timely data delivery is available by running analysis sessions as soon as the plates come out of the instrument, helping to save your money and time by shortening the analysis cycles.

- **Data storage**
  We ensure that your experimental results enable to be transmitted to our data warehouse rapidly and safekeeping. Furthermore, our customers have secure access to the data warehouse to obtain important information anytime.

Our Advantages

1. Our teams have ability to handle large volumes of data, and we can also perform hit series confirmation to generate leads for your project.
2. We also offer the best customized solution to meet your data management requirements.

Quiz 3: What Is Presenting Data means, and tools used

Big Data Storage and Analytics Platform

The Big Data storage and analytics platform provide resources and functionalities for storage as well as for batch and real-time processing of the Big Data. It provides main integration interfaces between the site operational platform and the Cloud data platform and the programming interfaces for the implementation of the data mining processes.

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Data acquisition in big data has two components: identification and collection of Big Data. Identification of Big Data is done by analyzing the two natural formats of data generated by digital and analogue. Digital data is the information which has been captured through a digital medium, e.g. a computer or smart phone app, etc.

This type of data has an ever-expanding range since systems keep on collecting different kinds of information from users. Digital data is traceable and can provide both personal and demographic business insights. Data in the form of pictures, videos and other such formats which relate to physical elements of our world are termed as analogue data. Analogue data requires conversion of data into digital format by using sensors, such as cameras, voice recording, digital assistants, etc. The increasing reach of technology has also raised the rate at which traditionally analogue data is being converted or captured through digital mediums. In agriculture domain and its applications, data collection from various sources plays an essential role. They are classified into two categories named public and private. Public data comprises of records that are collected, maintained and analyzed through publicly funded.

Opportunities and Advancements and Utilization of Big Data in Agricultural Industry

As opportunities for Big Data have surfaced in the agribusiness sector, big agriculture companies such as Monsanto and John Deere have spent hundreds of millions of dollars on technologies that use detailed data on soil type, seed variety, and weather to help farmers cut costs and increase yields. Other players include various accelerators, incubators, venture capital firms, and corporate venture funds (Monsanto, DuPont, Syngenta, Bayer, DOW etc.) (Lane, 2015). As the agri tech develops, an increasing number of small tech startups are launching products giving their bigger counterparts a run for their money. In the USA, start-ups like FarmLogs (Guild, 2014), Farm Link (Hardy, 2014) and 640 Labs challenge agribusiness giants like Monsanto, Deere, DuPont Pioneer (Plume, 2014).

One observes a swarm of data-service start-ups such as FarmBot (an integrated open source precision agriculture system) and Climate Corporation. Their products are powered by many of the same data sources, particularly those that are freely available such as from weather services and Google Maps. They can also access data gathered by farm machines and transferred wirelessly to the cloud. Traditional agri-IT firms such as NEC and Dacom are active with a precision farming trial in Romania using environmental sensors and Big Data analytics software to maximize yields (NEC, 2014). In the state of the art of big data applications in agriculture, the data are captured using sensors, open data, using biometric sensing genotype information (Faulkner and Cebul, 2014), (Cole et al., 2012), and (Van ‘t Spijker, 2014). The issue is the availability is limited and the quality of the sensors is immature due to the lack of developments (Tien, 2013). In data storage, the Cloud-based platform, Hadoop distributed file system and hybrid system are used. The system needs to improve quick and safe access of data along with installation and maintenance cost.

Wireless Cloud-based platforms are used for data transfer even though it has the issues on safety, agreements on responsibilities and liabilities. To make Big Data applications for Smart Farming work, an appropriate technological infrastructure is essential. The development in big data technologies improves the comprehensive productivity of agriculture and the overall productivity of agriculture using modern information technology and information systems (El Bilali et al., 2018). Because of volume, diversity, and complexity of agriculture data sets, there are number of challenges for innovative architecture and frameworks, algorithms, and analytics to manage, to extract values and hidden knowledge from it.

Big data may play a vital role for effective decision making for farmers, policy makers, companies involved in agri-business and agro-inputs, banks, insurance companies and service providers. The major opportunities and challenges lie with setting a benchmark in agriculture sector, because the factors influencing the agriculture will vary with climate, area, soil type, culture and tradition. The considerable challenges of agriculture big data exist at different stages, such as data collection, storage and analysis since the agriculture data set contains various data like soil, climate, seed, cultivation practices, irrigation facilities, fertilizers, pesticides, weeds, harvesting, post harvesting techniques, etc. A huge amount of data is generated and maintained by governments, universities, organizations, agri-business and agro-input companies for agriculture production, insurance, marketing, supply chain, packaging, distribution, etc. Because of the multimodal nature of data, it has several challenges like the improving methods for data collection, effective and efficient statistical and data analytical techniques to understand and support the functions of various agriculture verticals.

The agriculture big data is not so sensitive. So, there is less security or privacy issues in agriculture data. The agriculture practices guide agriculture data mining. The challenges are also in implementation costs side. The challenge is to automate data acquisition in such a way that there are virtually no costs. Because on-farm data will generally remain in the hands of individual companies, investments are needed in a common pool infrastructure to transfer and integrate data and finally make applications out of it.

Example: In side our university farm we have many constrains facing big data management, they are about limited field staff following some connections that confused as a result of conflict between students and Israel army activities, *Or other let's determine.*

The coordination between the Agricultural Business canters and Data Exchange Facilities of the area. The challenge in this area is if the coordination will be closed, proprietary systems or if these will be more open. Another business-related challenge of Big Data is how the potential of information across food systems can be utilized. The biggest challenges of Big Data governance are probably how to ensure privacy and security. Currently, this inhibiting developments when data are in silos, guarded by employees or companies because of this issue. They are afraid that data fall into the wrong hands (e.g. of competitors) (Gilpin, 2015b). Hence privileged access to Big Data and building trust with farmers should be a starting point in developing applications (Van 't Spijker, 2014). Therefore, new organizational linkages and modes of collaboration need to be formed in the agri-food chain. The ability to quickly access the correct data sources to evaluate key performance/core processes and outcome indicators in building successful growth strategies. Anonymization of data, so that it cannot be traced back to individual companies can also be a problem sometimes. Assessing impacts of new technologies and climate adaptation are challenging, most agricultural technology impact assessment is carried out after technologies have been disseminated. However, there is a growing recognition of the need for forward-looking, technology impact assessment designed to anticipate both intended and unintended impacts.

The most important growing applications of forward-looking impact assessment is for climate adaptation and climate smart agriculture present an illustrative analysis of how climate change may impact dry-land wheat producing farmers in the U.S. Pacific Northwest. Projected changes in climate are translated into changes in key climate factors affecting the grower's yields and these yield changes are transformed into net returns. Scientist observed that the users do not want models, but they want the information they can produce. This means that models must be embedded in decision support tools that have value to farm managers. One improvement could be to automate data collection using sensors on machinery and other mobile devices, as well as from web-based sources such as weather, and economic data such as prices.

Another area of improvement is inter-operability of tools with farm accounting and tax preparation software, so that information can be entered once and then utilized in an integrated way across multiple analytical tools. The available approach of manually carrying out this integration on a case-by-case basis makes this type of analysis costly even in a small geographic region, and often makes integration infeasible across larger regions. Second, the fact that virtually all stakeholders want access to model outputs, rather than access to the models themselves, means that there is a demand for "knowledge products," i.e., tools that facilitate access to model outputs and provide analytical capability to interpret model outputs for decision making. As Janssen et al. (2017) observe, "apps" on mobile devices, as is now being done for some types of decision making such as pesticide spray decisions – or as larger tablet computer dashboards for data visualization and additional processing through meta models and other analytical International Journal of Agricultural and Environmental Information Systems. The fact that these knowledge products have been slow to materialize suggests some form of "market failure". As suggested by Antle et al. (2017), one solution to these challenges appears to be private-public partnerships among the various organizations that have a mutual interest in assuring that the data are obtained efficiently and used appropriately for both private and public purposes. There have been major developments in the world related to food safety and traceability. Some of the initiatives come from governments to protect the health of the citizens, the others are private initiatives by growers and retailers in order to meet the expectations of their customers with respect to food safety and environmental sustainability.

Precision agriculture technology helps the food safety by developing a better decision support system for agriculture industry presents some specific challenges in information industry. Using network, internet and sensors gives a complete picture for precision agriculture along with the decease management and cattle movement. Analysis tools based on network theory can be used in the control and monitoring systems of food business operators by analyzing their commercial relations with each other (Baranyi et al., 2013; Chmiel et al., 2007). The management challenges in closely co-operating enterprises, as well as the mutual dependence of all participants in the food chain, necessitate the application of network science in this area (Fritz et al., 2008). The cattle identification and traceability are becoming a necessary pre-condition for the international competitiveness of cattle and the cattle-product export market (Schroeder et al., 2012). The network analysis approach has applied to analyze and prevent foot and mouth disease (Dube et al., 2009). Martinez-López et al. (2009) have analyzed the trans-boundary flow of animals with the purpose of implementing disease prevention measures and Bajardi et al. (2011, 2012) mapped the Italian cattle trade network and made great progress in analyzing dynamic patterns, using network science tools to optimize cattle farm surveillance.

Improving the technologies in data transmission is important for the agriculture sector. The lack of data or possible delays in providing updated records may make their use difficult, especially for time-varying patterns. The available data transmission models, i.e. cellular, wireless, and satellite are lagging behind the needs of agriculture production. The recent report Co-Bank (Tayler et al., 2016) released a report which briefs that the farmers utilize 30 plus gigabytes of data per month during the harvest period. This is more than double what they were using three years ago and the need keeps growing. Cellular and hard-wired providers are not able to reach much on the rural areas. However, satellite-based internet connectivity could provide an effective solution over larger geographic areas without signal interruption.

The amount of data generated from drones will depend on the type, frequency, and quality of images that are being taken. Bennett (2016) suggests that cellular connectivity is the only viable option for coverage map sharing. Insurance is another potential application of big data in the agriculture. It estimates the crop yields or crop losses within several days, thus allowing governments or insurance companies to respond to catastrophes in a much timelier manner (Castillo et al., 2016). Improved contract design and creative usage of satellite allow governments and the private sector to extend insurance coverage (William et al., 2010).

Utilization of real time information sharing between farmers and researchers enables service providers to supply real time and personalized services based on a wide range of factors such as: location, crop, management practices, mechanization level, irrigation type, farm size and soil type. These inform to the farmers about the different choices of cultivation and take necessary actions whenever needed. Minal Sawant et al. (2016) used PRIDE and mKRISHI business models. The farmers of Dindori tehsil of the Nashik district of Maharashtra state, India are trained by researchers in order to get more production within short span of time. Due to the personalized crop protocol, agro-advisory and timely alerts, the average increase in productivity was found to be 64% in 2013–2014 and 112% in 2014–2015. It also contributed to around a 90% increase in farmer participation in the second year.

Summary: The agriculture practices guide agriculture data mining. The challenges are also in implementation costs side. The challenge is to automate data acquisition in such a way that there are virtually no costs. Because on-farm data will generally remain in the hands of individual companies, investments are needed in a common pool infrastructure to transfer and integrate data and finally make applications out of it.

Big Data Challenges and Opportunities in Agriculture

Agriculture remains essentially a primary source of food for the population and raw material for a large number of industries, population growth, climate change and bio-energy crops are worldwide trends that are increasing the importance of using science to improve agriculture (Tilman et al., 2011). With the need to produce more food using fewer inputs, agriculture is seeking new products, practices and technologies. Research activities cantering on genomics, bioinformatics and computational biology of plants and animals enable the scientists and organizations to better feed the world and improve the quality of food and animal crops. Progress in agricultural growth can serve as a critical position for designing successful strategies to transform the economy and meet sustainable development (Christiaensen et al., 2010) and the investments in agricultural research play a key role to agricultural growth.

Farmers will have the tools to get the most from every acre. The future of farming depends largely on adoption of cognitive solutions. While large scale research is still in progress and some applications are already available in the market, the industry is still highly underserved. When it comes to handling realistic challenges faced by farmers and using autonomous decision making and predictive solutions to solve them, farming is still at a budding stage (Jones et al., 2017). Research on new generation agricultural design models shows that the data is most important parameter for This article, originally published under IGI Global's copyright on January 1, 2020 will proceed with publication as an Open Access article starting on February 2, 2021 in the gold Open Access journal, International Journal of Agricultural and Environmental Information Systems (converted to gold Open Access January 1, 2021), and will be distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/) which permits unrestricted use, distribution, and production in any medium, provided the author of the original work and original publication source are properly credited. International Journal of Agricultural and Environmental Information Systems Volume 11 • Issue 1 • January-March 2020 49 on-farm decision support, research investment and policy decision making. The agricultural industry will be transformed by data science and artificial intelligence. Collecting reliable agriculture data for farm management decision making is important scenario. The developments in the concept of smart farming make agriculture more efficient and effective with the help of high-precision algorithms (Baseca et al., 2019). The mechanism used in smart farming is machine learning (ML), the scientific field that gives machines the ability to learn without much programming. It has emerged together with big data technologies and high-performance computing to create new opportunities to ease, quantify and understand data intensive processes in agricultural operational environments.

