Horticultural Crops Production

Level - III

Learning Guide #12

Unit of Competence: -Operate Fertigation Equipment

Module Title: - Operating Fertigation Equipments

LG Code: AGR HCP3 M04LO1-LG-12

TTLM Code: AGR HCP3TTLM 0120v1

LO1: Prepare materials and equipments for operation

Instruction Sheet	Learning Guide #12

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Confirming materials and services
- Preparing materials
- Connecting injection or fertigation equipment
- Calculating and mixing fertilizer concentration
- Setting equipment

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Confirm materials and services as available and ready for operation.
- Prepare material to meet fertigation requirements.
- Connect injection or fertigation equipment as directed and calibrate.
- Calculate fertilizer concentration and mix the solution thoroughly.
- Set equipments to meet fertigation equipments**.**

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1 to Sheet 5”.
4. Accomplish the “Self-check 1 to Self check 5” **in page -8, 14, 19, 25 and 27** respectively.

Information Sheet 1	Confirming materials and services

Introduction

Fertigation is the application of fertilizers, soil amendments, or other water-soluble products through an irrigation system. It is the practice of supplying crops in the field with fertilizers via the irrigation water and it is a modern agro-technique, provides an excellent opportunity to maximize yield and minimize environmental pollution by increasing fertilizer use efficiency, minimizing fertilizer application and increasing return on the fertilizer invested.

Chemigation, a related and sometimes interchangeable term, is the application of chemicals through an irrigation system. Chemigation is considered to be a more restrictive and controlled process, due to the potential nature of the products being delivered - pesticides, herbicides, fungicides to cause harm to humans, animals, and the environment.

Fertigation is used to spoon-feed additional nutrients or correct nutrient deficiencies detected in plant tissue analysis and it is practiced extensively in commercial agriculture and horticulture. Fertigation is also increasingly being used for landscaping as dispenser units become more reliable and easier to use. Fertigation is used to add additional nutrients or to correct nutrient deficiencies detected in plant tissue analysis. It is usually practiced on the high-value crops such as vegetables, turf, fruit trees, and ornamentals.

Usually practiced with high-value crops such as vegetables, turf, fruit trees, and ornamental

- Injection during middle one-third or the middle one-half of the irrigation recommended for fertigation using micro propagation
- Water supply for fertigation kept separate from domestic water supply to avoid contamination
- Change of fertilizer program during the growing season in order to adjust for fruit, flower, and root development.

In micro-irrigation, fertilizers can be applied through the system with the irrigation water directly to the region where most of the plants roots develop.

This process is called fertigation and it is done with the aid of special fertilizer apparatus (injectors) installed at the head control unit of the system, before the filter. The element most commonly applied is nitrogen. However, applications of phosphorous and potassium are common for vegetables. Fertigation is a necessity in drip irrigation, though not in the other micro irrigation installations, although it is highly recommended and easily performed.

The basic components include the irrigation tubing, a fertilizer tank, an injector, a filter, a pressure gauge, check valves, and a pressure regulator. Sometimes parts of the equipment can be missing or disfunctioning. Basic components for micro-irrigation are present and equipment for fertigation is adapted. Fertilizer tank can be a simple tank that is put higher 50 cm above the irrigation tubing, and the solution is delivered through it with a valve located at the bottom of the tank. For most of the farmers, there is no real choice of the equipment and they take what is available in their area. Choice is more related to funding possibilities and to equipment availability than to technical characteristics.

Importance of fertigation

Fertigation is the application of fertilizers through the irrigation water. It can be applied in almost any irrigated crop, in both open field and greenhouses. Fertigation allows for a more efficient use of both water and fertilizers.

In irrigated crops, water must be applied in a relatively high frequency, depending on the soil type and water requirements of the crop. Such crops usually have an irrigation system in place, such as drip irrigation, pivot or sprinklers.

The use of an irrigation system provides an opportunity for a more efficient fertilizer application.

There are many types of fertigation systems, some are mechanical, without automation or control, and others are fully automated and controlled. Most modern fertigation systems use fertilizer injectors, which can be adjusted to apply specific rates of fertilizers. Controlled systems usually include EC (Electrical Conductivity) and pH sensors to adjust the injection of fertilizers according to the grower’s preferences.

Since in fertigation the fertilizers are delivered in a dissolved form, with the irrigation water, the distribution of the nutrients in the soil is almost the same as the distribution of water. This way, nutrients can be applied directly to the root zone. This is particularly true for nutrients that are not adsorbed to soil particles, such as nitrates ($NO3^-$) and sulfates (SO_4^-).

Other nutrients, such as phosphorus and potassium do not readily move in soil and will tend to remain in the top soil. Phosphorus reacts with calcium, aluminum and other elements, depending on the soil pH and potassium binds to soil clay particles, as it carries a positive charge, while soil clay particles have a negative charge.

Even more efficient nutrient distribution can be achieved when fertigation is done through a drip irrigation system.

In fertigation, plant nutrients can be applied at the time they are needed by the plant. In other application methods, such as broadcast or band application, split fertilizer applications are more complex and costly, making them impractical.

Plants absorb nutrients at different rates throughout their growth. Applying nutrients too early or too late might significantly affect the yield. For example, nitrogen in its nitrate form, is not retained by soil particles. Therefore, it tends to easily leach out the soil. If applied too early, it might be lost by leaching or volatilization and, as a result, much less nitrogen will be available to the crop when it actually needs it, later on in its growth cycle.

It was demonstrated in many trials that split application of nitrogen, using fertigation, results in higher efficiency and higher yields. This is mostly due to minimization of nitrogen losses.

Phosphorus might be lost by runoff. However, in many crops and soil types, it is common to apply at least 50% of the phosphorus at pre-plant.

An additional advantage of applying smaller fertilizer doses via fertigation, according to the growth stage of the crop, is that lower soil salinity can be maintained.

In fertigation, timing, amounts and concentration of fertilizers applied are easily controlled. The incorporation of fertilizers into the irrigation system demands the following basic requirements:

Equipment: In pressurized irrigation systems, the injected fertilizer solution has to be greater than that of the internal pressure. A filter to prevent dripper clogging by any solid particles from reaching the dripper .A back-flow preventing valve.

Fertilizers: Solubility of the fertilizers in the indigenous water source: irrigation water contains various chemical constituents some of which may interact with dissolved fertilizers with undesired effects. The degree of acidity of the fertilizer solution has to be considered in relation to its corrosiveness to the irrigation system components.

Fertilizer refers to a soil amendment that guarantees the minimum percentages of nutrients (at least the minimum percentage of nitrogen, phosphate, and potash). An organic fertilizer refers to a soil amendment derived from natural sources that guarantees, at least, the minimum percentages of nitrogen, phosphate, and potash. Examples include plant and animal by-products, rock powders, seaweed, inoculants, and conditioners. These are often available at garden centers and through horticultural supply companies.

Notes: Release Time Organic products require the activity of soil microorganisms before nutrients is available for plant uptake. Microorganism activity is generally dependant on soil temperatures greater than 50ºF in the presence of sufficient soil moisture. Dry and/or cold soil conditions will delay the release of nutrients from these organic sources. This period refers to how long these products are available if applied to the soil. Use this information to time the application of the product.

Application: - Different products may be applied in various ways. Some may be tilled in (worked into the soil with a machine or hand tool), others may be applied as a foliar spray (mixed with a surfactant and sprayed in a fine mist on the leaf surface while temperatures are below 80ºF), and some may be injected into a drip or overhead irrigation system (fertigation with a siphon mixer). Application rates in this fact sheet are generalized and based on some manufacturers' recommendations. Over- or under-fertilization may occur using these recommendations.

Advantages and disadvantages of fertigation

Advantages

The benefits of fertigation methods over conventional or drop-fertilizing methods include:

- Increased nutrient absorption by plants.
- Accurate placement of nutrient, where the water goes the nutrient goes as well.
- Ability to "micro dose", feeding the plants just enough so nutrients can be absorbed and are not left to be washed down to storm water next time it rains.
- Reduction of fertilizer, chemicals, and water needed.
- Reduced leaching of chemicals into the water supply.
- Reduced water consumption due to the plant's increased root mass's ability to trap and hold water.
- Application of nutrients can be controlled at the precise time and rate necessary.
- Minimized risk of the roots contracting soil borne diseases through the contaminated soil.
- Reduction of soil erosion issues as the nutrients are pumped through the water drip system. Leaching is decreased often through methods used to employ fertigation.

Disadvantages

- Concentration of the solution may decrease as the fertilizer dissolves, this depends on equipment selection. If poorly selected may lead to poor nutrient placement.
- The water supply for fertigation is to be kept separate from the domestic water supply to avoid contamination.
- Possible pressure loss in the main irrigation line.
- The process is dependent on the water supply's non-restriction by drought rationing.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is fertigation? 5 points
2. Discuss the advantages and disadvantages of fertigation. 10 points

Note: **Satisfactory rating - 15 points** **Unsatisfactory - below 15 points**

You can ask your teacher for the copy of your answer

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Answer sheet

Information Sheet-2	Preparing materials

Fertigation equipment

The choice of fertigation equipment has to take into account both crop requirement and irrigation system capacity.