The developments indicate that agriculture can benefit from machine learning at every stage like spices management, field management, crop management and livestock management. The artificial intelligence (AI) and machine learning are used in a number of agricultural applications today include the yield prediction algorithms based on weather and historical yield data, image recognition algorithms to detect pest and diseases in plants and robotics to harvest different types of specialty crops (Tibbetts 2018). This aspect needs an adaptive method to control the data sources and decision-making systems for better production and marketing with less waste of resource. Agriculture big data is playing important role by incorporating the AI and ML. The farmers are using data to calculate harvest yields, fertilizer demands, cost savings and even to identify optimization strategies for future crops as smart machines and sensors on farms and farm data grow in quantity and scope, farming processes will become increasingly data driven and data enabled. In order to obtain better productivity, the people are using precision agriculture (De Rango et al., 2019), (Somayeh et al., 2018) and (Maes and Steppe., 2019), automated irrigation scheduling (Li et al., 2018; Soulis & Elmaloglou, 2018), optimization of plant growth, farmland monitoring, greenhouse gases monitoring, production process management and security in crop

Smart Farming

Digitization has an important effect on the agricultural sector for quite some time now. This development can be described through the concepts of Precision Agriculture and Smart Farming. Precision Agriculture includes the implementation of automatically controlled agricultural machines, monitoring of the yields and various ways of seed drilling and fertilizer spreading. The right amount of seeds and fertilizers as well as adequate irrigation requirements can be determined based on soil and field data, aerial photography and historical weather and yield data. In addition, Smart Farming integrates agronomy, human resource management, personnel deployment, purchases, risk management, warehousing, logistics, maintenance, marketing and yield calculation into a single system.

The influence of digitization is not limited to traditional areas of agriculture, but also covers the increasing developments in livestock economy through sensor technologies and robots (e.g. milking robots).
The concepts described above use data from different sources, which are collected, analyzed, processed, and linked through various technologies.

The linking of this data is a distinguishing feature of big data in Smart Farming. This stands in contrast to the individual collection of so-called raw data, for example, weather data or the nutrient content of soil.

Smart Farming Technologies

Fundamental technologies for Smart Farming are tracking systems, such as GPS. They enable data to be allocated to a particular region of the farmland or determine the current position of agricultural machines or animals in the barn.

Thanks to GPS, highly precise and efficient self-driving agricultural machines stick to an ideal trajectory within the field tolerating a margin of deviation of only 2 cm. Simultaneously, sensors measure, for example the nitrogen content, the weed abundance and the existing plant mass in specific subareas. Research is currently looking into the development of sensors, which record the disease infestation of plants. The collected data is submitted to computers in the driver's cabin. These then calculate the best fertilizer composition for a specific area of the field based on a fixed set of rules and regulations and subsequently administer fertilizer to the area. Current research is engaged in developing robots, which could carry out certain field maintenance tasks on their own.
Farmers are even using drones to control their fields and plant growth. Images taken by the drones are being used to collect information about the entire farmland area. This data can be linked to the data collected by the sensors of the agricultural machines in order to create, for example, detailed digital maps of specific field areas. Additional data from other measurements can also flow into this data, such as infrared images, biomass distribution, and weather data.
The administration, management and interpretation of these data are further elements of big data. This data can be combined with plant cultivation rules stored in the system and used as decision-making algorithms in order to automatically determine management measures. An increasingly higher degree of automation is expected for the future.

Online systems that independently collect and analyze data and immediately convert it into management measures carried out by agricultural machines, allow for a high level of spatial and seasonal dynamic. In contrast, the decision processes in offline systems are based on static data, and the resulting instructions have to be transferred to the agricultural machines via storage mediums such as USB flash drives. Presently offline systems are more widespread, but real-time data systems are catching up. Real-time data systems are distinguished by their use of clouds. Through this process, all data connected with a specific product in one way or another, is merged on one platform, although those platforms are still in development.

In addition to precision and efficiency, the optimization of processes and anticipatory planning are key aspects of Smart Farming. A very good example is livestock farming, where microchips and sensors in collars measure the body temperature, vital data, and movement patterns of cows or other animals. Analyzing this data does not only allow to continuously monitor the health of the cows, but also to determine the appropriate time for insemination. Farmers and veterinarians are notified by a software controlled app. The milking of cows is already entirely carried out through robots, which also control the amount of milk and care for the udders of the cow. In the long run, the effective and useful implementation of big data for Smart Farming in the future requires the development of a nationwide digital infrastructure, especially in rural areas.

Quiz4: There is any difficulties in smart farm data implication's?

Social Implications

The evolution in agricultural engineering and management organization has many facets: self-driving agricultural machines, extensively automatized sowing, harvesting, and animal breeding, and also storage, analysis, and data evaluation through software and the use of decision-making algorithms. All those developments facilitate—at least in theory—a more accurate, efficient and ultimately more economical agriculture. But what are the consequences for stakeholders in the agricultural sector and for society as a whole? How does Smart Farming impact the environment?

The most obvious effects are the consequences for the farmers themselves. The machines connected to GPS significantly relieve the driver, allowing him/her to focus on the collected data. The monitoring of animals using sensors and computers reduces the need for presence in the stable to a minimum. It is doubtful though whether automatic rules can replace the experience and knowledge of farmers, and if this trend development really is an improvement. Also, the use of new technology is challenging and requires intensive periods of training for the farmers. Last but not least, there are costs for purchasing and installing the new technology. They can be quite substantial, thus favoring bigger companies, as the new technology is only profitable for companies of a certain size. The ever-increasing automation of procedures contributes to a continuing, decade-long structural change in Germany and the EU that results in the formation of even bigger companies and a simultaneous reduction of jobs.

Along with IT companies that collect and analyze data, new and old players enter the sector. Companies such as Monsanto collect and analyze data and make predictions concerning particular questions, such as predicting the best use of fertilizers. They are even able to predict the expected yield for the year by merging the data. Through these precise predictions, they gain advantages in futures exchanges and business negotiations. Apart from the dependence on seed companies, farmers could also become increasingly dependent on companies collecting and analyzing data. This dependence could be prevented—at least in part—by supporting "Open-Source Data Analytics".

Customers could potentially profit from the collection of data. The extensive recording of the production process allows customers to reconstruct for example where the wheat for their bread comes from and whether or not it has been chemically treated. It is also possible to coordinate supply and demand more efficiently by analyzing data of intermediaries and sellers. The exact amount of chemical and organic fertilizers used can be documented and the environmental impact then be analyzed. Digitalization simplifies the documentation of those procedures, as well as the detailed documentation of the entire production process from the purchase of the raw materials all the way through to the sale of the finished product, as required by EU regulations.

Environment impacts are also to be expected. On one hand, precise measuring should reduce the amount of pesticides and fertilizers used. This would result in less pollution of soil, groundwater and air. Also, better assessment of data, should reduce the use of antibiotics in livestock farming. On the other hand, those developments reinforce the current trend towards bigger companies and even bigger fields. This would have negative impacts on biodiversity and boost the use of monocultures. However, the use of Big Data in agriculture would also allow for a better assessment of the negative impacts of pesticides, for example neonicotinoids. Yet, at the moment, this data in most cases still is not made available for researchers.

Smart Farming is still in the developmental phase of an input- and capital-intensive agriculture and competes with alternative approaches such as ecological farming, which follows a holistic approach. In any case, the problem of world nutrition needs to be

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resolved by the small-scale agricultural farmers in developing countries. The focus on technical solutions might lead to disregard for alternative approaches.

Legal Implications

Smart Farming raises diverse legal issues, which, in their depth, still remain entirely unanswered. The amount that Smart Farming gains in economical, technical and social importance, the more pressing the legal issues will become in the future. So, where does a legal potential for conflict exist that needs to be addressed? New technologies are already valuable for farmers. Manufacturers of machines, seed producers and agricultural service providers are depending on the digital development in agriculture and expect to henceforth have an increased influence on the production methods.

In the USA, it is status quo that farmers submit data to service providers who professionally and individually prepare and analyze it to meet the needs and demands of the specific farmer. As a consequence, projects have been founded, that try to regulate publicity and privacy of the agricultural data of the parties involved.
The farmers' main fear is that the data could end up in the wrong hands. As newspapers report about disclosed security loopholes of technical systems on a daily basis, farmers fear not only data misuse by competitors or conservationists, but also misuse through commodity traders and data collecting service providers themselves. In this respect, IT safety is particularly crucial prerequisite.
In addition, state sanctioning and monitoring of farmers is being simplified, for example responsible environmental authorities can explicitly prove environmental law infringements. Whether this could in fact be a disadvantage to environmental protection, as a state objective according to article 20 (a) of the German constitution, remains to be seen.
It is certain that in digitalized agriculture, there is also a necessity to protect and safeguard data sets. This concern can only be guaranteed through interplay of technical data protection and legal protection. This is the only interaction which ensures that the farmers' data sovereignty is protected and potential misuse of the data inhibited. In Germany, Klaus Josef Lutz, the CEO of Europe's largest agricultural trader BayWa, claims that "data protection must have the highest priority".

Which Areas of Law Are Affected?

From a legal point of view, issues mainly arise in areas of data protection law and intellectual property law. Moreover, superordinate research challenges like the legal assignment of data and the related rights of data are an issue not only for Smart Farming, but for the entire Industry 4.0.

Data Protection Law

Data protection as an area of law is—in contrast to the decade long traditionally and conservatively influenced German agriculture—a comparatively new phenomenon. Besides the applicable special-law provisions in the German Telecommunications Act (TKG) or the German Telemedia Act (TMG), the German Federal Data Protection Act (BDSG) is, in particular, applicable regarding content data. The latter is applicable, if so called personal data is collected or processed. According to section 3 (1) BDSG data about the personal or objective circumstances of an identified or identifiable natural person is included.

The assignment of the data to a person is possible in a number of different ways. For example, data of animals can be assigned to the livestock owner. The same applies for data of agricultural products and especially for data of the farm field, which can be assigned to the owner, holder, tenant, or farmer. This is determined by using—for example—connected data of satellite monitoring, photos and landowner data from the Real Estate Register.
Further legal issues arise if modern machines, such as remote-controlled drones, have the ability to record other people and theoretically identify them. This is particularly relevant in densely populated areas.

Incidentally, in agriculture the basic principles of data collection apply, such as necessity, purpose, and data minimization in accordance with sections 3 (a), 31 BDSG. These principles are not only predestined to potentially conflict with Smart Farming and Precision Agriculture, but also with the general field of big data applications.

Conclusively, as of 2018, the European General Data Protection Regulation (GDPR) becomes relevant for the legal classification of content data. Its legal requirements for big data are still open for discussion.

Intellectual Property Rights Protection Shown by the Example of Database Manufacturers

The question that the farmer asks himself is how he/her can protect “his/her” data. Data protection law cannot solve this, as it only protects the right of personality of the person behind the data. This is where, in particular, the intellectual property rights come into play: It protects exclusive rights on intangible assets and regulates the granting of rights of use. Data itself cannot be—at least not yet—protected. Therefore, the copyright protection of databases will be discussed using the protection of data collections as an example.

Farmers can hereby arrange data—for example data of a specific field or crop—in a systematical and methodical way. If the data is individually accessible and the database shows that a substantial investment in either the acquisition, verification, or presentation of the content is required, a "database" within the meaning of the sui generis right, section 87a (1) German Copyright Act (UrhG), exists. The creator of the database would in most cases be the farmer himself according to section 87a(2) UrhG. If a substantial investment exists, depends on the individual circumstances. By using modern, high-quality sensors, or similar technologies, this threshold should be quickly reached. In the past, case law has not demanded high requirements. If all the requirements are met, the database maker is protected against the reproduction, distribution, and public communication of the whole database.

The issue of an abstract legal assignment of data is not only important for "intelligent" agriculture, but is of crucial importance for all big data industry sectors. In the smart farming sector, besides farmers, the data processing service providers and perhaps even the companies producing the machines and technologies will stake out a claim. Equally, liability issues—as in the case of insufficient data quality—are also of interest. The solution for all these problems is not only important for the agricultural sector, but also for all digital industries and in general for Industry 4.0. It will now be a matter of waiting to see what the global developments in research and practice will bring.