Gravity irrigation systems

This very simple method is only applicable to irrigation systems working at atmospheric pressure in which water flows in open channels. The fertilizer solution drips into the irrigation channel because the fertilizer tank is above the level of the channel. In order to obtain good mixing; the velocity of the irrigation stream must be high enough.

Pressurized irrigation systems

Injection of the fertilizer consumes energy in order to overcome the internal pressure of the irrigation network. Fertilizer injection equipment is classified into three principal groups, according to the means employed to obtain the higher pressure for the fertilizer solution:

1. Injection by a Venturi device: This is a unit that makes use of the Venturi suction principle by using the pressure induced by the flowing water to suck the fertilizer solution from the fertilizer tank into the irrigation line. A conical constriction in the pipe induces an increase in the water flow velocity and a pressure decrease to an extremely low value which causes fertilizer suction (through the filter screens) from the supply tank through a tube into the irrigation system. A valve can be adjusted to control the difference between the water velocities across the valves.
2. Injection by differential pressure: This system utilizes an air tight pressure metal tank with anti-acid internal wall protection in which a pressure differential is created by a throttle valve that diverts part of the irrigation water into the tank. This is the only fertigation system that enables the use of both solid and liquid fertilizers. The entire fertilizer amount in the tank is delivered to the irrigation area. The concentration at the water emitter end is kept constant as long as a solid fertilizer is present in the tank and solubility of the fertilizer is quickly achieved. Once the solid fraction is completely dissolved the fertilizer concentration is reduced at an exponential rate. In practice, when four tank volumes have passed through it, only a negligible amount of fertilizer is left in the tank. This equipment was used in the early stages of fertigation development. A limited area can be irrigated at a time according to the tank volume. The use of solid fertilizers must be handled with care.

Fertilizers that have endothermic reaction when dissolved, like KNO_3, $Ca(NO_3)_2$, Urea, NH_4NO_3,KCl and $5Ca(NO_3)_2 \cdot NH_4NH_3 \cdot 10H_2O$ decrease the temperature in the tank and when added during cold hours in the early morning before irrigation, part of the solution can freeze, leading to unexpected changes in the nutrient concentrations.

3. Injection by positive pressure: Injection pumps are able to raise the pressure of the liquid fertilizer from a stock solution tank at a predetermined ratio between fertilizer solution volumes to irrigation water volume, hence achieving a proportional distribution of nutrient in the irrigation water. The advantages of using injection pumps are the lack of pressure loss of the irrigation water, its accuracy and the ability to provide a determined concentration through the irrigation cycle. Two types of injectors are commonly used in fertigation: **piston pumps** and **diaphragm pumps**.

The most common power sources for fertigation pumps are:

A. Hydraulic energy: The device uses the hydraulic pressure of the irrigation water to inject nutrient solution while the water used to propel it (approximately three times the volume of solution injected) is discharged. These pumps are suitable for fertigation in areas devoid of sources of electricity.

B. Electric dosing pumps: The device activates the fertilizer pump. These are common in glasshouses and in areas where electricity is available and reliable. Commonly used nutrients are plant nutrients can be applied through irrigation systems. Nitrogen is most commonly used nutrient. Other nutrients include nitrate, ammonium, urea, phosphate, and potassium.

Installing Fertigation systems into existing irrigation systems for golf courses or playing fields is easy and fairly inexpensive. The technique is to tie liquid fertilizer tanks into the main irrigation lines to evenly distribute fertilizer into the system. Injection rates are managed by a heavy duty chemical metering pump. This pump is controlled by a controller which is tied into the irrigation control panel and monitors the rate of flow of irrigation water.

The metering pump is then calibrated to rates dependent on the specific fertilizer being applied. There are also control valve options and multiple head systems which allow multiple tanks to be on the same system. The fertilizers can then be applied separately or combined for a specific blend.

The successful application control of liquid fertilizer revolves around the nutrient Control and Injection station. The better injectors come as a complete system and include a microprocessor controller; an in-line water-flow sensor that controls the pump motor speed for proportional injection; stainless steel main-line injection lances, pumps capable of pumping out of bulk-storage tanks or drums. These systems should be fully integrated into an easy-to-use, flexible configuration.

The basic components of a fertigation system include:

- one or more tanks to dissolve dry fertilizer into water or store pre-made liquid fertilizer mixes
- A means of injecting the dissolved fertilizer into the irrigation line.

There is a wide range of fertigation equipment available. A common misconception is that the most expensive and elaborate system is the best. The best system is one that suits your farm size, layout, irrigation system and budget. Management skills, style and personal preferences are also important.

System configuration

The type of equipment needed and how the system is configured will depend on the irrigation system (i.e. drip or sprinkler) and how frequently fertilizer is to be supplied. These considerations are important because on most farms there are different aged trees, different varieties and a range of rootstocks which would typically be in different irrigation blocks. So water and fertilizer needs are likely to be different between irrigation blocks.

Quantitative fertigation:- Injecting a large amount of dissolved fertilizer during an irrigation event is commonly known as ‘slug dose fertigation’, and is known technically as quantitative fertigation (i.e. a specific quantity of fertilizer is injected during the irrigation shift regardless of the irrigation volume). It is the simplest approach, and requires less sophisticated equipment. It is more commonly used on medium to heavy textured soils (i.e. loams and clays) that are able to hold higher amounts of nutrients. On these soils, fortnightly or monthly injections are usually sufficient to maintain adequate levels of nutrients in the root zone.

Proportional fertigation:- Injecting a small amount of fertilizer solution into the flow of irrigation water (usually around 1–2 liters per 1000 L of irrigation water) is referred to as proportional fertigation. It requires more expensive equipment to inject the fertilizer solution and control the injection.

This approach is better suited to light sandy soils with a low nutrient holding capacity because the soil can't hold a large dose at one time. Proportional injection systems are commonly used in advanced fertigation programs.

Multiple in-field injection points:-multiple, small, in-field injection stations can be installed for each individual irrigation block or even individual tree rows and the control of these doesn't need to be more complicated than choosing to add or not to add fertilizer to an in-field tank.

Figure 2.1. A single tank injection system based on a centrifugal pump.

Central injection point: - A central fertigation station can service a whole farm and is easier to manage because fertilizer storage and mixing occurs in the one place. A central fertigation station operated daily with a low output irrigation system and a proportional injection system can have some limitations. This scenario usually requires that the whole farm, or large sections of it, be irrigated in the one shift. This means all plantings will receive the same concentration of nutrients. The amount of nutrient applied is related to the amount of water applied and this makes it difficult to apply exact amounts to specific blocks or adjust fertilizer supply to different varieties (e.g. mandarins versus oranges). Central injection stations that can irrigate at any time with a medium output irrigation system and fertigate quantitatively generally allow more flexibility to target specific fertilizer amounts to individual blocks.

Figure 2.2. Fully automated twin multi-tank fertigation system.

Single or multi-tank systems:- A single tank system allows mixing of compatible fertilisers in the one tank and the dissolved fertilizer is usually quantitatively injected during an irrigation shift. A single tank system is relatively inexpensive to purchase, install and house. A multi-tank system has at least two tanks and allows otherwise incompatible fertilizers to be dissolved separately and injected into the irrigation line during the same irrigation event, though not necessarily at the same time. For example, nitrogen (N) (except calcium nitrate), phosphorus (P) and potassium (K) fertilizers could be dissolved in one tank and calcium (Ca) fertilizers could be dissolved in the other tank.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List and discuss fertilizer injection equipments. 9 points
2. What are the basic components of fertigation equipments? 8 points
3. Discuss the differences of central injection point and multi in field injection points. 8

Note: **Satisfactory rating – 25 points** **Unsatisfactory - below 25 points**

You can ask your teacher for the copy of your answer

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Answer sheet

Information Sheet 3	Connecting injection or fertigation equipment

Several techniques have been developed for applying fertilizers through the irrigation systems and many types of injectors are available on the market. There are two main techniques: the ordinary closed tank; and the injector pump. Both systems are operated by the system's water pressure.

The injector pumps are mainly either Venturi type or piston pumps. The closed tanks are always installed on a bypass line, while the piston pump scan be installed either in-line or on a bypass line.

Fertilizer (closed) tank: - This is a cylindrical, epoxy coated, pressurized metal tank, resistant to the system's pressure, and connected as a bypass to the supply pipe of the head control. It operates by differential pressure created by a partially closed valve, placed on the pipe line between the inlet and the outlet of the tank. Part of the flow is diverted o the tank entering at the bottom. It mixes with the fertilizer solution and the dilution is ejected into the system. The dilution ratio and the rate of injection are not constant. The concentration of fertilizer is high at the beginning and very low at the end of the operation. However, this apparatus is still in service on a very small scale in some countries because of its low cost and easy manufacture.

Venturi type: - This is based on the principle of the Venturi tube. A pressure difference is needed between the inlet and the outlet of the injector. Therefore, it is installed on a bypass arrangement placed on an

open container with the fertilizer solution. The rate of injection is very sensitive to pressure variations, and small pressure regulators are sometimes needed for a constant ejection. Friction losses are approximately 1.0 bar. The injectors are made of plastic in sizes from_ to 2 in and with injection rates of 40-2 000 litres/h. They are relatively cheap compared to other injectors.

Piston pump:-This type of injector is powered by the water pressure of the system and can be installed directly on the supply line and not on a bypass line. The system's flow activates the pistons and the injector is operated, ejecting the fertilizer solution from a container, while maintaining a constant rate of injection. The rate varies from 9 to2 500 litres/h depending on the pressure of the system and it can be adjusted by small regulators.

Made of durable plastic material, these injectors are available in various models and sizes. They are more expensive than the Venturi-type injectors.

Chemical injectors and injection techniques

Fertigation injection devices work either on piston flow (positive displacement pumps) or on vacuum generation (suction or negative pressure, venturi-type) principles. Positive displacement pumps include proportional injectors, rotary pumps, and peristaltic pumps. The injection energy for positive displacement pumps is provided by an electric, gasoline, or hydraulic motor. Accurate chemical application and easy adaptation for automation are among the major advantages of positive displacement pumps. Rotary and peristaltic pumps can transfer chemicals from the supply tank to the irrigation system; the former transfer the solution through the action of rotating gears, while the latter transfer the solution by creating of partial vacuum. A more or less constant chemical flow is generated, and the chemical injection rate is not affected by the change in irrigation application rate. Peristaltic pumps are used to inject chemicals in micro sprinklers. The required chemical injection is achieved by the squeezing action of the rotating rollers on a flexible tube. Because the injected chemical passes through a tube and does not touch the inner components of the pump, the peristaltic pump material is protected against any corrosive impact caused by the chemical. Because injectors based on the venturi principle utilize differential pressure generated across the device (Fig. 1), the rate of chemical injection varies with the differential pressure generated. Chemical injection rate is influenced by the pressure drop; the larger the pressure drop, the higher the injection rate. Proper operation of these devices requires a pressure drop across the venturi; some minimum pressure for even a low rate of chemical injection is required. This constraint results in poor chemical injection efficiency and problems in quantitative fertigation.

Most centrifugal pumps work on vacuum-generation principles. Advantages of vacuum injection methods include,

- Simple operation and no moving parts
- Easy installation and maintenance
- Better control on injection rates
- Ideal for dry formulations
- No power or fuel needed for pump operation.

Fertilizer Injector:-there are several chemical injectors available that can be used to inject selective fertilizers into the irrigation water but each has its limitations to adequately work depending on the area and rate to be fertilized, available operating pressure and water flow rate. The most basic form of injector is the pressure differential tank or venturi system and both should work very well for a high tunnel system. The tank system is based on the principle of a pressure differential being created by a special valve in the main water line that forces water through a bypass pipe into a pressure tank and out again, carrying a small amount of the dissolved fertilizer from the tank. The venturi system basically draws the liquid fertilizer solution from a container by differential pressure created with venturi device and then injects the fertilizer into the irrigation water line at a controlled rate. Both of these systems should be installed into the main water line as close as possible to the drip system and in a by-pass piping arrangement to be able to be easily connected or disconnected from the system at any time as well as to help in creating the needed differential pressure or controlling the injection rate. Regardless of the injection device, it should always be installed up-stream of the last filtering unit to be certain the filter removes any undissolved solids before entering the drip tubing.

If the irrigated site has more than one tunnel and or open field acres and one desires to inject a more constant rate of nutrient at each time irrigation, the next step-up fertigation system would be to install a proportional injection pump that can be more easily controlled as well as handle a larger rate of nutrient injection. Regardless of the type and size of unit needed for the drip system, the injector system should be connected into the main water line via a by-pass piping arrangement with the appropriate valves and as near as possible to the drip tubing but always up stream of the last filter before the drip tubing header. The injecting device should also always be located downstream of the necessary backflow prevention equipment to provide protection to the water supply.

In drip irrigation:-To manage the irrigation and fertigation system effectively one needs to know about the watering performance characteristics of the irrigation systems such as water application rate (inches of per hour), water discharge rate (gallons per minute) of all of the drip tubing, amount of time to make an application event, the fertigation injection rate range and the uniformity of water application distribution. In addition one also needs to know the desired fertilizer chemical solution application rate (xx units per acre).

The water application rate for a trickle system depends greatly on operating pressure, emitter size and emitter spacing.

Manufactures give the flow rate for a given product by either gallons per unit of time (hours or minutes) per emitter or gallons per unit of time (hours or minutes) per 100 feet of tubing at a given emitter spacing. Manufactures usually have available in their literature one or more charts to help a user determine the application rate per hour for a given wetted width and length of run like 100 feet

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What are main injector pump of fertigation equipment? 10 points
2. Discuss the advantages of vacuum injection method of fertigation equipments. 6 points

***Note:* Satisfactory rating - 15 points** **Unsatisfactory - below 15 points**

You can ask your teacher for the copy of your answer

Score = ___________

Rating: _____________

Name: ___________________________ Date: ________________

Answer sheet

Information Sheet 4	Calculating and mixing fertilizer concentration

Basic calculations for fertigation:-Basic fertigation calculations involve determining the velocity of a water-soluble chemical, which is directly related to the velocity of irrigation water in the application system. Fertigation time is therefore related to the time needed by irrigation water to travel from the point of injection of the material to the furthest emitter, e.g., of a drip line. Travel time is calculated as $T = D/v$, where Dis the distance traveled by the dissolved nutrient, or the length of pipe through which the irrigation water flows, and v is the velocity of the irrigation water. Fertilizer solution travel time is used to calculate fertilizer injection rate (IR) for a particular irrigation system. For a micro sprinkler system, IR can be calculated based on the following relationship. IR= (A*Q/F*T*P)*100where A is the area to be irrigated (hectares), Q (kg/ha) is the quantity of chemical to be applied per hectare, F is the chemical fraction (fertilizer per liter of fluid injected, %), and ρ (kg/L) is the chemical solution density. Using the above relationship, a quantity of 3 kg/ha of N is applied to a 25-ha orchard with a 10-0-10 5-kg/L dense fertilizer solution that is injected for 1 hour at the rate of 150 L/ hr. Because micro sprinkler irrigation systems do not irrigate the entire soil surface, the fertilizer applied using these systems is delivered only to the irrigated portion of the soil surface. For a simple case of 50% irrigated soil surface, the N application rate in the irrigated zone (i.e., A/2 = 25/2 = 13.5), using the above revised relationship and the above information, will be slightly less than 6 kg/ha, as follows:

Q=IR*F*T*P/A*100=150*10*1*5/13.5*100=5.56 kg/ha

Because micro-irrigation systems do not apply water and chemicals to the entire soil surface, chemical applications to micro-irrigated crops are often made on an individual plant or tree basis, rather than on a gross-area basis. The above relationship for IR on the number of trees on an area basis becomes: IR= (A □□Qp□□n/ F *T*P)*100 where Qp (kg/tree) is the quantity of fertilizer to be applied per tree, n is the number of trees per ha, and all other variables are same as previously defined. In a 10-ha grove of young trees, e.g., citrus trees, the quantity of 0.05 kg of N from a 5 kg/L dense 8-0-8 solution, at 1 hr fertigation time for a 100 trees/ha grove will require 125 L/hr IR, calculated as follows:

IR = (10*.05*100/8*1*5)*100=125L/hr

It is recommended that the duration of injection should be greater than the time the chemical needs to travel from the point of supply tank to the most distant emitter of dripper or sprinkler in the field. Flushing time is also an important consideration, to completely clean the system, and it should also be half of the time of duration of fertilizer injection; nonetheless, excessive flushing time may lead to leaching loss of nutrients.

Fertilizer Calculations and Practice Questions

Fertilizer injectors (proportioners) take a concentrated fertilizer solution from the stock tank and add it to the irrigation water. If we have an injector ratio of 1:100, this means 1 gallon of fertilizer concentrate is added to 99 gallons of water. For a 1:100 injector, the fertilizer in the stock tank P is 100 times more concentrated than the water that the plants will receive. This means that if a plant receives fertilizer at 200 ppm nitrogen, in the stock tank this will be mixed at20, 000 ppm nitrogen.

Part 1 – Calculations using the fertilizer label

The bags of commercial fertilizer that we use contain a label which specifies how much to use to achieve a given fertilizer concentration. On the table, simply find the column that corresponds to your injector ratio; and the row that corresponds to your target fertilizer concentration.

Ounces of Peters Professional 20-10-20 General Purpose Per Gallon of Concentrate

Nitrogen ppm N	Injector Ratios* 1:15	1:100	1:128	1:200	1:300	E.C.** mmhos/cm
25	0.35	1.69	2.16	3.38	5.06	0.16
50	0.5	3.38	4.32	6.75	10.13	0.33
75	0.75	5.06	6.48	10.13	15.19	0.49
100	1.0	6.75	8.64	13.50	20.25	0.65
150	1.5	10.13	12.96	20.25	30.38	0.98
200	2.0	13.50	17.28	27.00	40.50	1.30
300	3.0	20.25	25.92	40.50	60.75	1.95
400	4.0	27.00	34.56	54.00	***	2.60

Question 1a: You wish to apply Peter's 20-10-20 fertilizer at a rate of 150 ppm N. You have a 1:200 injector. How many ounces / gallon of fertilizer concentrate will you need for the stock tank?

From the chart above find the row for 150 ppm N and the column for 1:200 – this shows us that 20.25 ounces per gallon of fertilizer is needed in the stock tank.