Conclusion and Forecast

Big data and agriculture is virtually a blank canvas, in particular, from the legal point of view. Issues regarding Smart Farming and related matters are still new items on the agenda, in contrast to discussions concerning self-driving or Connected Cars.

Therefore, the legislators have the opportunity to effectively regulate a new phenomenon from the very start to provide a safe environment for innovation and investments as efficiently as possible. To what extent this will be done remains to be seen. The factor of time should not be underestimated. Who would have thought a few years ago that farmers will be needing legal advice from IT lawyers in the future?

It should be ensured, that the technical developments do not take the agricultural sector by surprise and that the farmers lose their power and influence. Data collection and analysis can be important in the future, not only for more transparent production processes and a more efficient use of resources, but through facilitating an even better control and enforcement of environmental protection requirements. After all, successful environmental protection should also be an aim of the agriculture sector, as it creates a stable foundation for regeneration and use of fields.

One thing is certain; digitalization will substantially influence and change the work in farming, as it is known today. Although the use of big data applications in agriculture is not as advanced as other sectors yet, the developments in agriculture are of paramount importance for population and society; it is ultimately all about their own nutrition.

Assignment 1: Review one article discuss big data analysis related smart agriculture

Assignment 2: Visit benefit sensors data site and compare the data daily, weekly and compare results

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Boosting Innovation in Education and Research of Precision Agriculture in Palestine

Course name: Principles of crop physiology

Module name: Precision agriculture based on crop physiological principles

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Introduction:

Agriculture must provide an ever-increasing amount of quality food, fiber, feed, and fuel for humankind. And it must do this in a manner that is environmentally, economically, and socio-politically sustainable. This will become even more challenging in the future as there is no single technology that can solve this problem. The development and proper implementation of precision agriculture therefore can be a great help toward achieving this very important task.

Precision Agriculture: “an integrated information- and production-based farming system that is designed to increase long-term, site-specific and whole farm production efficiency, productivity and profitability while minimizing unintended impacts on wildlife and the environment.” The key to this definition is that it identifies PA as a “whole-farm” management strategy (not just for individual fields) that utilizes information technology and that the aim of management is to improve production and minimize environmental impact. It also refers to the farming system which in modern agriculture may include the supply chain from the farm gate to the consumer

Precision agriculture has under delivered partially because it has been based on technology focused on increasing the resolution of spatial variation in soil and yield and more recently automation, with less effort in incorporating the physiological principles of crop responses to environmental variation. We considered that a successful implementation of PA at farm level requires a detailed characterization of the yield limiting factors such as soil water holding capacity and extreme temperatures, the identification of agronomically meaningful, homogeneous management macro zones, and the selection of the most appropriate crops and their management for each zone. We will refer to this type of PA as “zone management”. Crop physiological principles are critical to develop and implement effective zone management at farm level.

To supplementary develop the perception, PA can be reflected as the application of information technologies, combined with production experience, to:

- optimize production efficiency
- optimize quality
- minimize environmental impact
- minimize risk

Plant growth and development

In order to increase crop yields, it is important to understand how plant growth and development interact with environmental factors including light, temperature, soil characteristics, and water availability. To model, physiological processes involved in growth, such as water and nutrient uptake, photosynthesis and carbon absorption should be considered.

Understanding the physiological aspects of seed germination, seedling growth, crop establishment, vegetative development, flowering, fruit and seed setting and crop maturity, plant hormone interaction, nutrient physiology, stress (biotic/abiotic) physiology etc., provides a reasonable scientific base for effective monitoring and beneficial manipulation of these phenomenon's.

Photosynthesis is probably the single most important process in plant growth. Respiration is the process by which the food matter produced by photosynthesis is converted into energy usable for growth of the plant. Photosynthesis and respiration make these processes possible, and the balance between these results in growth. It must be emphasized that growth involves the plant in hundreds of chemical processes, occurring in the different organs and tissues throughout the plant.

Growth is a difficult term to define because it really encompasses the totality of all the processes that take place during the life of an organism. However, it is useful to distinguish between the processes which result in an increase in size and weight, and those processes which cause the changes in the plant during its life cycle, which can usefully be called development.

The following environmental requirements for photosynthesis are explained in detail below:

- carbon dioxide
- light
- adequate temperature
- water

Photosynthesis :

Photosynthesis is the absorption of light energy and its conversion into chemical energy. During photosynthesis, CO2 and water transformed into simple carbohydrates and O2 is liberated into the atmosphere.

The simple CH2O3 produced during photosynthesis are converted by additional metabolic process, into lipids, nucleic acids, proteins and other organic molecules.

♦ These organic molecules in turn, are elaborated into leaves, stems, roots, tubers, fruits, seeds and other tissues and organ system.

Thus, the overall reaction of oxygenic photosynthesis can be represented as.

$$6\,CO_2 + 6\,H_2O \xrightarrow[\text{CHLOROPHYLL}]{\text{LIGHT}} C_6H_{12}O_6 + 6O_2$$

This equation is frequently represented by the simplified form:

$$CO2 + 2\,H2O \longrightarrow (CH2O) + H2O + O2$$

The photosynthetic process is carried out by three steps:

i i. The absorption of light and retention of light energy.

ii ii. The conversion of light energy into chemical potential.

iii iii. The stabilization and storage of chemical potential.

Based on the three steps, the yield of a crop can be expressed by an equation

Y = Q x I x E x H

Q = Quantity of solar radiation received by the leaf or striking the leaf.

I = Fraction of Q utilized by plants.
E = Overall photosynthetic efficiency of the canopy (i.e. efficiency of the conversion of solar energy to chemical energy) in terms of total dry matter produced by the plants.
H = Fraction of dry matter allocated to the harvested parts (Harvest index).

Photochemical reaction:

In a photochemical event, only one above or one molecule is activated for each photon absorbed. Therefore, the number of excited molecules equals the number of photons absorbed. While observing the structure of a pigment molecule, nucleus possess the protons and neutrons. Whereas electrons are seen at various distances away from the nucleus. The electrons have different energies, depending on the distance from the nucleus. Nearer the electron to the nucleus, greater is the pull or attraction of the nucleus on electrons. If a photon of appropriate energy strikes the pigment, the electron in an inner shell is raised to an outer shell and the pigment is said to be in an excited state.

The excited molecule will participate in the chemical reaction (chlorophyll 'a') or it may transfer the excitation energy (accessory pigment) to the neighboring pigments molecule by resonance transfer. Otherwise, the excited molecule may return to the ground state by two processes. 1. By emitting the radiant energy (Emission of radiant energy) or 2. By dissipating the heat (Heat dissipation).

Emission of radiant energy:

Chlorophyll molecules are capable of absorbing both red light and blue light. Red light is lesser energetic than blue light. Following the absorption of red light (660 nm), chlorophyll molecule attains the excited level called the first excited level. The lifetime of the excited molecule is quite short, often of the order of 10-10 to 10-8 s. When the energy is transferred to another pigment, excited chlorophyll returns to the ground state through the loss of energy by the emission of light. The emission of light within this short period of time (10-10 to 10-8S) is referred to as fluorescence. The red light at the wavelength of 700 nm has raised the electron to the first excited level, whereas more energetic blue light of shorter wavelength (400 nm) raised the electron to the second excited level. The life time of this excited molecule is long i.e. 10-2 to 10-1 seconds. Such long lived excited molecules have much greater probability of interacting with neighboring molecules and participating in photochemical reaction or the energy of the long lived molecule is emitted as light. This process is referred to as 'Phosphorescence'. The major difference between fluorescence and phosphorescence is that fluorescence occurs rapidly whereas the light emission by phosphorous is delayed. The excited chlorophyll molecule is involved in the transformation of radiant energy to chemical energy. As the result of the transformation of radiant energy, the chemical potentials such as ATP and NADPH are found besides releasing O2.

Environmental factors affecting photosynthesis:

Carbon dioxide

In order that a plant may build up organic compounds such as sugars, it must have a supply of carbon which is readily available. **Carbon dioxide** is present in the air in concentrations of 330 ppm (parts per million) or 0.03 per cent, and can diffuse into the leaf through the stomata. Carbon dioxide gas moves ten thousand times faster in air than it would in solution through the roots. The amount of carbon dioxide in the air immediately surrounding the plant can fall when planting is very dense, or when plants have been photosynthesizing rapidly, especially in an unventilated greenhouse.
This reduction will slow down the rate of photosynthesis, but a grower may supply additional carbon dioxide inside a greenhouse or polythene tunnel to enrich the atmosphere up to about three times the normal concentration, or an optimum of 1000 ppm (0.1 per cent) in lettuce. Such practices will produce a corresponding increase in growth, provided other factors are available to the plant. If any one of these is in short supply, then the process will be slowed down. This principle, called the law of limiting factors, states that the factor in least supply will limit the rate of the process, and applies to other non- photosynthetic processes in the plant. It would be wasteful, therefore, to increase the carbon dioxide concentration artificially, e.g. by burning propane gas, or releasing pure carbon dioxide gas, if other factors were not proportionally increased.

Figure 1. CO2 burner enriches the glasshouse environment, so helping provide an optimum growing environment. (Biocyclopedia),https://biocyclopedia.com/index/principles_of_horticulture/photosynthesis.php.

Light

Light is a factor required for photosynthesis to occur. In any series of chemical reactions where one substance combines with another to form a larger compound, energy is needed to fuel the reactions. Energy for photosynthesis is provided by light from the sun or from artificial lamps. As with carbon dioxide, the amount of light energy present is important in determining the rate of photosynthesis – simply, the lighter or greater illuminance (intensity) absorbed by the plant, the more photosynthesis can take place. Light energy is measured in joules/square metre, but for practical purposes the light for plant growth is measured according

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to the light falling on a given area, that is lumens per square metre (lux). More recently, the unit ‘ microwatts per sq. metre ’ has been introduced. One lux, in natural sunlight, is equal to microwatts per sq. metre. Whilst the measurement of illuminance is a very useful tool for the grower, it is diffi cult to state the plant’s precise requirements, as variation occurs with species, age, temperature, carbon dioxide levels, nutrient supply and health of the plant.

However, it is possible to suggest approximate limits within which photosynthesis will take place; a minimum intensity of about 500–1000 lux enables the plant’s photosynthesis rate to keep pace with respiration, and thus maintain itself. The maximum amount of light many plants can usefully absorb is approximately 30 000 lux, while good growth in many plants will occur at 10 000–15 000 lux. Plant species adapted to shade conditions, however, e.g. Ficus benjamina , require only 1000 lux. Other shade-tolerant plants include Taxus spp., Mahonia and Hedera.
In summer, light intensity can reach 50 000–90 000 lux and is therefore not limiting, but in winter months, between November and February, the low natural light intensity of about 3000–8000 lux is the limiting factor for plants actively growing in a heated greenhouse or polythene tunnel. Care must be taken to maintain clean glass or polythene, and to avoid condensation that restricts light transmission. Intensity can be increased by using artificial lighting, which can also extend the length of day, which is short during the winter, by supplementary lighting. This method is used for plants such as lettuce, bedding plants and brassica seedlings.

The type of lamp

Lamps are chosen for increasing intensity, and therefore more photosynthesis. All such lamps must have a relatively high efficiency of conversion of electricity to light, and only gas discharge lamps are able to do this. Light is produced when an electric arc is formed across the gas fi lament enclosed under pressure inside an inner tube. Light, like other forms of energy, e.g. heat, X-rays and radio waves, travels in the form of waves, and the distance between one wave peak and the next is termed the wavelength. Light wavelengths are measured in nanometres (nm); 1 nm

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one thousandth of a micrometre. Visible light wavelengths vary from 800 nm (red light – in the long wavelength area) to 350 nm (blue light – in the short wavelength area), and a combination of different wavelengths (colours) appears as white light. Each type of lamp produces a characteristic wavelength range and, just as different coloured substances absorb and reflect varying colours of light, so a plant absorbs and reflects specific wavelengths of light.
Since the photosynthetic green pigment chlorophyll absorbs mainly red and blue light and reflects more of the yellow and green part of the spectrum, it is important that the lamps used produce a balanced wavelength spectrum to include as high a proportion of

those colours as possible, in order that the plant makes most efficient use of the light provided. The gas included in a lamp determines its light characteristics.
The two most commonly used gases for horticultural lighting are mercury vapour, producing a green blue light with no red, and sodium, producing yellow light. This limited spectrum may be modified by the inclusion of fluorescent materials in the inner tube, which allow the tube to re-emit wavelengths more useful to the plant emitted by the gas and re-emit the energy as a shorter wavelength. Thus, modified mercury lamps produce the desirable red light missing from the basic emission.