Question 1b: Your stock tank holds 5 gallons. So how many ounces of 20-10-20 will you need from question 1a to mix up 5 gallons of concentrated fertilizer?

Since 20.25 ounces per gallon of concentrate are required; and our stock tank holds 5 gallons we will need:

20.25 (oz/gal) × 5 gal = 101.25 oz

Question 1c: Given the ounces of fertilizer needed from question 1b. Convert the answer from ounces to grams.

If you are using a scale to weigh in grams, the conversion factor is:

1 ounce = 28.3 grams **Equation 1** So we simply multiply our answer from 1b by 28.3 to get the answer:101.25 oz × 28.3 (g/oz) = 2,865.4 g

The fertilizer table also lists the EC (salt reading) that should result from this fertilizer. We can use this to calculate the EC of the water that will reach our plants. By checking this water coming off the end of the hose we can make sure that our stock tank was mixed correctly and our injector is functioning correctly. Remember that the tap water you are using also has some level of salts dissolved in it (for example the salt reading from Cornell water is 0.4 mmhos/cm). You can calculate what the final EC should be of the water hitting your plants from the equation below. final EC = EC of tap water + EC of fertilizer **Equation 2**

Question 1d: What should be the EC of the water hitting your plants using the fertilizer mix described in questions 1a-c?You can see from the fertilizer label (above) that our fertilizer EC should be 0.98,so fill this into equation 2 final EC = 0.4 (EC of Cornell tap water) + 0.98 (EC of fertilizerfinal EC = 1.38 mmhos/cm (note that: mmhos/cm = dS/m)

Part 2 – Calculations using the percentage of a nutrient in the fertilizer

Now let's look at the case where we need to mix a fertilizer that does not have a table to give use the mixing values. When we mix fertilizers we typically have a target in mind in terms of ppm(parts per million) of a particular nutrient.

However, fertilizers are usually weighed in ounces and then mixed in stock tanks measured in gallons. Because we are converting from ppm (parts per million) to ounces per gallon we need to use a conversion factor:

1 ounce E / 100 gal water = 75 ppm **Equation 3**

(Where E is any soluble element)

In the fertilizers we use, any given element (such as nitrogen or calcium) is only 1 part of the fertilizer, therefore we need to know the percentage it makes up of the fertilizer. In the case of N this is usually quite easy as the fertilizer bag lists the percentage of N-P_2O_5-K_2O (so we know that our bag of 20-10-20 contains 20% nitrogen), for other fertilizers we may need to look up the values from a table, for example: epsom salts (magnesium sulfate or $MgSO_4 \cdot 7H_2O$) contains 9.9% Mg and 13% S). Note that the percentage can be represented as a decimal fraction (df), ex: 9.9% _ 0.099 and 13% _ 0.13. Once we have the decimal fraction we can easily calculate the ounces of fertilizer needed to achieve a target ppm using the following equation:

ozfert per gal irrigation water = target ppm / (75 × 100 × df) **Equation 4**

where df = the decimal fraction of the element of interest

Note: the equation calculates ounces per gallon of final irrigation water; to account for the injector we must multiply by the correct proportion (ex: multiply by 100 for a 1:100 injector)

Question 2a: We wish to make up a solution of 30 ppm magnesium using Epsom salts ($MgSO_4 \cdot 7H_2O$); how many ounces per gallon of final irrigation water are required; and assuming we are using a 1:200 injector; how many ounces are required per gallon of concentrate in the stock tank.

Using a lookup table we found that Epsom salts contains 9.9% magnesium, so the decimal fraction is 0.099, plug this and the target concentration (30 ppm) into equation 4 and solve:

ozfert per gal irrigation water = 30 ppm / (75 × 100 × 0.099)= 30 / (742.5)

= 0.04 ounces per gallon irrigation water

Now account for the 1:200 injectors:

0.04 oz per gal × 200 (injector proportion) = 8 oz per gal stock concentrate

Now let's say we wanted to know how much sulfur was provided by adding 30 ppm magnesium with Epsom salts, we can use a related equation to calculate this, but in this case use the df for sulfur, because that is the nutrient of interest:

ppm = ounces fert per gal irrigation water × 75 × 100 × df **Equation 5**

Question 2b: What ppm of sulfur was provided when Epsom salts was added at the rate of 30 ppm magnesium?

ppm = 0.04 (oz Epsom salts per gallon) × 75 × 100 × 0.13= 39 ppm S

Equation 4 can also be used with fertilizers that contain micronutrients (ex: iron chelate products, etc.) you just have to get the correct percentage for the nutrient of interest and convert to the df (decimal fraction).

Question 2c: We want to apply a 1-time soil drench of 20 ppm Iron (Fe). We will use an iron chelate product (Fe-EDDHA) that contains 6% Iron. How many ounces of the product are required per gallon of irrigation water? How many ounces per gallon of stock concentrate if we are using a 1:200 injector?

To solve, use equation 4, noting that 6% iron _ 0.06 df

ozfert per gal irrigation water = 20 ppm / (75 × 100 × 0.06)

= 20 / (450)

= 0.044 ounces per gallon irrigation water

Now account for the 1:200 injector:

0.044 oz per gal × 200 (injector proportion) = 8.9 oz per gal stock concentrate

Conversion Factors

1 ounce = 28.3 grams

1 gram = 0.035 ounces

To convert from ounces to grams multiply by 28.3

To convert from grams to ounces multiply by 0.035

The three numbers on the fertilizer bag are listed in terms of N-P_2O_5-K_2O

If we want to know the amount of P and K, a conversion is needed

1 ounce of P_2O_5 = 0.44 ounces of P

1 ounce of P = 2.3 ounces of P_2O_5

To convert from P_2O_5 to P multiply by 0.44

For example: 10 ounces of P_2O_5 = 4.4 ounces of P

Similarly, 100 ppm of P_2O_5 = 44 ppm of P

1 ounce of K_2O = 0.83 ounces of K

1 ounce of K = 1.2 ounces of K_2O

To convert from K_2O to K multiply by 0.83

For example: 10 ounces of K_2O = 8.3 ounces of K

Similarly, 100 ppm of K_2O = 83 ppm of K

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. You wish to apply Peter's 20-10-20 fertilizer at a rate of 150 ppm N. You have a 1:200 injectors. How many ounces / gallon of fertilizer concentrate will you need for the stock tank? 15 points

Note: **Satisfactory rating – 15 points** **Unsatisfactory - below 15 points**

You can ask your teacher for the copy of your answer

Score = ____________
Rating: _____________

Name: __________________________ Date: _______________

Answer sheet

Information Sheet 5	Setting equipments

Private sellers provide equipment to farmers; they can also provide its design and installation and even its funding with a loan. On farms, different kinds of equipment are observed; there is either sophisticated equipment run by technicians or “do-it-yourself” solutions adapted by others. The basic components include the irrigation tubing, a fertilizer tank, an injector, a filter, a pressure gauge, check valves, and a pressure regulator. Sometimes parts of the equipment can be missing or disfunctioning. Basic components for micro-irrigation are present and equipment for fertigation is adapted. Fertilizer tank can be a simple tank that is put higher 50 cm above the irrigation tubing, and the solution is delivered through it with a valve located at the bottom of the tank. For most of the farmers, there is no real choice of the equipment and they take what is available in their area. Choice is more related to funding possibilities and to equipment availability than to technical characteristics.

Fertigation controller injection equipment, Orchard spray tank, Pressure different. Venturi injection, Water pressure operated, pump Single tank and centrifugal pump, Positive displacement pumps, Centrifugal injection pump

Self-Check -5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Discuss the importance of setting equipments. 10 points

Note: **Satisfactory rating - 10 points** **Unsatisfactory - below 10 points**

You can ask your teacher for the copy of your answer

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Answer sheet

References

https://en.wikipedia.org/wiki/Fertigation

https://cropaia.com/blog/fertigation/

Ben-Gal, A., N. Lazarovitch, and U. Shani. 2004. Subsurface drip irrigation in gravel filled cavities. The Vadose Zone Journal. 3:1407-1413.A204.

Horticultural Crops Production

Level - III

Learning Guide #13

Unit of Competence: -Operate Fertigation Equipment

Module Title: - Operating Fertigation Equipments

LG Code: AGR HCP3 M04LO2-LG-13

TTLM Code: AGR HCP3TTLM 0120v1

LO 2: Operate the fertigation process

Instruction Sheet	Learning Guide #13

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Implementing start up sequence
- Operating and monitoring fertigation process
- Monitoring fertigation equipment
- Implementing corrections to the process and equipment adjustments

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Implement start up sequence according to operations manual
- Operate and monitor fertigation process
- Monitor fertigation equipment
- Implement corrections to the process and equipment adjustments

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1 to Sheet 4".
4. Accomplish the "Self-check 1 to Self check 5" **in page -35, 44, 49 and 51** respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1 in page **36**.
6. Do the "LAP test" **in page – 37** (if you are ready).

Information Sheet-1	Confirming materials and services

The fertilizer solution in liquid form is fed into the system at low rates repeatedly, on a continuous basis, during irrigation. The flow rate of the injector should be such that the calculated amount of solution is supplied at a constant rate during the irrigation cycle, i.e. starting fertigation right after the system starts operation and finishing a few minutes before the operation ends. Regarding the choice of the fertilizers, apart from the amount and the kind, other parameters need to be considered, such as solubility, acidity, compatibility and cost.

Solubility. The fertilizer stock solution should always be dissolved in a separate container and then poured into the suction tank. The types of fertilizer should be highly soluble and when dissolved in water must not form scrums or sediments which might cause emitter clogging problems.

The solution should always be agitated, well stirred and any sludge deposited in the bottom of the tank should be periodically removed. The injector suction pipe should not rest on the bottom of the tank. Hot water helps dissolve dry fertilizers. Their degree of solubility varies according to the type and the country of origin. Potassium nitrate (13-0-46) seems to have a low solubility of approximately 1:8, i.e. 1 kg of dry fertilizer in 8litres of water. The solubility of potassium chloride (0-0-62) is 1:3, while ammonium nitrate (34-0-0) and calcium nitrate (15.5-0-0) have a high solubility of approximately 1:1. Dry phosphorous fertilizers have a lower solubility than nitrates at about 1:2.5.

Acidity. The acidity produced by the several forms of nitrogen varies from type to type and is greatly affected by the kind of irrigation water and the type of soil. At least one check on the soil pH should be carried out at the beginning of the season and one at the end. Furthermore, a complete ionic analysis of the water is necessary.

Quantity. A simple method for calculating the amount of fertilizer required for fertigation is to divide the annual application by the number of irrigations. Various recipes nave been developed in different countries based on the conventional nutrition dosages. The total quantity of fertilizers applied is also related to the length of the growing season and the irrigation requirements.

Fig 1.1. confirming materials and services of fertigation equipments

The above recipes are recommended for irrigation water with very low salinity. As a rule of thumb for average quality water, the maximum fertilizer concentration, which is added to the irrigation total salinity, should have an EC of about 0.5 dS/m. For higher concentrations, the salinity level in the soil root zone must be checked frequently and the application adjusted according to the soil test results.

Fertigation assists distribution of fertilizers for farmers. The simplest type of fertigation system consists of a tank with a pump, distribution pipes, capillaries, and dripper pen.

What should be considered

- Water quality
- Soil type
- Nutrient consumption (daily)

Appropriate nutrient materials possible strategies to be used

- Injecting for short time-periods at the beginning, middle, and end of irrigation cycle
- Injecting during middle 50% of the irrigation cycle
- Continuous irrigation
- Postering index Imex

Fertigation System Design with Variable Speed Dive Pump Stations

Due to the fact that Variable Speed Drive pump stations vary the flow rate with demand the design of a fertigation system requires more thought that is normally required for this process. There are a number of ways to vary the injection of chemical into a mainline but the common factor with all systems is to get feedback from a flow meter. This is imperative for accurate dosing of chemical.

The typical layout for a Variable Speed Pump station is detailed above. There are 4 main components:

1. Pumps
2. Filter
3. Switchboard
4. Fertigation system

1. Pumps

The pumps are always sized to suit the full flow capacity of the system and set up to operate on both full demand and also minimum demand. This means that the fertigation system will need to be able to track the full capacity of the pump station. Any type of pump can be used with the Tethys.

Corporation control systems so it is very important when designing the fertilizer injection pump to account for both high and low flows.

2. Filter

The filter is typically sized at 80 micron (200 mesh) which provides a 6:1 filtration ratio for the sprinkler nozzles. This ratio will protect blockages down to 0.5mm sprinkler nozzles.

Any injection of chemical should be downstream of the filter or else that filter will back flush the chemical when a flush cycle is initiated. This can create serious troubles as the backwash water is generally not treated and increased concentrations of injected chemicals can accumulate in the backwash recovery zone.

3. Switchboard

The switchboard houses the control microprocessor, contactors and all of the associated Switchgear. Also enclosed in the switchboard are two VFD's: one for the main pumps and one for the fertigation equipment. More detail of the control method is provided further on.

4. Fertigation Equipment

The fertigation equipment consists of 2 x storage tanks for mixing and dispersing the chemical, a chemical dosing pump sized to match the flow requirements for the system and the associated pipe work. It is important to note that all of the pipe work and tanks should be assembled form inert materials such as poly or PVC. The use of any brass or ferrous materials should only be done with the full understanding of the material compatibility of the ferrous material and the injected chemical.

Control

The control of the fertigation pump is done within the switchboard with all of the indicators and switches located on the exterior panel. The fertigation will operate via a signal from the Irrigation controller which will switch on the Fertigation VFD or from operating the local control switch. This will allow the fertigation pump to operate continuously at the proportional rate as set. If the manual option is selected then the fertigation pump will run at full speed continuously. There is a low level protection circuit built into the system to stop the pump operating when the level in the fertilizer tank becomes too low for suitable operation. If this occurs then the pilot light on the front panel will illuminate and indicate the fault. To reset fill the tank or switch off the system.

Tuning the Fertigation System

The fertigation system will operate on the basis of proportional speeds. This is due to the fact the variable speed pump station operates at different speeds for different required flow rates. To tune the fertigation system to give specific proportional injection of chemical requires that a tuning process be performed. This will give ability to "DIAL UP" specific proportions based on chemical requirements.

The two factors to be balanced are:

Fertilizer flow rate & Main Irrigation Pump flow rate

This proportion is typically nominated in a measure called "PARTS PER MILLION" (ppm).

To tune the fertigation system follows these steps:-

1. Set the main irrigation pump operating at a fixed flow rate
2. Start the Fertigation system
3. Determine the main irrigation flow rate by reading the flow meter if you have an instantaneous flow rate meter.

If you have a volumetric flow meter, measure a specific flow over a fixed time period. This will give a flow rate…..…………………………………... Q

4. Determine the fertilizer injection flow rate …………Qf

The fertilizer injection proportion = Q

Qf

If this proportion is not the value required vary the vernier on the fertilizer injector if the change is small.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Discuss things that should be considered during fertigation activity. 5 points
2. List and explain the components of Variable speed pump stations layout. 10 points

Note: **Satisfactory rating –15 points** **Unsatisfactory - below 15 points**

You can ask your teacher for the copy of your answer

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Answer sheet

Operation Sheet -1	Implementing start up sequence of fertigation equipments

Steps to select to implement start up sequence of fertigation equipments are:-

1 - Set the main irrigation (fertigation) pump operating at a fixed flow rate.

2. Start the Fertigation system

3. Determine the main irrigation flow rate by reading the flow meter if you have an instantaneous flow rate meter

4. Determine the fertilizer injection flow rate

LAP Test	Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instruction: Given necessary templates, tools and materials you are required to perform the following tasks within 2 hours.

Task 1. Implement start up sequence of fertigation equipment.

Information Sheet-2	Operating and monitoring fertigation process

The Fertigation Controller is a micro-processor-based system used in fertilization and irrigation control for greenhouses or open fields with powerful, flexible programming features. The main function of the Fertigation Controller is supplying and controlling the necessary water and fertilizers for crops according to several parameters such as acidity, conductivity and received solar radiation.

The user interface is structured in two parts:

1. Consulting (numbered panels indicated by Cxx)
2. Setting (numbered panels indicated by Sxx).

This instruction manual will present the interface in 2 forms:

1. Fertigation Controller functions
2. Panel order

Fertigation Controller is capable of executing the following functions:

- Irrigation control by time or by volume
- PH control
- Conductivity control
- Fertilization control
- Irrigation adjustment due to solar radiation
- Manual correction
- Agitator control
- Filter control
- Water supply control
- Main pump control
- Sector control
- Serial communication
- Alarm function
- Logging function

Irrigation Control

The Fertigation Controller can control 8 to 32 sectors (one valve per sector) for each of the ten irrigation programs:

- 1 to 32 valves (sectors) can be selected specifying the sector's number and the desired value of irrigation time or volume for a specified irrigation program-using Panel S 38 (SET SECTORS). The panel displays the number of set sectors for the respective irrigation program
- The current status, set value plus irrigation extension and "Done" time/ volume value for the selected irrigation program/sector are shown on Panel

C 14 (SECTOR STATE). Irrigation can be controlled by time or volume – irrigation control mode can be switched between time and volume using panel S 53 (IRRIG CTRL MODE). Each irrigation program can be started by: TIME: - 1 to 6 different timetables (values) per program can be set using panel S 35

(SETSTART TIME). "Start cond" must be the selected option on panel S 34

(START CONDITION).

Accumulated Solar Radiation

- A Solar Radiation set point can be established for starting each program
- The accumulated solar radiation level can be used as a starting condition for each program
- There are 3 parameters used to start a program by solar radiation:
- The solar radiation sensor threshold value can be established for each irrigation program. When the solar radiation measured value exceeds the sensor threshold value the accumulated solar radiation value is increased.

This parameter can be modified on panel S 43 (Level: xxxxW/m2).