Electroluminescent lamps, e.g. LEDs, emit light by applying an electric field to a material. In general, LEDs are more advLEDs are characterized by their long lifetime, their robustness and their stable output when an electric current is applied. In addition, they are compact and lightweight and turn on instantaneously, and the light output can be easily controlled.
Finally, LEDs are available in several colour types allowing the control of the spectral distribution of emitted lightantageous compared with other lamp types.

Carbon dioxide enrichment should be matched to artificial lighting in order to produce the greatest growth rate and most efficient use of both factors.

Temperature

The complex chemical reactions which occur during the formation of carbohydrates from water and carbon dioxide require the presence of chemicals called enzymes to accelerate the rate of reactions. Without these enzymes, little chemical activity would occur. Enzyme activity in living things increases with temperature from 0°C to 36°C, and ceases at 40°C. This pattern is mirrored by the effect of air temperature on the rate of photosynthesis. But here, the optimum temperature varies with plant species from 25°C to 36°C as optimum. It should be borne in mind that at very low light levels, the increase in photo-synthetic rate with increased temperature is only limited. This means that any input of heating into the growing situation during cold weather will be largely wasted if the light levels are low.

Integrated environmental control in a greenhouse is a form of computerized system developed to maintain near-optimum levels of the main environmental factors (light, temperature and carbon dioxide) necessary for plant growth. It achieves this by frequent monitoring of the greenhouse using carefully positioned sensors. Such a system is able to avoid the low temperature/light interaction described above. The beneficial effects to plant growth of lower night temperatures compared with day are well known in many species, e.g. tomato. The explanation is inconclusive, but the accumulation of sugars during the night appears to be greater, suggesting a relationship between photosynthesis and respiration rates. Such responses are shown to be related to temperature regimes experienced in the areas of origin of the species.

Figure 2. The glasshouse environment may be controlled by means of (a) a computer situated in the glasshouse, while (b) conditions are monitored throughout the glasshouse. (Biocyclopedia),https://biocyclopedia.com/index/principles_of_horticulture/photosynthesis.php.

Water

Water is required in the photosynthesis reaction but this represents only a very small proportion of the total water taken up by the plant. Water supply through the xylem is essential to maintain leaf turgidity and retain fully open stomata for carbon dioxide movement into the leaf. In a situation where a leaf contains only 90 per cent of its optimum water content, stomatal closure will prevent carbon dioxide entry to such an extent that there may be as much as 50 per cent reduction in photosynthesis. A visibly wilting plant will not be photosynthesizing at all.

Plant Physiology and Ecology Monitoring System:

Plant physiological and ecological monitoring system is a plant physiological and ecological data acquisition system, which uses wireless sensors to monitor plant physiological status and environmental factors for a long time.

Figure 3. Plant Physiology and Ecology Monitoring System, TOP CLOUD AGRI TECHNOLOGY), https://www.agri-instrument.com/plant-physiology-and-ecology-monitoring-system.html.

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PAR Sensor

The PAR (Photosynthetically Active Radiation) Sensor measures photosynthetic light levels in both air and water. The sensor responds to visible light in the spectral range that is used by plants in photosynthesis (400–700 nm). It features a waterproof sensor head and reports the Photosynthetic Photon Flux Density (PPFD), which is measured in µmol m-2 s-1 (micromoles of photons per meter squared per second). The sensor is calibrated for use in sunlight, but can also be used to measure PPFD from electric light sources. This sensor is ideal for experiments that investigate photosynthesis and primary productivity and can also be used in many agricultural and environmental science applications.

Leaf Temperature Sensor

Leaf temperature is a key variable governing plant physiological processes, such as photosynthesis and respiration. Further, very high temperatures can lead to leaf necrosis. Increasing warming of the atmosphere and occurrence of heatwaves means that understanding physical and physiological processes of leaf temperature is of increasing importance.

The Leaf Temperature Sensor is a sub-miniature touch probe that measures absolute temperature of a leaf.

The lightweight stainless steel wire clip holds a high precision glass encapsulated thermistor, which is about millimeter in diameter. Small size of the probe and its special design provide almost negligible disturbance of the natural leaf temperature.

The thermistor is typically positioned on the underside of the leaf blade where it comes into equilibrium with the leaf's temperature. As the leaf transpires, through stomatal conductance or the loss of water vapor through tiny pores (stomata) on the leaf, the temperature of the leaf will be lower than ambient air temperature. Plants under low irrigation or drought stress will have a leaf temperature closer, or higher, than ambient air temperature.

The thermistor is connected to the clip by a thin 0.15 mm leads to minimize heat conduction and response time. All conductors are proofed to avoid corrosion under the wet operating conditions.

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Leaf Wetness Sensor

The leaf surface wetness sensor is an important tool for observing and studying the leaf surface wetness, preventing diseases and insect pests, and controlling sprinkler irrigation. The leaf surface wetness sensor can accurately measure the leaf surface wetness, and can monitor the trace moisture or ice crystal residues on the leaf surface.

Leaf wetness refers to the amount of dew and precipitation remaining on the surface. The level of leaf wetness has an important influence on plant infection pathogens. When the plant leaf surface wetness is too high, it will increase the breeding probability of field bacteria and increase the risk of leaf infection. Once the plant is infected with the disease bacteria, the disease bacteria will damage the leaf surface structure, which is not conducive to the growth and development of the plant.

Sap Flow Sensors

Sap flow is the movement of fluid (water and nutrients) through a plant. It can be used as an indicator of transpiration. Increased sap flow is a signal of a healthy plant which is actively transpiring. Sap flow will reduce as a plant goes from an irrigation cycle to a stress cycle.

Measuring sap flow

Sap flow sensors measure the movement of fluid in the xylem. Sap flow sensors are installed by inserting probes into the plant's sapwood. Sensors use a heater probe to measure the velocity of fluid moving through the stem.
Conversion factors are then used to translate readings to sap flow values which are measured in liters per hour.

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Figure 4. Sap flow sensor probe (right) and data logger on a pear tree. (Edaphic Scientific), https://edaphic.com.au/products/sap-flow-sensors/multi-sensor-sap-flow-system/

Interpreting sap flow

Sap flow can be continuously logged to determine the amount of water used (transpired) by the plant each day.

Sap flow is highest during the day when plants are actively transpiring, and low during the night when little or no transpiration occurs.

Sap flow changes in response to the climatic conditions as it is directly related to transpiration. On a cloudy day, transpiration rates will be lower and sap flow declines. Similarly, wet canopies can have reduced (up to half the normal) transpiration rates, causing lower sap flow.

Peak sap flow will decline is a plant enters water stress. This can help indicate when an irrigation event is needed.

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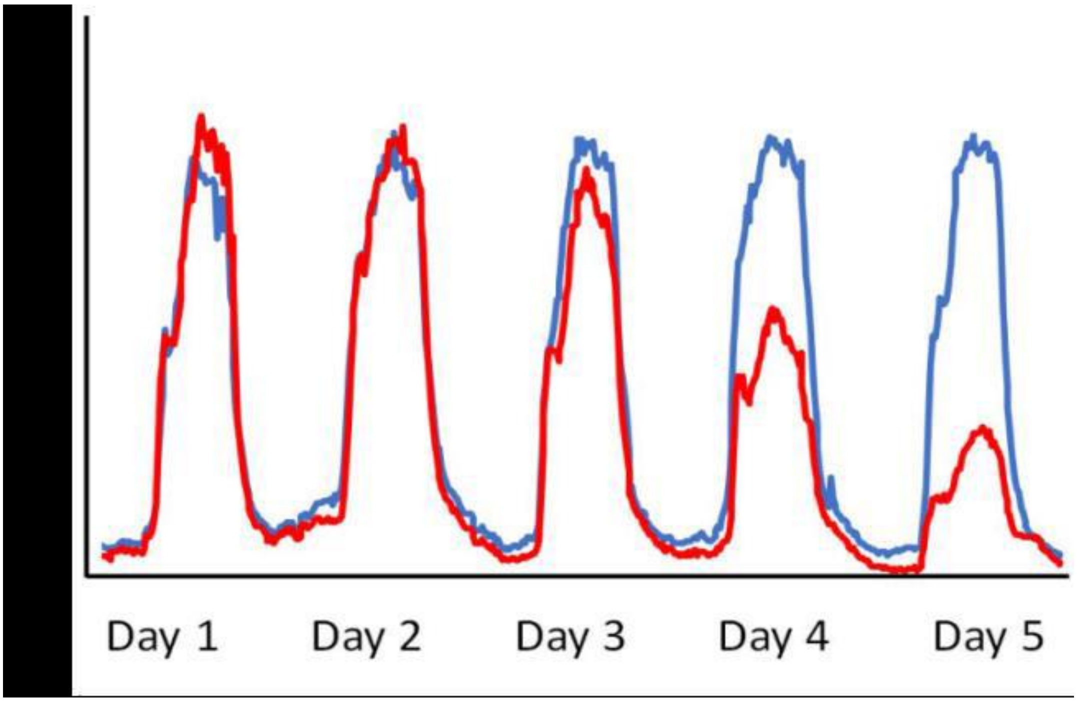

Figure 5. Daily sap flow patterns for two trees. The red line shows a tree entering water stress on day 3. (Edaphic Scientific), https://edaphic.com.au/products/sap-flow-sensors/multi-sensor-sap-flow-system/

Sap flow readings can also be compared to daily evapotranspiration data or maximum air temperature to help identify when an irrigation event is needed. High evapotranspiration readings should correspond to high sap flow, if water is not limiting.

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Quiz

Q1. Explain the importance of the physiological aspects of precision farming?

Q2: What is a PAR sensor?

Q3: Explain the importance of measuring leaf temperature for crops?

BENEFIT

Boosting Innovation in Education and Research of Precision Agriculture in Palestine

Course name: Introduction in Animal Production

Module name: Application of precision agriculture in closed poultry farm

Prepared by

Iyad Badran

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Introduction of Precision livestock farming (PLF)

Precision livestock farming (PLF) is defined as the management of livestock production using the principles and technology from process engineering. PLF though an integrated management system (IMS) attempts to recognise each individual animal, and is typically applied to the more intensive husbandry of pigs and poultry, and dairying. Processes suitable for the PLF approach include animal growth, milk and egg production, detection and monitoring of diseases and aspects related to animal behaviour and the physical environment such as the thermal micro-environment and emissions of gaseous pollutants. The advance of monitoring and control systems has led to the development of automatic milking machines now being marketed by several European manufacturers. Essentially, automatic attachment of teat-cups connects each cow, at a time of its own choosing, to the vacuum milking line. The cups must be applied firmly but gently to the cows' teats, avoiding damage to the cow and the likely consequent damage to the machine. These voluntary milking systems handle 65 or more cows on an average of 2.7 times per day. New systems include milk monitoring systems to check fat and microbial levels, helping to indicate potential infections, as well as new robotic feeding systems, weighing systems, robotic cleaners, feed pushers and other aids for the stockman such as imaging systems to avoid direct contact with animals.

The economic justification for these expensive units is that they offer each cow the opportunity to be milked more often than the usual procedure (twice a day). This is beneficial for the caws and it increases milk yield. New systems for data monitoring for feed and water consumption can be used to the early detection of infections. Other developments include the monitoring on the growing herd where measurement of growth in real time is important to provide producers with feed conversion and growth rates. Acoustic sensors detect an increase in coughing of pigs as an indicator of respiratory infection. Recent studies discuss that improved management could raise cow yields to 20,000 litres per life time whilst increasing the life expectancy of cows. Higher yield and longer life could reduce agricultural methane emissions by 30%. Quality of feed is difficult to measure but by using a pH bolus in the rumen of sentinel cows the pH can be accurately tracked and feed adjusted as necessary.

Other sensors are now used to provide alerts concerning birthing and fertility. A vaginal thermometer monitors the temperature, imminence of birthing and the breaking of waters, and communicates to the farmer via SMS. Also, a sensor placed on an animal's collar records parameters to detect signs of oestrus and the readiness for fertilisation. An SMS message then allows the farmer to plan for insemination.

As part of precision farming, managing livestock is one of the current challenges for agriculture]. The term ‘precision livestock farming’ (PLF) appeared in the early 21st century, with the first PLF conference held in 2003 as an innovative production system approach , playing a key role in the fourth industrial revolution, also known as Industry 4.0 . PLF is potentially one of the most powerful developments amongst a few interesting new and upcoming technologies that have the potential to revolutionize the livestock farming industries.

PLF uses a combination of tools and methods to measure different variables from each animal with high precision, supporting farmers to make decisions concerning the livestock production systems. Decisions are often based on the acquisition, collection, and analysis of quantitative data obtained by continuous real-time from animals and the environment. These tools include sensor technology cameras, microphones, wireless communication tools, Internet connections, and cloud storage, among others.