- The accumulated solar radiation value is used to keep track of the measured solar radiation level during the time interval determined by the previous start moment of the irrigation program and the actual moment. This parameter can be seen on panel S 06 (Irrig = xxxxWh/m2).The accumulated solar radiation starting level value is used as a thresh old value for the accumulated solar radiation. When the accumulated solar radiation value exceeds this threshold level the irrigation program is started

(or it is brought in READY state if there are other programs currently running at that moment). This parameter can be modified on panel S 43 (Acc= xxxxWh/m2) and can be seen also on panel C 06 (Acc = xxxxWh/m2)

External Tank Level

- One external tank (level indication) can be assigned to each irrigation program, that can start the specified irrigation program – this option is set using panel S 34 (START CONDITION).

Manual Activation

- A program can be started using panel S 47 (PROG MAN START)
- A program can be stopped using panel S 48 (PROG MAN STOP)Each irrigation program can be repeated a specified number of times. The number of repetitions as well as pause time between two repetitions can be specified using panel S 36 (PROGRAM REPEATS).Each irrigation program can be given a priority in relation to others (5 priority levels). Priorities and maximum open sectors per group can be specified for each program and can be set using panel S 33 (SET PRIORITY).Below we present the setting requirements for each irrigation program:

The Working Period

- (between start date (day/month) and end date (day/month)) – use panel S31 (ACTIVE TIMETABLE).

The Working Time during a Day:

- (between start time and end time) – use panel S 31 (ACTIVE TIMETABLE).

The Cycle Work/ Rest Day

- can be set using panel S 32 (WORKDAY).

The Working Days In A Week

- use panel S 32 (WORKDAY).

Working time status for each irrigation program, if selected (irrigation program is in work period of year, day and week) is displayed in panel C 08 (WORK TIMECOND).

The percent of irrigation time or set volume can be automatically modified by the following factors:

Solar Radiation Factor

- This option can be set using panel S 42 (CORRECTIONS). This factor affects the irrigation time or volume extension in accordance with the set value of the solar radiation sensor level and solar radiation accumulation. The solar radiation accumulation extension setting and current value is displayed on panel C 06 (SOLAR RAD IRRIG). Solar radiation extension correction can be viewed using panel C 11 (SOL RAD EXTENT).

Manual Factor

- This option can be set using panel S 42 (CORRECTIONS). Percentage and corresponding value of time or volume can be viewed using panel C12 (MAN FACTOR).

Total correction percentage, time or volume value is displayed on panel C 13(TOTAL CORRECTION).

PRE/POST IRRIGATION: In each irrigation program the pre-irrigation and post-irrigation time or volume value (used to clean the irrigation pipes with pre-irrigation water) can be set using panel S 37 (PRE/POST IRRIG).Panel C 01 (GENERAL INFO) displays the active irrigation program and active sectors.

The active irrigation program is displayed on panel C 02 (SENSORS STATE).Related data regarding the active irrigation program (active irrigation program number, last start condition and current / set repetition number) are displayed on panel C 03 (PROGRAM STATE).Information about selected irrigation program, priority and irrigation program conflict are displayed on panel C 09 (PRIOR & CONFLICTS). Set value data, correction value and irrigation completion ("Done") value are displayed on panel C 10 (IRRIG STATE).Information about the last start condition, date and time are displayed on panel C 18 (PROG LAST START).Total accumulation value from a previous date is displayed on panel C 19 (TOTAL ACCUMUL).Accumulation value from previous date and activation number for a selected irrigation program are displayed on panel C 20 (PROGRAM ACCUMUL).Accumulation value from previous date, for a selected sector, is displayed on panel C 21 (SECTOR ACCUMUL). In addition, this panel displays the valve number assigned with the corresponding sector.

- Accumulations erase mode can be chosen on panel S 61 (ERASE STATISTICS).

The accumulation erase can be per sectors using one of the following ways:

- Manually
- Every day at specified hour
- Automatically when the accumulations counter value overflows

Conductivity Control

Conductivity control is used to control the fertilization and a reading can be obtained with one to three conductivity sensors, one to two for fertilization control and one for water supply conductivity control.

When using two conductivity sensors, the second for safety, the maximal admissible difference between these two sensors can be set using panel S 55 (SENSORSCONFIG).A third conductivity sensor can be used to measure the conductivity of the water supply. Conductivity sensor (S1 main, S2 second and S-for water input) status and conductivity reference are displayed on panel C 05 (EC STATE). In addition, the main conductivity sensor value is displayed on panels C 01 (GENERAL INFO)and C 02 (SENSORS STATE);Solar radiation accumulation setting and current value for conductivity reference correction is displayed on panel C 07 (SOLAR RAD FERT).

The conductivity control is made in accordance with a preset conductivity reference value, specific for each irrigation program. In addition, the conductivity reference has a minimum offset and maximum offset. The reference value, minimum and maximum offset can be set using panel S 41 (COND CONTROL).

When the conductivity is not within the specified range for a period of time (more than the time specified) or the difference between the 2 primary conductivity sensors is greater than the specified difference, the conductivity control will generate a conductivity alarm . Specified difference can be set using panel S 55 (SENSORS CONFIG). The conductivity alarm threshold can be set using panel S 41 (COND CONTROL). “EC Out of Range”-the conductivity alarm can also be generated when the EC IN sensor’s value exceeds the specified EC sensor difference. Given a conductivity alarm condition, conductivity control can be maintained if“Ctrl on EC alarm” is selected using panel number S 52 (ALARM BEHAVIOR).

Statistical values of total conductivity are displayed on panel C 22 (TOTAL AVERAGES).For each irrigation program’s conductivity average see panel C 23(PROGRAM AVERAGES) and for each individual sector’s conductivity average see panel C 24 (SECTOR AVERAGES).

Fertilization Control

Fertigation Controller can use up to 4 fertilizer tanks. Each irrigation program can specify the percentage for each type of fertilizer. These values can be set using panel S 39 (SET FERTILIZERS).The fertilization is done in accordance with the conductivity control.

Each irrigation program has a specified conductivity target value (conductivity reference value which is set using panel S 41 (COND CONTROL);

The percent of applied fertilization can be automatically modified with respect to an amount of solar energy accumulated since the previous application. The current fertilizer status (set and current percentage value) can be checked on panel C 16 (FERTILIZ STATE).

Fertigation is also present in high-input farms. These farms are specialized; they can be owned and run by technicians who have a technical background. In such farms, more equipment is present and investment can be important for irrigation equipment. Hence, fertigation is used by very different farmers with very different background and very different practical experience. They can have a long experience of traditional irrigation for fruit trees, citrus and vegetables or they can run specialized and modern farms.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is fertigation controller? 6 points

2. List the functions of fertigation controller. 10 points

3. Discuss the setting requirements for each fertigation (irrigation) program. 4points

Note: **Satisfactory rating - 20 points** **Unsatisfactory - below 20 points**

You can ask your teacher for the copy of your answer

Score = ____________

Rating: ______________

Name: ___________________________ Date: ________________

Short Answer Questions

Information Sheet 3	Monitoring fertigation equipment

Chemigation and Fertigation operators protect human health and the environment from the potential hazard of pesticides and fertilizers. To accomplish this goal:-

Generate and distribute materials,

Conduct programs and demonstrations,

Provide individual consultation, and

Perform on-site visits when requested.

Chemigation and Fertigation activities are conducted in cooperation with agricultural organizations, grower group, and producer-administered associations as well as other governmental agencies, tribes, and environmental organizations. By increasing operator understanding of the potential impact that irrigation activities have on ground and surface water quality and by implementing appropriate management practices.

- Environmental Impact – Using controlled fertigation reduces the chance of over fertilizing, and subsequent fertilizer loss to river systems.

.

3.1. Fertilizer dosing in fertigation

To apply the same doses of fertilizers during the specific
Phonological stage of a plant, two different patterns of application can be made depending on the crop, soil type and farm management system:

1. Quantitative dosing: A measured amount of fertilizer is injected into the irrigation system during each water application. Injection may be initiated and controlled automatically or manually.
2. Proportional dosing: In this process, a constant predetermined ratio between the volume of the irrigation water and the volume of the fertilizer solution is maintained, resulting in a constant nutrient concentration in the irrigation water.

3.2. Suitability of fertilizers for fertigation

A large range of fertilizers, both solid and liquid, are suitable for fertigation depending on the physicochemical properties of the fertilizer solution. For large scale field operations, solid fertilizer sources are typically a less expensive alternative to the commonly used liquid formulations. The solubility of these fertilizers does vary greatly. When switching to a solid fertilizer source, problems can be avoided in the nurse tanks by ensuring that ample water is added to the stock solution.

Four main factors in selecting fertilizers for fertigation should be considered

- ✓ Plant type and stage of growth
- ✓ Soil conditions
- ✓ Water quality
- ✓ Fertilizer availability and price

The type of fertilizer for fertigation should be of high quality, with high solubility and purity, containing low salt levels and with an acceptable pH, and it must fit in the farm management program. The fertilizer characteristics as well as their effects on soils and crops are presented later.

The suitability of the fertilizer to the injection method as follows:

- **Form:** Soluble solid and liquid fertilizers are both suitable for fertigation depending on availability, profitability and convenience.
- **Solubility:** High and complete solubility is a prerequisite for fertilizers used in fertigation. Fertilizer solubility generally increases with temperature, depending on the fertilizer.
- **Interaction between fertilizers in solution**: When one type of fertilizer or more are prepared and mixed by the grower, or in the irrigation line (but to a lesser extent), the compatibility between them must be checked. There are usually some basic precautions that must be taken:
- **Make sure that the fertilizers used are compatible to prevent precipitation.**

Especially, avoid mixing fertilizer solutions that contain calcium with solutions containing phosphates or sulfates when the pH in the solution is not sufficiently acidic.