However, the application of the existing tools for PLF can be challenging under extensive livestock management because this occurs on natural pastures that are large, heterogeneous, and highly dynamic environments. Therefore, the main purpose of PLF is to enhance farm profitability, efficiency, and sustainability by improving on-farm acquisition, management, and utilization of data management and the utilization of data, in order to enhance the nutritional and other management aspects from distinct species of animals. PLF could also deliver additional food safety, traceability, welfare, and environmental benefits. In addition, PLF aims the management of crop processes to create perfect synergy with livestock feeding. If properly implemented, PLF could (a) promote product segmentation and better marketing of livestock products; (b) reduce illegal trading of livestock products; and (c) improve the economic stability of rural areas. In this section, we present some of the technological advancements and scientific research involved with PLF

The increase of global population comes along with growing demands on protein resources. To meet such demands, world poultry meat and egg production. Precision Poultry Farming (PPF) features applications of continuous, objective, and automated sensing technologies and computer tools for sustainable and efficient poultry production; and it offers solutions to poultry industry to address challenges in terms of poultry management, environment, nutrition, automation and robotics, health, welfare assessment, behavior monitoring, waste management, etc.

We invite original research papers, on a global scale, that address sustainability and efficiency of poultry industry and explore above mentioned areas through applications of PPF solutions in poultry meat and egg production for this special issue of "Precision Poultry Farming".

GENERAL INFORMATION OF POULTRY PRODUCTION

Chicken meat and eggs provide not only high-quality protein, but also important vitamins and minerals

A major advantage of eggs and poultry meat as human food is that there are no major taboos on their consumption. In addition, a chicken provides a meal for the average family without the need for a refrigerator to store left-overs. Meat from other livestock such as pigs and cattle is kept mainly for special festive occasions and celebrations, partly because of a lack of storage facilities (no refrigerator or electricity supply). Eggs can be purchased relatively ever likely to eat.

poultry has a major role to play in developing countries. Produce is relatively inexpensive and widely available. The commercial poultry industry provides employment and is growing rapidly. To produce 1 kg of meat from a commercial broiler chicken only about 1.7 kg of feed is needed.

Poultry production has a less detrimental impact on the environment than other livestock, and uses less water. Semi-scavenging backyard indigenous poultry are extremely important in providing income and high-quality protein in the diets of rural people whose traditional foods are typically rich in carbohydrate but low in protein. The vexed question of the cholesterol content of eggs and human health seems to have been exaggerated.

Poultry housing

Improvements to poultry housing systems in developing countries have focused on providing an environment that satisfies the birds' thermal requirements. Newly hatched birds have a poor ability to control body temperature, and require some form of supplementary heating, particularly in the first few days after hatch. Many developing countries are located in tropical areas where minimal heating is required.

Large-scale commercial farms

Commercial houses in developing countries are clear-span structures with litter on the floor for meat birds or cages for laying hens. The commercial chicken meat industry in some developing countries is vertically integrated, with single companies owning feed mills, breeder farms, hatcheries and processing plants. Arrangements typically involve agreements in which the farmer or landowner provides the housing, equipment and labour, while the company provides the chicks, feed, medication, transport and supervision.

systems are common. Most large-scale commercial farms use controlled-environment systems to provide the ideal thermal environment for the birds (Glatz and Bolla, 2004). Birds' performance in controlled-environment sheds is generally superior to that in naturally ventilated houses, as the conditions can be maintained in the birds' thermal comfort zone. Achieving the ideal environment for birds depends on appropriate management of the poultry house

Modern houses are fully automated, with fans linked to sensors to maintain the required environment. Some commercial operators use computerized systems for the remote checking and changing of settings in houses. Forced-air furnaces and radiant heating are the main methods of providing heat to young chicks

Precision Livestock Farming (PLF) has yet to become a widespread commercial reality in the poultry sector

It found that PLF development has most commonly focused on broiler farming, followed by laying hens, and mainly involves the use of sensors (environmental and

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wearable) (51.89%) and cameras (42.42%) followed by the use of microphones (14.02%). Almost all papers (96.21%) described prototype systems, suggesting there were very few commercially systems available. The commercially available technologies were the eYeNamic Camera systems, and environmental sensors to measure temperature, ambient dust, relative humidity, vibration, ammonia concentration, carbon dioxide concentration and a thickness and crack sensor for eggs.

Why is there a lack of commercial PLF systems?

The reason for the lack of commercial PLF systems could be, according to some studies, that research does not involve manufacturing companies from the start. Few systems undergo trials under commercial conditions and there is sometimes incomplete development of technology, especially when equipment shows poor robustness or reliability. This coupled with the uncertain payback period for farmers investing capital in PLF, is affecting the industry.

Poultry use of PLF lags behind other species

While the obstacles affect other sectors, it appears that PLF in the poultry arena is lagging behind other species, such as dairy cattle. Commercially available PLF technology in the dairy sector includes devices to identify, track and milk individual animals, feed animals automatically and obtain diagnostic data about a range of health and performance issues

More publications had animal health and welfare (63.64%) than production (51.14%) as one of the goals. Likewise, for the publications with only one goal, more publications had animal health and welfare as the only goal (39.77%) compared to production (27.27%).

Application of PLF in poultry farming

Poultry welfare

PLF technology may offer more objective measures of welfare than traditional assessment methods carried out by human observers, providing real data to the otherwise subjective discussion process. PLF allows modern, large-scale farms to replicate and even to improve on the benefits of caring farmers who know their animals, transferred to a larger scale. This could be done via closer monitoring than farmers can provide to even a few animals, as well as integration of data via decision algorithms.

Welfare advocates' concerns about PLF systems

However, this has led to concern among animal welfare advocates that PLF systems, in aiding the management of intensive farming systems, may entrench the use of such systems that have limited potential for achieving good animal welfare issues. On the other hand, some scientists have argued that PLF technologies can serve to highlight the welfare issues of poor systems and inform evidence-based strategies for their improvement. Others have said PLF use in the broiler sector can only be part of a solution to improve welfare, alongside for example, using slower growing strains, reducing stocking density and increasing the dark period length in houses.

The review said that while the potential for welfare had been substantially discussed, it remained unclear as to whether improving bird welfare had been the goal or if the focus had been on improving production efficiency.

There is a need for future work around overcoming barriers to commercialisation and on expanding the range of welfare measures, particularly those involving behaviour, that can be used as part of PLF. And there is a need for more large-scale commercial trials that involve manufacturing companies, farmers and other stakeholders from the outset.

Precision management of animals using technology is one innovation in agriculture that has the potential to revolutionize whole livestock industries including the poultry sector. Limited research in precision livestock farming (PLF) in the poultry production has been so far conducted and most of them are conducted within the past 5-10 years. The PLF collects real-time data from individual or group of animals or birds using sensor technology, and involves the multidisciplinary team approach to give it a reality. Poultry scientists play a central role in executing poultry PLF with collaboration from agri-engineers and computer scientists for the type of measurements to be made on biological or environmental variables. A real-time collection of environmental, behavioral and health data from bird grow-out facilities can be a strong tool for developing daily action plans for poultry management. Unlike other livestock farming, the attributes of poultry rearing such as a closed housing system and vertically integrated industry provides a greater opportunity for poultry sector to adopt technology-based farming for enhanced production output.

“Precision”, a focal word in livestock farming including the poultry sector, refers to the precise control and optimization of production processes in order to improve animal welfare, productivity and profitability . Precision management of animals using technology is one innovation in agriculture that has the potential to revolutionize whole livestock industries. Precision livestock farming (PLF) of commercial poultry has both challenges and opportunities because of the large size of the flock as PLF, in principle, involves monitoring farm animals at an individual level . An important dimension of PLF that requires an initial consideration would be evaluating spatial distribution suitability of farm geography so that there is minimal environmental impact and greater prospect on economic viability of farm construction in a specific area . Siting of a farm could be evaluated for slope gradient, land type, ecology conservation, cultural

relics, soil fertility demand, distance to transport route, distance to surface water, distance to residential area, and distance to existing large-scale livestock and poultry farms . There is an ongoing discussion on whether the PLF technology in poultry precision management at individual bird level would be feasible or would still need considerable research and development before its acceptance to the poultry sector. Nonetheless, tremendous opportunity lies in the poultry sector for PLF technology.

Because of the fast growth rate, modern broilers are vulnerable to problems such as lameness, contact dermatitis, and metabolic diseases. Using proper sensors and artificial intelligence technology such as ultra-wideband (UWB) tracking, computer vision (CV), accelerometers, or radio frequency identification (RFID), the potential remains to monitor the flock at an individual bird level . The RFID is a form of wearable sensor technology whereas CV is the remote sensor technology. The RFID can be utilized in bird behavior study . It becomes even more meaningful for poultry sector if PLF technology can be fully adopted as compared to its application in other livestock species as thousands of birds in the flock can be saved from early detection of one sick bird that needs to be culled from the flock before the situation transforms to endemic.

The strength of PLF technology lies in its ability of distinguishing abnormal behavior or activities in early stage and real-time as a consequence of disease, injury or any type of stressors, and thus, applying corrective action to the affected flock that sick animal or bird represents. The poultry farming, like any other livestock farming, is faced with many challenges as more concerns are raised in animal welfare, antibiotic-free (ABF) production, and environmental impacts while producing the food animals . Poultry producers and growers are optimizing their profit margin handling larger flocks with limited labor access and availability.

A survey with poultry growers in one of the states in US showed the average number of employees per farm was 1.42 .This necessitates an application of new technologies in grow-out facilities. The data outputs of PLF aid in enhanced monitoring of flock at the individual level with minimal labor involved and promote in taking daily wholesome decision regarding flock management . Unlike other livestock farming, poultry rearing is conducted in a closed housing system. Furthermore, the industry is vertically integrated, which allows more opportunity for the industry to adopt technology-based farming. This paper highlights the need of research and development of PLF in poultry sector, and traces the past and current research on the sensors and technology used in poultry facilities to collect and understand the barn environment

PLF Is a Multi-disciplinary Approach with Poultry Scientists in a Key Role

The PLF is a multi-disciplinary team approach of mainly poultry scientists, agri-engineers, and computer scientists to make poultry PLF a success or a reality. The poultry scientists play a key role in precision poultry farming as understanding the fundamentals of bird biology and management cannot be overruled.

The PLF collects real-time data from individual animals or birds using sensor technology. The sensors can be installed in the barn unit or can be wearable by animal in the least intrusive way while allowing the animal to fully express its natural behavior. Poultry scientists will play a central role in collaborating with agri-engineers and computer scientists and articulating for the measurements to be made on biological or environmental variables. Agri-engineers can help design the PLF technology according to the need as expressed by poultry scientists. The concerted efforts produce an output, such as animal friendly sensors and/or data management systems, to generate information for decision making. In complex cases, handling the large pool of data (visual, categorical or numerical) will require aid of artificial intelligence to develop algorithms or patterns where computer engineers and data scientists come into picture. By comprehending these algorithms and patterns, it helps poultry scientists to take timely and real-time appropriate management decisions. PLF system not only helps capture the animal-related data but also gives insights on the impacts of facility design on the performance of birds. By utilizing the data generated from animals/birds using PLF technology, it facilitates the considerations to be made to reengineer the whole facility design. PLF can be applied to several areas of poultry production.

PLF in Improving Management, Health and Welfare, and Feeding of Poultry

PLF in the poultry sector have been so far conducted and most of them are conducted within the past 5-10 years The PLF researches in the poultry sector concentrated on taking data related to barn environment and health and behavior of bird to assess the welfare Various automated sensors have been in use in poultry grow-out facilities to monitor air temperature, air velocity and humidity. Very few researches have been conducted in precision feeding or feeding behavior Combining the environmental data with bird behavior data measured from utilizing sensors, the algorithms can be developed . The pattern discovered from using algorithms can be a valuable tool to make decisions regarding daily bird management or improving welfare. A study utilized a prototype sensor to monitor volatile organic compounds (VOCs) in the air inside the barn, where it was shown to detect the presence of early coccidiosis infection . Several wireless-based sensors and use of Internet of Things (IoT) tools to monitor environmental parameters have been proposed as a promising tool in PLF . Footpad dermatitis is one major welfare concern in broiler production that is linked to poor grow-out environmental conditions. Broilers affected with footpad dermatitis develop ulcers in footpads affecting their gait, and eventual inability to reach to feed or water. Welfare assessment in broilers using the manual scoring resource is time-demanding and can risk farm from biosecurity measure. Strong co-relation was predicted ($p < 0.001$) for footpad incidence in broilers with thermal temperature and humidity index . Several other studies proposed the fully automated monitoring system for early detection of lameness . Sensors have also been utilized for the early detection of viral disease states. Avian influenza can sometimes be epidemic and pose a potential health threat to both birds and humans. A research team developed an avian influenza monitoring system utilizing sensor network by a simulation of the spread of highly pathogenic avian influenza viruses in chickens, and the results showed the capability of sensors detecting the avian influenza virus two days earlier than conventional detection of disease outbreak . Other respiratory diseases can be timely detected using appropriate sound technologies . Sensing devices such as video cameras have been utilized to identify and differentiate broiler and breeder

behavior pattern to predict their health condition in confined and non-confined conditions . Feed intake of birds can be measured utilizing the sound technology and by developing a correlation between numbers of pecking and feed intake of broiler chickens . Precision feeding of broilers can be important to optimize the genetic growth potential of meat broiler strains and to maintain increased protein turnover that these birds are undergoing . In breeder hens, the practice of precision feeding can help maintain target body weight (BW) of hens within a specified BW curve to retain their optimal reproductive state. Precision feeding showed the unprecedented flock BW uniformity ($CV < 2\%$) versus the lowest reported in convention feeding of 6.2% CV in breeder hen rearing . Furthermore, the precision feeding breeder pullets showed relatively less expenditure of energy as heat, which was due to the reduced need to store and mobilize nutrients compared to pullets undergoing conventional restricted feeding , PLF technology in the poultry sector will help enhance the overall poultry production and profitability improving the management decisions on bird health, nutrition and welfare . However, adopting a new technology for taking daily management decision at farm level can be challenging. Technology adoption by growers needs data to be presented in the end-user format , The companies pay incentives to growers based on how well the growers manage their flocks in terms of performance compared to flock performance of other farms in the region . Educating growers on adoption of new technologies in production and management processes can enhance overall health and flock performance, and the overall economic return.

Climate condition of poultry farm

ventilation systems for broilers and laying hens are engineered to provide precise control of the climate inside the facility, even when the climate outside of the building is extreme or changing.

Climate conditions are controlled with a range of products including ventilation fans, evaporative cooling, heating, inlets and precision controls.

During summer periods farmers can experience heat stress in their bird populations, which negatively affects growth and productivity for broilers and layers, something that would need to be avoided in intensive poultry production. This makes air exchange rates and ventilation rates crucial in growing chickens or producing eggs.

During winter periods or cooler parts of the year, depending on where the production is situated, minimum ventilation is critical. Due to increasing energy prices, farmers want to limit the amount of fresh air to what is absolutely necessary for keeping a sufficient air quality in the broiler or layer house. If the minimum ventilation rate is exceeded by bringing more cold air from the outside, the farmer’s cost for heating will increase and farm profitability is jeopardized.

FCR, or Feed Conversion Ratio, can be addressed with climate control equipment. There is an explicit correlation between maintaining the correct environmental indoor conditions avoiding temperature fluctuations and optimized FCR. Even the smallest changes in FCR at any given feed price, can have a substantial impact on financial margins for the farmer.

All this said the environment control in layers or broiler houses is crucial and according to philosophy it should be done with the smallest possible environmental impact and instead with environmental excellence.

the equipment and knowledge to help you take control and produce your perfect climate whether it is for broiler, layer or breeder

- Poultry management

The aim of management is to provide the conditions that ensure optimum performance of the birds (Bell and Weaver, 2001). Given reasonable conditions, broody hens are very successful at hatching their chicks, but good hatchability using artificial incubation (both large and small) relies on careful management of temperature, humidity, ventilation, position and egg turning. During incubation, the egg loses water vapour through its shell. The rate of water loss depends on both the shell structure and the humidity of the air surrounding the egg. The quality of the hatch also depends on the age and health of the breeder flock, and on the evenness and cleanliness of the eggs set.

Factor involved in poultry management

Temperature effects Farmers need to compensate for undesirable climatic conditions by manipulating control systems or modifying the house to ensure that the welfare and environmental needs of the birds are satisfied. Environmental extremes (heat and cold stress, excessive or inadequate ventilation, poor air quality) can be managed if the design of the poultry house is appropriate for the conditions. Birds require adequate space, sufficient feed to meet their nutritional requirements, and an adequate supply of good-quality water. Use of a stringent quarantine programme to prevent disease is an essential element of good management, and farmers must be able to recognize disease and treat it as soon as possible. A suitable vaccination and medication programme is essential in commercial operations.

- Management of lighting Poultry have seasonal and daily biological rhythms, both of which are mediated by light, particularly day length. For day length to exert its controlling effect, there needs to be a dark phase (night) when light levels should be less than 0.5 lux. Day length and light intensity during the breeder bird’s life have an important role in development of the reproductive system. The difference in day lengths and light intensities between the rearing and the laying phases is the principal factor responsible for controlling and stimulating ovarian and testicular development (Lewis and Morris, 2006). The response to increases in day length and lighting intensity depends on the body weight profile during rearing, which in turn depend on the nutritional regime. The effects of light are predominantly on the rate of sexual maturation and egg production.

Climate in Poultry Houses

The climate in poultry houses influences the wellbeing and health of humans as well as the birds. Respiratory, digestive and behavioural disorders are more likely to occur in houses in which the climatic conditions are not up to standard. The efficiency with which feed is utilised is related to the health status of the flock. Animals that are not healthy cannot be expected to perform optimally. The younger the animals are or the higher their production level, the more sensitive they become to the climatic conditions in the house. Climate can be defined as the sum of environmental factors which influence the functioning of man and animal.

Climatic Factors

The following factors must be measured at animal level.

- Temperature
- Relative humidity
- Air composition
- Air speed and air movement
- Light

Factors influencing climatic conditions and the birds' micro-climate

House climate can be influenced by insulation of roof, walls and floor, ventilation, heating, cooling and lighting. The climate directly surrounding the birds is called the micro-climate (for example, chickens in a brooding ring). In fact, the micro-climate is the only thing that is of importance for the birds. It is possible that the climate in the house is acceptable but the climate at bird level is unsuitable. For example, CO_2 is a heavy gas and CO_2 levels at bird level can be much higher than at 2 m height. Another example is the brooding ring. The use of brooding rings means that the temperature of the house can be lower as long as the temperature at chicken level (under the brooder) is correct. This principle is applied in order to save on heating expenses. The advantages should be weighed against the disadvantages i.e. with brooding rings you can save on energy but often the labour to make and manage the brooding rings is more.

Temperature

Layers are warm blooded (homeothermic) i.e. within a certain range, their body temperature is quite constant. On average, the body temperature of birds is between 41°C and 42.2°C. Body temperature is kept quite constant and is regulated by part of the chicken brain (the hypophyse). This part of the brain is comparable to a

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thermostat. Contraction and widening of blood vessels and the speed of respiration influence heat emission and retention which consequently influence the body temperature. It takes some time before heat regulating mechanisms start functioning in newborn animals and therefore they need a higher ambient temperature than adult animals do. Furthermore, the ratio between the surface area and weight of young animals is unfavourable and they do not have any fat reserves.

Temperature zones

The comfort zone is defined as the temperature zone in which the birds are able to keep their body temperature constant with minimum effort. This temperature zone also depends on the feeding level and housing conditions. Behaviour of birds will change when temperatures rise to above the comfort zone as they will start to pant and change their body position. When temperatures are below the comfort zone birds will also change their body position and huddle together.

The thermoneutral zone is defined as the temperature zone in which the birds are able to keep their body temperature constant with the help of physical heat regulation . This temperature zone depends on feeding level and housing conditions of the birds and other factors. The lowest temperature in the thermoneutral zone is called the **lowest critical temperature** (LCT). If temperatures fall to under this temperature the bird will start to use feed energy to warm itself (i.e. maintain its body temperature) and will consequently consume more feed. The highest temperature in the thermoneutral zone is called the **highest critical temperature** (HCT). If the temperature rises above this temperature the birds can no longer dissipate their heat. They will start to consume less feed and production will drop as a result.

The highest and lowest critical temperature depend very much on:

1. Age
2. Body weight
3. Housing system
4. Feeding level
5. Relative humidity
6. Air velocity
7. Health

Physical heat regulation

When temperatures are not within the comfort zone, birds have several mechanisms which enable them to keep their body temperature constant without having to produce extra heat. This is referred to as physical heat regulation and factors that influence physical heat regulation include:

- Tissue insulation – if birds have a layer of subcutaneous fat, they can afford to let their skin temperature drop. Only if the animals are fed properly can they deposit a subcutaneous fat layer when temperature decreases.

- Feathers – feathers have an insulating effect and decrease the amount of heat that is lost to the environment.

- Changing body position and huddling – birds can effectively regulate heat loss through body position. Heat loss can be minimised by huddling close together. In hot weather, on the other hand, the birds increase their body surface as much as possible.

- Vaporisation of water – if temperatures are high, or extremely high, sensible heat loss is minimised and almost all heat will have to be lost as insensible (latent) heat. Latent heat loss is the heat lost from the body through the elimination of respiratory moisture.

- Flow of blood through skin and mucous membranes – the flow of blood to the skin and mucous membranes can be controlled through the contraction and widening of blood vessels. The larger the flow of blood is, the more heat is lost.

Chemical heat regulation

Another way in which poultry can regulate their body temperature is chemical heat regulation. When the ambient temperature is not within the thermoneutral zone the birds can:

1. Increase feed intake when the temperature is below thermoneutral zone
2. Decrease feed intake when the temperature is above the thermoneutral zone.

Measuring and assessing temperature

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The best instrument for measuring temperature is the animal itself. Assessing the temperature by observing the birds themselves should only be done when the animals are at rest, not when they are active or eating. Obvious indicators of unsatisfactory house climate are:

- Behaviour of the animals
- Abnormal body position
- External abnormalities
- Abnormal plumage may point to mistakes in house climate
- Coughing/sneezing frequencies
- Activeness

Measuring the temperature is the most common way of assessing the climate in a house. Such a measurement can give a lot of useful information and is not expensive or hard to do. There are several ways of measuring the temperature:

1. Minimum/maximum thermometer (in every house or section of a house)
2. Temperature sensor (computerised climate control)
3. Thermometers (alcohol, electronic)
4. Infrared thermometers – electronic thermometers

Location of the thermometer

The temperature in a house is not uniform and therefore, there are several places where the sensor should not be placed (i.e. it should not be hung close to the wall or behind something which hinders the air flow) and should not be hung too high in the house. Furthermore, the location of the air inlet and heating equipment is important in determining the best position for the temperature sensor. It is best to place it as close to the animals as possible and in such a way that the fresh air passes the sensor before it reaches the animals.

Recommended temperatures for layers and broilers

The critical temperature for layers is 20°C. For every 1°C lower than 20°C, the birds require an extra 1.5 g of feed per day. The most efficient temperatures for layers are between 20 – 24°C. When temperatures rise above 24°C, shell quality and egg weight will reduce. The critical temperature for broilers and rearing birds is highly dependant on age.

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The recommended house temperatures for poultry are given in the following table.

Table 1. Recommended temperatures for broilers

First day	32-34°C
1st week decrease	30°C
2nd week decrease	26°C
3rd week decrease	22°C
4th week decrease	20°C

Note: These temperatures are recommended temperatures and should be adapted to local situations as necessary.

Relative Humidity

The following concepts are used to measure the humidity of air in poultry houses:

- Absolute humidity = grams of moisture present in 1 m^3 of air.
- Maximum humidity = maximum grams of moisture that can be present in 1 m^3 of air at a given temperature.
- Relative humidity = the relationship between the moisture content of the air and the maximum moisture content at the current air temperature expressed in percentages.

Example of relative humidity %
If the air temperature is 10 °C and contains 5.7 g of moisture, the relative humidity is 5.7/9.5 x 100 = 60%. (See the table 3 on absolute moisture content in g/m^3 of air for the moisture content in air with a temperature of 10°C). If the same air is heated without adding moisture until it reaches a temperature of 20°C, the relative humidity will be 5.7/17.5 x 100 = 33%. So it can be concluded that heating air results in lower relative humidity. Conversely, cooling the air will result in a higher relative humidity e.g. if the same air was 4°C the relative humidity would be 5.7/6.4 x 100 = 89%. This demonstrates that the warmer the air, the greater its capacity to contain moisture.

Measuring humidity
Relative humidity in poultry houses is measured to determine whether respiratory disorders are due to too high or too low relative humidity. If the relative humidity is too high, condensation can accumulate in the house. This has a direct effect on the growth of micro-organisms.

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Measuring and controlling humidity

There are several ways to measure the moisture content of the air in a poultry house, with the most common being the psychrometer dry/wet bulb or the mechanical hygrometer. Measuring the moisture content in the air may be useful, however there are higher relative costs involved in the measurement of the humidity compared to measurement of temperature alone. Due to this, the moisture content of air is not commonly measured.