- Check the solubility and potential precipitation with the local water chemical composition. Before using a new fertilizer, mix 50 ml of the fertilizer solution with 1 liter of the irrigation water and observe for precipitation within 1-2 hours.
- Check the temperature resulting from mixing various types of fertilizers under field conditions. Some fertilizers alone or in combination may lower the solution temperature to freezing levels (e.g. KNO_3, $Ca(NO_3)_2$, urea, NH_4NO_3, KCl and $5Ca(NO_3)_2 \cdot NH_4NH_3 \cdot 10H_2O$. However, when purchasing ready-to-use liquid fertilizers, the endothermic reaction does not occur in the field, hence, slightly
higher concentrations of nutrients in the solution can be achieved.
- **Corrosivity**. Chemical reactions may occur between fertilizers and metal parts in the irrigation and fertigation systems. Corrosion can harm metallic components of the system like uncoated steel pipes, valves, filters and injection units

Like any other form of technology, some aspects of Fertigation require you to learn a few principles so you'll use it most effectively and without experiencing significant problems. Knowing a little about the potential problems before using Fertigation prevents a lot of frustration later. Most of the problems encountered in the use of Fertigation relate to the quality of the fertilizers you use. A large part of the problems revolves around phosphorus fertilizers and their solubility. Depending on formulation, phosphorus-fertilizer solubility may range from 30 percent to almost 100 percent. Most potassium and inorganic nitrogen (N) fertilizers are almost 100 percent soluble.

Blending fertilizer materials can induce another set of problems. A poorly blended fertilizer material may not stay in solution. It can precipitate, settling to the bottom of the tank to form a messy sludge. This can result in a fouled system and incorrect fertilization rates. The best way to prevent this occurrence is to ensure that the fertilizer is high-quality and soluble. The best way to do this is to buy from reputable suppliers that stand behind their products.

However, even high-quality fertilizers designed for Fertigation systems can precipitate or salt-out under certain conditions. Temperature variations can cause this occurrence, and you should consider the potential for this problem before storing fertilizers for extended periods. Check with your supplier to ensure that the fertilizer you've chosen is formulated for the time of year you'll be using it and the expected temperatures in your area. In the event that salt-out problems occur, dilute the concentration in the tank with water until the problem dissipates. In extreme cases, you'll need to remove solid material at the bottom of the tank either manually or by suction pump.

Compatibility can be a problem.

Keep in mind that not all liquid-fertilizer materials are compatible. It is important to rinse the tank before you introduce new materials into it. For example, phosphorus can be a particularly difficult nutrient to use in fertigation systems when other nutrients are present. Phosphorus will react with magnesium sulfate and calcium sulfate to form insoluble precipitates. When a precipitate forms, your system may clog up and stop working properly.

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Discuss the environmental impacts of fertigation. 5 points

2. List the four main factors in selecting fertilizers for fertigation. 4 points

3. What are types of fertilizer dosing in fertigation? 5 points
4. List the suitability of the fertilizer to the injection method. 6 points

Note: **Satisfactory rating – 20 points** **Unsatisfactory - below 20 points**

You can ask your teacher for the copy of your answer

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Answer sheet

Information Sheet 4	Implementing corrections to the process and equipment adjustments

Fertigation safety requires proper and secure connection of the system components, including the supply tank, injection devices, and irrigation system. The supply tank is connected to the irrigation system via a supply pipeline. Two small open-ended tubes are placed in the supply pipeline; the end of one tube faces upstream, while the end of the other tube faces downstream. The water that flows through the supply tank displaces the chemical stored in the tank, and the displaced chemical is forced into the irrigation supply line. The water pressure causes water to flow into the upstream tube and the chemical to flow out of the downstream tube, as a result of differential pressure between the up- and down-stream ends. The water pressure can be controlled using a pressure-reducing valve that is installed between the inlet and outlet ports in the supply pipeline. There is a high risk of contamination if a proper backflow prevention mechanism is not used. Possible contamination causes include discontinuation in water supply and the simultaneous operation of the chemical injection unit. This situation can worsen if the irrigation water flows back through the injection unit into the chemical storage tank, causing the tank to overflow. Check valves (in the main line and in the injection line), vacuum relief valves, low-pressure drains, and interlocking circuits are among the useful backflow prevention devices. At regional level, crop water requirements are adapted by extension from average monthly evapotranspiration (ET) and corrected by crop coefficients. Through that estimate, amount of water given to the crop is determined and converted as duration of irrigation by farmers. For tomato, irrigation is planned every day for half an hour to two hours. From that basic pattern, the amount of water can be modified by farmers; they will correct the duration of irrigation according to their own observation of crop behavior. On most of the farms, there are no measurements of soil water content and on few farms, weather data can be used to adapt the duration of irrigation.

Considering observations on different farmers fields, water consumption of a tomato crop varied between 6000 m3 and 10000 m3/ha, which represents between0.9 and 1.5 of time total estimated Penman evapotranspiration. In other situations, total water consumption can be reduced to 5000 m3/ha, but this is related to a reduction in water availability in July. When water is limited, water stress can be observed.

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Discuss the importance of implementing corrections to the process and equipment adjustments. 6 points
2. How water pressure in the fertigation equipments is controlled? 4 points

Note: **Satisfactory rating – 10 points** **Unsatisfactory - below 10 points**

You can ask your teacher for the copy of your answer

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Answer sheet

References

https://en.wikipedia.org/wiki/Fertigation

https://cropaia.com/blog/fertigation/

http://www.dpi.nsw.gov.au/agriculture/resources/water/irrigation/crops/publications/

Ben-Gal, A., N. Lazarovitch, and U. Shani. 2004. Subsurface drip irrigation in gravel filled cavities. The Vadose Zone Journal. 3:1407-1413.A204.

Horticultural Crops Production

Level - III

Learning Guide #14

Unit of Competence: -Operate Fertigation Equipment

Module Title: - Operating Fertigation Equipments

LG Code: AGR HCP3 M04LO3-LG-14

TTLM Code: AGR HCP3TTLM 0120v1

LO3: Shut down fertigation equipments

Instruction Sheet	Learning Guide #14

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Flushing out injection equipment
- Cleaning equipment
- Managing waste generated by both the fertigation process and cleaning procedures
- Recording and reporting fertigation activities

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Flush out injection equipment
- Clean equipment
- Manage waste generated by both the fertigation process and cleaning procedures
- Record and report fertigation activities

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1 to Sheet 4".
4. Accomplish the "Self-check 1 to Self check 5" **in page -57, 60, 65 and 67** respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1 in page **61**.
6. Do the "LAP test" **in page – 62** (if you are ready).

Information Sheet-1	Flushing out injection equipments

Flush out **injected equipment** or flush out valves should be placed at the ends of all irrigation or fertigation operation. There must be a means of flushing debris from the pipe to reduce emitter clogging. Flush out and flush valve installations should be designed and installed in a way that allows quick location and easy access for maintenance. Installation of the flush device in a valve box is preferred.

- Folded over and clamped pipe is unsightly and can leak. A manual shut-down valve should be installed between the potable water supply and the backflow prevention unit. A ball valve is recommended.
- A manual shut-down allows installation and repair without interrupting flow to the house.
- A manual shut-down allows for winterizing the downstream components of the point of connection.
- Ball valves must be opened and closed slowly.

Prior to starting the first irrigation season (and at any time system pressure or flow rate is reset)

1. Filter system adjustment

• Media cleaning
• Backflush flow adjustment
• Backflush frequency adjustment
• Backflush duration adjustment
• Backflush dwelling-time adjustment (the time between flushing of each two consecutive tanks)

2. System evaluation – test flow rate, operating pressure and distribution (emission) uniformity

Annually before the beginning of irrigation season

1. Undertake system evaluation – test flow rate, operating pressure and distribution (emission) uniformity
2. Inspect pumping station and pump/motor maintenance
3. Test bore and pump
4. Inspect all system components and replace defective ones
5. Inspect media and screen filters
6. Flush system

During the irrigation season

- Daily observations
    - Walk the field and repair any system irregularities
    - Check screen/media filter performance
    - Check and record system pressure and flow rate
- Weekly observations
    - Ckeck for emitters clogging
    - Clean screens and strains
    - Flush laterals
- Monthly observations
    - Perform screen /media filter maintenance
    - Measures and records laterals- compare to system design
    - Measure emitter discharge rate at selected locations
    - Check PH of water from lateral flushin- maintain below PH 6.5

As needed

- Acid injection
- Chlorine injection

Annually before system shutdown

- System flushing
- Chlorination/fertigation

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Discuss the importance of flushing out injection equipments before shutdown fertigation equipments. 8 points
2. Explain the advantages of manual shutdown of fertigation equipments. 4 points

Note: **Satisfactory rating - 12 points** **Unsatisfactory - below 12 points**

You can ask your teacher for the copy of your answer

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Answer sheet

Information Sheet-2	Clearing equipments

The system need to be flushed at least once a month. The frequency can be increased or reduced depending on the amount of impurities in the irrigation water. When the irrigation is complete, all the equipments and their component should be cleaned and stored safely in a safe place.