Humidity is controlled by the intense heating or cooling of house air in response to the temperature outside the house. When outside temperatures are low, relative humidity in the house is low, which often results in dry dust circulating in the air within the house. If the relative humidity is too high, this may result in wet litter. The ideal relative humidity for poultry is 60-80%.

Air Composition

The most important components of air are nitrogen (N_2, approximately 79%) and oxygen (O_2, 20.3%). In addition to these main components there are several other gasses such as carbon dioxide (CO_2), and water (H_2O). Birds inhale O_2 and exhale CO_2 and H_2O. True 'lack of oxygen' does not occur in poultry houses because animals can inhale sufficient oxygen even if the oxygen levels in the air are substantially lower than normal. What is called 'lack of oxygen' in practice is, in reality, often a combination of high CO_2 concentration, high temperatures and high humidity.

Harmful gasses in poultry houses are:

- Carbon dioxide (CO_2) – The carbon dioxide in poultry houses largely originates from air exhaled by the birds. The CO_2 content of the air is used to measure the effectiveness of ventilation.
- Ammonia (NH_3) – Ammonia is a product of bacteriological processes in the manure. It is easily bound to water. Ammonia is lighter than air and thus it rises in the air. The ammonia content of the poultry house air depends on ventilation, temperature, relative humidity and stocking density. High ammonia concentrations irritate the mucous membranes.
- Hydrogen sulphide (H_2S) – H_2S is released when organic matter (protein) in the manure decomposes. It has an offensive smell (rotten eggs) and is a very dangerous gas. When the manure is stirred or removed from the pit, the H_2S is released into the air. Even low concentrations of hydrogen sulphide in the air can

be fatal for humans and animals. This is why it is important to ventilate at maximum capacity while stirring or removing the manure.

- Carbon monoxide (CO) – Carbon monoxide is an odourless, very dangerous gas. It is the result of incomplete combustion due to a lack of oxygen (O_2) in gas heaters (clean filters).
- Sulphur dioxide (SO_2) – Sulphur dioxide develops when oil is used as fuel. The cleaner the oil, the less SO_2 is formed. The Maximum gas concentrations allowed in European poultry houses are in the table below.

Table 2. Gas Standards for European poultry houses

CO	0
CO_2	<2500 ppm = 0.25 VOL%
NH_3	<25 ppm = 0.0025 VOL%
H_2S	0.0
SO_2	0.0

(1 volume % = 10,000 ppm)

Measuring gas content of air

A gas detector can be used to measure the gas content of the air. All measurements should be done at animal level. The device consists of a pump and its most important components are the tubes which are necessary to determine the gas content. The tubes are filled with a chemical substance that changes colour when air which contains the gas being measured passes through it. There are special tubes for determining the CO_2, NH_3, H_2S, SO_2 and CO contents of the air.

Measuring and controlling dust particles

Dust is harmful to the health of humans and animals and has a negative influence on the house climate. The functioning of equipment may also be seriously hampered by dust, including heating, lighting, and ventilation, and dust has also been shown to carry micro-organisms. The dust in poultry houses mainly consists of skin particles, feathers, feed particles, litter and dried manure.

The amount of dust in poultry houses is seldom measured. It can be measured in many different ways, however the processes are cumbersome and often require a multiple

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pieces of equipment as it is not known what is being carried in the dust each time the measurement is taken. It is currently difficult to give practical advice on how to measure the amount of dust, and what to measure for.

The amount of dust in a house depends on many different factors. These include temperature, relative humidity, type and age of the animals, type of litter used, feeding system, hygiene, etc. Proper maintenance of poultry houses and regular cleaning creates more comfortable conditions for animals and better working conditions for humans.

Air Movement and Airspeed

Whether or not birds are comfortable is very much influenced by air velocity and air temperature. Young animals are more sensitive to these factors than older, heavier animals. Taking into consideration the recommended temperatures, the air velocity at animal level is allowed to vary between 0.1 and 0.2 m/second. If house temperatures are low, the animals experience higher air velocities as a (severe) draft which can lead to disease. A simple way of determining the (negative) effect of drafts is the ‘draft value’.

The draft value is the temperature difference between the house air and the incoming air (in degrees Celsius) multiplied by the airspeed in m/sec (D= (OT – IT) X S D = Draft value OT = Outside Temperature IT = Inside temperature S = airspeed at bird level in m/sec). The standard for the draft value is a value less than 0.8. If the draft value is more than 0.8 there is risk for drafts to occur in the poultry house. If temperatures are higher than 25-30°C, air velocities of higher than 0.1-0.2 m/second will actually have a positive effect and help to cool the animals.

The air movement pattern within a house is easier to control in this way as the influence of air velocity and outside temperature are less. It is not possible to give rules for the air movement pattern within a house because the air movement patterns depend on the ventilation within a house, the house width, the slope of the roof and the way the house is organised.

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In intensive commercial egg production or layer farming there are four production systems used; cages, barn, free range and organic production. Correct ventilation is key to reach the optimum production output of eggs.

The conventional battery cages have been banned in the European union since 2012 and the cages used there now are of the type ‘enriched’ cages. Enriched cages must allow at least 750 cm^2 per hen, and contain a nest, litter, perch and clawing-board. The alternatives to cages are barn or free range rearing systems.

Free-range eggs come from hens that should have access to an outdoor area during the day. A barn production system means that hens are free to move around in the barn area, limited only by partitions. Aviary systems is commonly used today in Europe, a system which allows the hens to move around freely in an open area, with a non-cage system which may be single or multi-tier (up to four levels).

Organic egg production requires organic feed, the birds must have access to the outdoors and cannot be raised in cages. Furthermore, organic egg producers cannot use antibiotics, except during an infectious outbreak.

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FCR, Feed Conversion Ratio

is a measure of an animal's efficiency in converting feed mass into increases of the desired output. In Layers the output is egg. There is an explicit correlation between maintaining the correct environmental indoor conditions avoiding temperature fluctuations and optimized FCR. Even the smallest changes in FCR at any given feed price can have a substantial impact on financial margins for the layer farmer.

Feed efficiency per kg egg mass
This takes into consideration of the feed intake, egg weight and egg production. It is the ratio between the feed consumed and the egg mass.

Broiler House Ventilation

Utilizes sophisticated software combined with extensive experience in livestock ventilation to generate a design proposal to suit any broiler production. The resulting design will not only specify the right equipment to deliver the required airflow, but will also deliver increase profit margins for growers and farmers, here is how.

Broiler farming requires precisely designed ventilation and climate control in order to decrease your feed conversion ratio, but that is not the only reason to have a proper air exchange rate and air circulation. The broilers' health and welfare also strongly depend on the internal barn environment, as does the health of the staff working in the barn. A perfect climate for broiler farming provides environmental excellence, increases profits for the contract grower, and gives a healthier product for consumers.

Ventilation management

In large-scale automated operations, correct air distribution can be achieved using a negative pressure ventilation system. When chicks are very young, or in colder climates, the air from the inlets should be directed towards the roof, to mix with the warm air there and circulate throughout the shed. With older birds and in warmer temperatures, the incoming air is directed down towards the birds, and helps to keep them cool. Evaporative cooling pads can be placed in the air inlets to keep birds cool in hot weather. Tunnel ventilation is the most effective ventilation system for large houses in hot weather.

Tunnel ventilation: These systems are popular in hot climates. Exhaust fans are placed at one end of the house or in the middle of the shed, and air is drawn through the length of the house, removing heat, moisture and dust. Evaporative cooling pads are located at the air inlets. The energy released during evaporation reduces the air temperature, and the resulting airflow creates a cooling effect, which can reduce the shed temperature by 10 °C or more, depending on humidity. Maximum evaporation is achieved when water pumps are set to provide enough pad moisture to ensure optimum water evaporation. If too much water is added to the pads, it is likely to lead to higher relative humidity and temperatures in the shed.

fogging systems:

Fogging systems are sometimes used to reduce the shed temperature. Fogging works best in dry climates, and usually involves several rows of high-pressure nozzles that release a fine mist throughout the house. The cooling effect is significantly increased by airflow from the use of fans within the shed. Natural ventilation is common in medium- and small-scale operations and in areas where the climatic conditions are similar to the temperatures required by birds. Ventilation is usually provided by prevailing breezes. Natural ventilation works best in poultry sheds where the long axis runs east to west, to avoid heating of the sidewalls by the sun during the morning and afternoon.

-

Minimum ventilation fans

wall and chimney fans for perfect climate control in minimum ventilation

If you are sitting in a meeting room and the ventilation system is switched on/off or badly regulated you can take your jacket or sweater on and off. But the animals cannot regulate the “clo- value” if we do not provide them with the optimal uniform climate. (“Clo-value” describes the insulation of the clothes). So livestock engineers have to be smarter than engineers creating climate solutions for people.

In turn-key projects it can often be difficult for ventilation companies to sell the optimal climate solution.

Often the investors or farm industry want to cut the total project cost. If we as ventilation companies are not good at arguing why our climate solutions should not be cut in price, the investors will reduce the ventilation enterprise instead of the feed system or building enterprise. You can cut the ventilation enterprise by using fewer, larger fans with single speed. However, then the room temperature can fluctuate

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around wanted optimal temperature and provide draft in the animal zone during minimum ventilation.

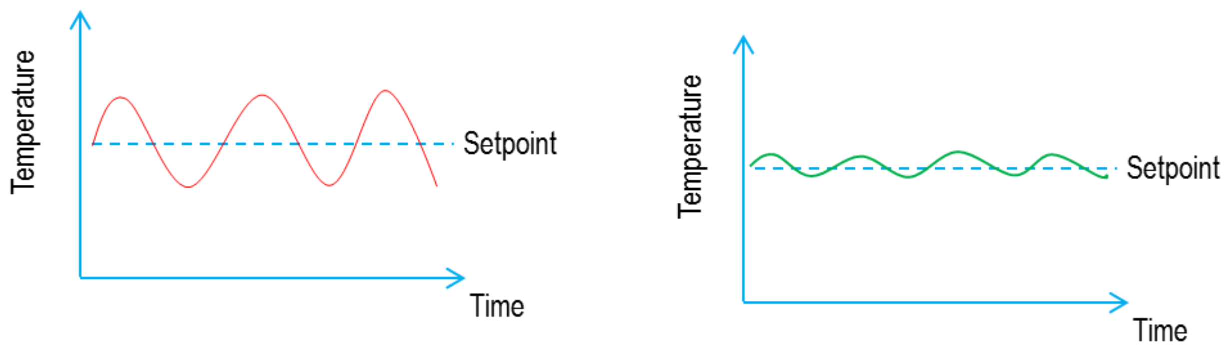

Fig. 1

Choose the right size of minimum fans in order to have a uniform room temperature around the set-point. Set-point is the optimal and wanted temperature added to the controller.

Red curve illustrates measured temperature when we use too large fans in minimum without optimal regulation.

Green curve illustrates measured temperature with correct size of minimum fans, which provides a smooth and stable temperature in the animal zone.

If the chosen fans are too big and not variable regulated, it can result in unstable room temperature. It can create draft in the animal zones, which will stress the animals and can result in tail biting, reduced production results and increased need for antibiotic. Also minimum fans with the new Drive reduce the energy cost per produced animal. So it is a win-win situation both for farmers and ventilation companies to add state of the art minimum fans to the project.

The key to profitability is controlling bird movement.

- Decrease feed conversion rates
- Better bird distribution
- Reduce paw lesions
- Maintain litter moisture levels with reduced ammonia content
- Less bird stress
- Better air quality for birds and workers

- Improve overall bird health and production

Heating

produces a range of energy efficient top-notch heating solutions for livestock and greenhouse applications.

Depending on the type of fuel used and the application in which it is used, air heaters, can have many configurations. Choose from the wide range of heaters to meet your needs. Heating of the animals' zone also optimizes the Feed Conversion Ratio (FCR) and saves money for the farmer. In greenhouses, heating addresses problems like fungus due to excessive humidity levels, and to prevent cold spells. In other words, efficient heating spells increased productivity and reduced losses.

Heat Stress

Heat stress can be counteracted! In all the mentioned scenarios below a cool relief can be obtained by installing a climate control system

The signs of heat stress are open mouth panting, wing spreading, and squatting close to the ground. In broiler flocks, heat stress means the birds will not reach the required weight levels or even lose weight and the mortality rate will increase. For layer hens it means that the egg size is reduced and egg shell quality deteriorates. Among breeders the effects of heat stress is a reduced fertility rate.