The procedure for the network is as follows:

• Flush mains, sub mains, manifolds and laterals.

• Inspect for possible damage to the network and repair it.

• Open fully and drain completely all valves.

• Remove dirt, corrosion and other foreign material from the component parts.

• Check emitters for possible clogging, damage, wear and signs of deterioration, and replace where necessary.

• Store all emitters in a dry clean place on shelves away from fertilizers, chemicals, oil, grease and lubricants.

• Examine the condition of air and check valves.

• Flush and drain filtration and fertilizer injection equipment.

• Clean all filter elements.

• Check condition of gaskets and seals; remove, clean and store in a dry place.

• Retrieve all portable plastic tubes by rolling them up in coils; store properly.

• Inspect all portable metal pipes for any kind of damage and consult suppliers for repair; store properly away from power lines and wiring.

• Drain completely all pipes left in the open

1) The job site shall be kept in a neat, clean, and orderly condition at all times during the installation process.

2) All scrap and excess materials are to be regularly removed from the site and not buried in trenches.

3) Trenching, laying pipe and backfilling shall be continuous so that the amount of open trench at the end of each work day is minimized. Any open trench or other excavations shall be barricaded and marked with high visibility flagging tape.

Next to tidiness, cleanliness is one of the most essential elements in maintaining a healthy and safe work environment. Not only does a clean workplace reflect the professionalism of a business or facility and help motivate employees, it also promotes a healthy workforce as a clean environment prevents accidents and the spread of germs.

Many office managers strive to maintain a clear work site policy, few succeed. However, each employee should be responsible for keeping their individual work area tidy and clean. It takes very little time to adopt a “clean and tidy as you go” policy and it needn’t hinder work performance. Furthermore, there is no reason why employees shouldn’t contribute to keeping the common work areas clean and tidy. Simple acts such as putting rubbish in the correct bin, placing cups in the dish-washer or washing them up and putting them away would contribute greatly to achieving a better working environment.

Like Health & Safety, maintaining a clean work environment is the responsibility of everyone.. However, there is only so much cleaning the team can do during each shift and in such cost conscious times it makes sense for employees to adopt some simple good housekeeping practices and allow the cleaning team to concentrate on hygiene and deep cleaning tasks.

Preventing mess as well as clearing up as you go along helps create a healthy workplace and provides the professional cleaning teams with a good platform to make effective use of their time on-site, allowing them to concentrate on hygiene, germ containment, recycling and deep cleaning. Working together we can all contribute to creating a safe and healthy workplace and a professional looking facility for employees, visitors and customers.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What are the advantages of cleaning fertigation equipments at the completion of work? 7 points
2. List steps/techniques of cleaning fertigation equipment. 10 points

Note: **Satisfactory rating – 17 points** **Unsatisfactory - below 17 points**

You can ask your teacher for the copy of your answer

Score = ___________

Rating: ____________

Name: ___________________________ Date: _______________

Answer sheet

Operation Sheet -1	Cleaning fertigation equipments

Steps/ techniques to clean fertigation equipments are:-

1. Flush mains, sub mains, manifolds and laterals.
2. Inspect for possible damage to the network and repair it.
3. Open fully and drain completely all valves.
4. Remove dirt, corrosion and other foreign material from the component parts.
5. Check emitters for possible clogging, damage, wear and signs of deterioration, and replace where necessary.
6. Store all emitters in a dry clean place on shelves away from fertilizers, chemicals, oil, grease and lubricants.
7. Examine the condition of air and check valves.
8. Flush and drain filtration and fertilizer injection equipment.
9. Clean all filter elements.
10. Check condition of gaskets and seals; remove, clean and store in a dry place.
11. Retrieve all portable plastic tubes by rolling them up in coils; store properly.
12. Inspect all portable metal pipes for any kind of damage and consult suppliers for repair; store properly away from power lines and wiring.
13. Drain completely all pipes left in the open

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: _________________________ Time finished: ________________

Instruction: Given necessary templates, tools and materials you are required to perform the following tasks within 3 hours.

Task 1. Clean ferigation equipments

Information Sheet 3	Managing waste generated by both the fertigation process and cleaning procedures

In fertigation management, fertilizer choice and irrigation water quality are the two most important considerations. The water characteristics influencing the fertigation operation are ion composition, water salinity level, pH, bicarbonate concentration and redox potential.

Two main aspects are of importance when water quality is considered in fertigation:

1. The effect of water quality on plant nutrition;
2. The fertilizer-water interactions in the irrigation system.

Fertility Management Native soils are generally used as the growing medium in most high tunnel systems and therefore the first step in managing fertility in a high tunnel is to obtain a routine soil test. Soil pH, P, K, Ca, Mg, and micronutrients should be monitored every two to three years or more often if problems are occurring. In addition, a soluble salts test (also known as an electrical conductivity test) is recommended to ensure that salts are not building up. For most situations, adjustment of pH, phosphorus fertility, and micronutrients should be done before planting.

Fertilizers are an important resource input in conventional agriculture, however the over-application of nutrients can cause a host of environmental problems including polluting water resources and emitting nitrous oxide (a potent greenhouse gas) into the atmosphere.

Environment protection

- Is aware of relevant catchment management plans and ensures fertilizer use is consistent with those plans and with the soil's present fertility status.
- Knows and understands the relevant environmental values of local water bodies
- Is aware of the priority pollutants of local water bodies.
- Recognizes the indicators of eutrophication in water bodies.
- Is aware of whom to contact and the procedures to follow should a fertilizer spill occur in a farm dam or waterway.
- Understands the main pathways for nitrogen and phosphorus fertilizer loss from farms, specifically.

Fertigation is another management tool for growers to use in production of selected vegetable crops. It is an extremely effective and efficient method of applying fertilizers and other chemicals via the drip irrigation system. However, it does require more management and attention to details than other methods of fertilizer application. Success in using this system will depend on a sound fertility program based on soil testing and a drip irrigation system that is designed and operated properly.

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Why need of managing waste materials generated by fertigation process and cleaning process? 6 points
2. Discuss the impact of wastes management in environmental protection. 6 points

Note: **Satisfactory rating – 12 points** **Unsatisfactory - below 12 points**

You can ask your teacher for the copy of your answer

Score = ___________

Rating: _____________

Name: _________________________ Date: _______________

Answer sheet

Information Sheet 4	Recording and reporting fertigation activities

One of the best sources of information in planning a major overhaul should be the maintenance records for the unit or units involved. These records should provide details on the history, present condition, and any unusual maintenance problems of the fertigation unit. This can help identify specific items that may need attention during the overhaul. Reports of previous overhauls can prevent the same mistake from being made twice and may provide tips that can expedite the overhaul procedure. The maintenance files may also provide names of sources for parts and materials and fertigation equipment

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Explain the importance of recording and reporting of fertigation activities at the completion of activities. 7 points
2. What are the fertigation activities should be recorded and reported. 8 points

Note: **Satisfactory rating - 15 points** **Unsatisfactory - below 15 points**

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

References

https://en.wikipedia.org/wiki/Fertigation

https://cropaia.com/blog/fertigation/

http://www.dpi.nsw.gov.au/agriculture/resources/water/irrigation/crops/publications/

Ben-Gal, A., N. Lazarovitch, and U. Shani. 2004. Subsurface drip irrigation in gravel filled cavities. The Vadose Zone Journal. 3:1407-1413.A204.

NO.	TTLM developer Name	Back ground Qualification	College Address	College Name	Cell Phone	E-mail
1	DeribowGonfa	Plant science(Bsc)	Oromiya	FitchePollyTVET	0912774688	gonfad24@gmail.com
2	TesfayeTekola	Agronomy (Msc)	BenishangulGumuz	Assosa ATVET	0910550651	tttekola@gmail.com
3	BerhanuMammo	Horticulture (BSc)	Federal	Mizan ATVET	0912676883	birehanmammo@gmail.com
4	HaftuMehari	Plant science(BSc)	Tigray	Maichew ATVET	0914312311	Kalabkalab61@gmail.com
5	MelakuBawoke	Agronomy (Msc)	Federal	Gewane	0920258287	Melakubawoke10@gmail.com
6	TadesseYasin	Horticulture (BSc)	Amhara	KombolchaPollyTVET	0921626541	-
7	ZewdePaulos	Agronomy(Msc)	SNNPR	Sodo ATVET	0921004814	Zedpa2013@gmail.com
8	BekeleBelete	Agronomy (Msc)	SNNPR	Sodo ATVET	0916379025	Bekelebelete6@gmail.com
9	FeteneMuluken	Agronomy (Msc)	Amhara	Woreta ATVET	0986911690	Fetenemuluken9@gmail.com
10	Misgana Belay	Agronomy (Msc)	Oromia	Nedjo ATVET	0911983854	Misbel2000@gmail.com
11	SadikEbrahim	Agronomy (Msc)	Federal	Agarfa ATVET	0920617776	sadikebra@gmail.com
12	Birhanureda	Horticulture(BSc)	Tigray	Maichew ATVET	0923452395	birhanureda@gmail.com

Profile of trainers participate on specialty Horticultural Crops Production

TTLM development for level III at Adama 012020