Feed Conversion Ratio (FCR)

FCR optimized for farmer profit

The farmers' cost for animal feed is one of the main expenditures consisting of 60-70% of the overall producer costs. These producer costs are impacted by climate control performance through the FCR. There is an explicit correlation between maintaining the correct environmental indoor conditions avoiding temperature fluctuations and optimized FCR. Even the smallest changes in FCR at any given feed price can have a substantial impact on financial margins.

Precision Agriculture develops and manufactures energy efficient climate control systems for optimum growth and the development of poultry, pig and dairy production. Through a wide range of products and application technologies, we can create just the right climate for the farmer's specific needs. Our climate control systems have generated growth and development for many farmers and growers all over the world.

product portfolio consists of energy-efficient fans for extraction and circulation purposes, cooling pads running on air and water, air inlets, heaters to prevent fluctuations between day and night temperatures, light filters, ammonia cleaners for outdoor emission control. The true heart of each climate system consists of a climate controller which orchestrates the operation of all climate control equipment.

Increase egg production and animal welfare in Layers

The various egg production systems that are used all over the world create a need for flexible and reliable ventilation solutions. When mentioning flexibility, the one thing that should not be flexible or random is the cost of running that same ventilation system. Farmers and growers want to know that their ventilation system performs well, but also what the operations costs are.

Whether a layer farmer uses cages, enriched cages, barn, free range, aviary or organic production methods, the climate control system needs to properly ventilate every nook of the building. If there is a sudden cold spell, the system needs to be prepared for adding the right amount of heating power and a system for emergency opening when there is a power loss.

All of the above coupled with sufficient feed and water access makes the laying hens comfortable and healthy, and we all know that this makes them produce better egg quality and improve the number of hen days.

we take great pride in being able to deliver an **energy efficient** and well performing climate control system that fits any of the above mentioned production systems, and also with the objective for the farmer/ grower to have as low Total Cost of Ownership (TOC) as possible to increase farm profit.

Let us look at which parameters we focus on when meeting a farmer. In most cases the **production system** has been chosen by the farmer which more or less decides the layout and design of the ventilation system. The next thing to take into consideration is the **ambient climate condition** of the specific location. Average winter & summer temperatures and humidity levels as well as other specific weather types that the climate control system needs to be ready for are carefully collected and investigated. The control unit at the heart of the system will be configured so that it responds to changes in temperature, humidity and eg. strong winds.

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In a large hen house there are several design challenges and they are all more or less unique to every layer house we come across, but it is possible to outline some general challenges. One important challenge is to **create uniformity,** especially in an aviary free range production system. With the hens being free to move around the layer house, this is essential to look at. Uniformity means there can be no cold or warm spots in the house. If that occurs during cold periods, the hens will be clustered around warmer spots and there is a risk of disturbances, overload on the egg handling system or fighting in the flock. The same scenario of clustering will occur during warm periods if there are cold spots, likewise creating an imbalance in the house.

Uniformity always starts with placement of the climate equipment for an even distribution of fresh incoming air and taking stale air out of the house. The type of inlet chosen depends of the climate conditions where the house is located. If the incoming air is cold for a period of the year, one generally wants to avoid that cold air drops down directly towards the birds, something which will inevitably disturb them and cause a non-uniform climate. For these cases, a horizontal and radial spread of air is desired which will mix it with warmer air next to the attic or ceiling before it drops down on the flock.
In the design phase, attention also needs to be paid to the distance between the ceiling/attic air inlets so that the optimum air flow inside the building can be reached.

How do we know that we got it right? Well, there is no second chance; we have to design it correctly from the start. We get a receipt that it is working when you see that the birds are very uniformly spread as in this video, shot in a layer house in Denmark **https://www.youtube.com/watch?v=5tsRJQYJOTY**

In this video you will probably notice that the inside of the fan looks dirty. These kinds of deposits which are full of grease, feather and dust are normally occurring at any farm, especially towards the end of a flock. It is not possible to go and clean the ventilation equipment during a cycle without considerably disturbing the animals and causing wet litter etc. Before the flock is replaced, the entire house including equipment can be hosed down with high-pressure cleaners and disinfectants. The second challenge for a climate control system is **bedding quality** at least for free range production systems where birds move around on the floor. This typically consists of straw, wood shavings or sand.

Source of pictures

https://www.munters.com/en/campaigns/aghort-campaigns/munters-air-cleaner-for-poultry/

The layer farmer wants the bedding material to remain dry so that it does not stick to the birds' feet and ends up in the nests, thereby clinging to the egg shells and causing dirty eggs that the farmer will not get paid for. Wet bedding material mixed with manure will increase the ammonia levels inside the house, affecting both animals and people negatively. A well ventilated building with sufficient air flow and heating on a need basis will ensure that the bedding material is kept dry. So there are lots to win for the farmer when it comes to keeping the bedding material dry; and it all spells better farm economy and improved profits.

The third challenge for the layer farmer affects floor eggs and how to avoid that. It is a cumbersome job to collect these (several times per day), man-hours that could be used for other jobs on the farm, and it could mean a lost income if the floor eggs get dirty. There is actually something that could be done to prevent this from happening also from a ventilation point of view. The ventilation design needs to make sure that there are no drafts in the nesting areas of the layer house. As long as the nesting area is a comfortable zone for the hens, this is where they prefer to lay their eggs and this means that the egg handling system will take care of the product.

The fourth climate challenge for poultry farms is light control. How can lighting be related to climate, you might ask? We'll get to that, but let us first establish that getting at least eight hours of sleep is crucial for the layer hens. During summer especially in the northern hemisphere, creating eight hours of darkness can be pretty challenging in itself. Pitch-black is not necessary but a brownout effect is. Light spots on the floor or cages are something the farmer would want to avoid since it prevents the chickens from falling asleep. Light spots can be avoided by carefully designing the climate control system and choosing products which counteract light spots. Drip pans underneath chimney fans and deflector disks of ceiling inlets reflect the light from outside back up towards the ceiling or walls. The reflected light does not prevent the birds from getting their rest. By properly configuring the climate system and equipping each project with the products and accessories suitable for that specific location, we can make sure that the farmer doesn't end up with exhausted animals that don't thrive or perform well.

Inlets and extraction openings are handled by actuators controlled by a controller. A back up system makes sure that animals are not suffocated should there be a power loss at the farm. The inlets and fan dampers will automatically be set wide open ensuring sufficient natural ventilation airflow in case of emergency such as power loss.

Set at the heart of each climate control system, you will find a number of controllers which orchestrate the equipment, the silo controller which controls the chicken feed, the Farm Master & Center controllers enabling the farmer to set temperature curves for the building(s), control the minimum ventilation and tracking historical data from his/her house.

Efficiencies are what drive us forward

Improving the efficiency of fans can often be obtained from making small incremental improvements, but to really make a difference, a breakthrough is sometimes required. to significantly improve efficiency of ventilating buildings, we can no longer make incremental improvements to fans by solving existing problems, we should avoid them. The concept of how buildings are ventilated needs to be challenged and improved

Ventilation inefficiencies can be traced back to 3 major causes:

1. The types of motors used - Even though conventional significant improvements had been made at improving the efficiency of AC, the inherent design has limitations and there are other types of motor designs that are more efficient
2. Belt drive systems - For optimum efficiency, propellers need to turn at low revolution speeds, while conventional motors turn at high revolution speeds, which means a belt drive system is required to transfer the power from the motor to the propeller and the right revolution speed.- Due to friction, energy is lost through a

belt drive system - Ventilation efficiency is lost through slippage of the belts resulting in lower revolution speeds of the propeller and less air being moved by the fan - Belt drive systems do require a high level of maintenance

3. Fixed Speed - AC motors operate at a single revolution speed and consequently fans have a fixed capacity. But the ventilation demand for buildings is constantly changing variables such as the outside weather patterns or animal age change. Because motor speed and fan capacity is fixed, opportunities for saving energy when ventilation demand is low cannot be captured.

Drive avoids these limitations by:

1) New motor architecture

The drive has a fundamentally different and more efficient architecture from a standard AC motor, opening the way for a motor that can operate at a much higher efficiency than a normal AC motor

2) Direct Drive

With a motor that turns at the same revolution speed as the optimum propeller speed, the need for a drive system is eliminated

- *Eliminating friction losses*

- *Guaranteeing constant performance levels from the fan*

- *Significantly reducing the need for maintenance*

3) Variable Speed

By being able to reduce motor speed and fan capacity when ventilation demand is low, the route to unlock significant energy savings is secured.

By combining the energy efficiency benefits that Drive offers over a conventional fan, users have been able to reduce annual ventilation costs by up to 40% and additionally saved a similar amount in maintenance cost reduction.

By mid-2015 there had been more than 4,500 units sold to more than 200 different farms in applications ranging from layer, to broiler, to hog, to dairy and even greenhouse. The oldest running motors have exceeded 20,000 hours of trouble free operation!

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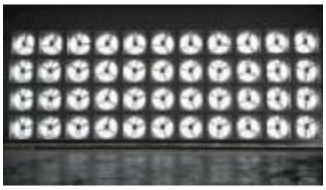

Traditional Ac Motor vs. Drive EC motor

In a conventional AC motor opposing magnetic fields are induced in the rotor and stator. This opposing force makes the rotor turn. Motion is maintained through the polarity changes of the Alternating Current (AC) power supply. The way the architecture of an AC motor works one revolution of the magnetic field in the stator does not equate to 1 revolution of the rotor. In fact, the rotor turns less than 1 revolution (called slippage) which causes magnetic fields to cross which is a loss of energy. This loss of energy can be observed as heat generated by the motor while in operation.

This means the rotational speed of the motor is fixed and determined by the frequency of the power supply (50Hz or 60 Hz) and the number of magnetic poles in the motor.

Some examples are:

Drive: The product that people in the know wants because:

- Drive reduces utility bills by lowering electricity consumption
- Drive reduces utility bills through better rates by avoiding inrush currents at startup
- Drive reduces initial capital expenditure by qualifying for rebates from utility companies
- Drive reduces initial capital expenditure by reducing the complexity and cost of electrical wiring
- Drive saves a lot of maintenance costs because of the simple yet reliable design
- Drive enables you to shrink your carbon footprint, making your products more appealing to consumers
- Existing or New installation; you can enjoy the benefits of Drive either in new fans or as retro-fit kits for existing fans (even those of other manufacturers!)

Drive gets your fans ready for accommodate developing technologies such as improvements on ventilation schemes and communication.

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Air Cleaner for layers and broilers

Globally the Air Cleaner (MAC) is the only air cleaner which can be efficiently used in poultry houses. Air cleaners from competitors have filters which will quickly clog with dust, the MAC does not use these filters therefore eliminating the chance for dust blockage. 80-90 Percent Ammonia Reduction depending on the ammonia concentration in the exhausted air from the poultry house, the ammonia reduction through the air cleaner will be around 80-90 % on average during a year.

Up side - Down!

The MAC uses nearly the same principle as the well-known gas scrubber tower,

which is currently widely used in the agriculture industry. The original version of the Air Cleaner was a gas scrubber tower which worked well in the pig industry but not in the poultry industry. The air from chickens is much more dusty and greasier, and would take too long for the poultry producer to wash the top of the gas scrubber tower.

Rather than a traditional vertical gas scrubber tower it was now rotated on its side. Furthermore, the droplet separators can be easily pulled out and accessed from the side. By doing this it can now be cleaned with a traditional pressure washer from outside. It is no longer necessary to enter the air cleaner to clean filters. All in all, the air cleaner has improved the working environment for the farmer dramatically.

Ammonia cleaning process

1or 2 fans are located in the end of the air cleaner and pull air from the poultry house through the air cleaner. Inside the air cleaner the exhausted air will first pass a through a mist of acidified water droplets. These droplets react with the ammonia and capture the ammonia from the air. Next the exhausted air passes through two sets of mist eliminators which capture the mist droplets. In the end the dirty exhaust air from the poultry house, travels through the MAC, and is emitted as cleaned air to the outside.

has very good experience with mist eliminators from many different industries and has factories in Germany, which produce mist eliminators for the different industries including agriculture.

QUIZ

What is meaning of **FCR, Feed Conversion Ratio in broilers and layers**

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is a measure of an animal's efficiency in converting feed mass into increases of the desired output. In Layers the output is egg. There is an explicit correlation between maintaining the correct environmental indoor conditions avoiding temperature fluctuations and optimized FCR. Even the smallest changes in FCR at any given feed price can have a substantial impact on financial margins for the layer farmer.

ASSIGNMENT

Explain how increase profitability by controlling bird movement and improve performance

- Decrease feed conversion rates
- Better bird distribution
- Reduce paw lesions
- Maintain litter moisture levels with reduced ammonia content
- Less bird stress
- Better air quality for birds and workers
- Improve overall bird health and production

REFRENCESS

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