FERTIGATION TRAINING: BEYOND SYSTEM UNFORMITY

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Abstract
Growers are faced with the change of making sure their use of nutrient is efficient and sound. In the hands-on training workshops we offer, we emphasize the concepts of irrigation distribution uniformity (DU) and fertilizer uniformity. We emphasize that DU is a prerequisite for efficient fertigation, but irrigators have to go beyond this step. By using fertilizer travel time, injection time and flush time of irrigation lines, they can provide their plant with uniform and effective fertilization without causing degradation to the environment.

Key words: fertigation, distribution uniformity, flush time, injection time, travel time

Introduction

For decades, farmers and irrigators have practiced the science of fertigation, the injection of fertilizer through irrigation. With the advent and wide adoption of drip irrigation, this practice gained wider acceptance. Drip fertigation supplies nutrients directly to the roots of the plant and offers the ability to spoon feed them at a rate that closely follows their pattern of nutrient uptake.

In California's central coast, the majority of vegetable crops are irrigated and fertilized using drip irrigation. These irrigation systems are well managed with good distribution infirmity. However, with increasing environmental concerns and resulting regulatory pressures to manage nutrient pollution, it became clear that irrigation distribution uniformity (DU) alone, while critical, is it not enough to ensure good nutrient management and certainly will not compensate for poor fertigation strategies.

Irrigation distribution uniformity

Obtaining an even distribution of nutrients using fertigation can be challenging on the central coast. Growers are often managing many small fields with different shapes and sizes that are located at varying distances from where fertilizer is injected into the irrigation system. They may not know how much time is needed for the injected fertilizer to travel through the irrigation system. Many growers practice short, frequent water applications and fertigation, a practice that may not allow for complete flushing of the system. In addition, there are growers who have fields with poor irrigation uniformity that translates into poor fertigation results. In our outreach effort, we developed and continue to deliver a series of hands-on training workshops that use a demonstration drip system to teach the principles of drip irrigation and fertigation to growers, foremen, and irrigators. In these workshops, we focus on the importance of the two concepts of proper irrigation and fertilizer injection.

Good water management starts with a good uniform irrigation system. This concept is conveyed via hands-on exercises to evaluate system uniformity. Training attendees carry out pressure balancing of the demonstration system to detect friction losses or plugged emitters. They used pressure gauges and Schrader valves affixed to drip tape ends.

Afterward, they carry out an evaluation of outflow by collecting discharges for emitters at different locations in the field. The discharge rate of the tape is measured by collecting water during a 10-minute period from individual emitters at locations that represent the head, middle, tail, and sides of the field or irrigation block.

The collected water data is then used to calculate a DU value. The distribution uniformity can be calculated from these data by computing the ratio of the lowest quarter average and that of all the volumes measured collected during the exercise, according to the following equation:

$$distribution\, uniformity\, of\ lowest\, quarter = \frac{average\ of\ lowest\, 25\%\ of\ volumes\ measured}{average\ of\ all\, volumes\ measured}$$

Afterward, the participants engage in a discussion of the data, how it relates to DU, and what corrective measures they can take if DU values are low. Once the DU is determined and is brought up to a desirable level (equal or greater than 85%), then we conduct the fertilizer injection exercise.

Fertilizer distribution uniformity

Discussion of the second phase of the hands-on workshop focuses on two topics, fertilizer use and even nutrient distribution. We discuss fertilizer types and review the appropriate fertilizer materials suitable for injection. This segment also covers possible incompatibilities of different products and how to perform a simple test prior to injection to avoid the formation of precipitates which can plug the emitter. Finally, we discuss fertilizer quantities to use and their correlation to plant growth stages.

The demonstration prototype is set in two sub-blocks, simulating two irrigation blocks on a farm. Each block is set up to inject at a different injection rate (1X and 2X). The goal is to compare the effects of fast and slow injections on fertilizer travel time. A concentrated solution of dissolved nitrogen fertilizer and food-grade dye is injected at contrasting rates in each block. Participants collect water discharged from the emitters in cups at locations that represent the head, middle, tail, and sides of the field. A timekeeper notes down the time the dye was first observed at each location in the field. The time required for the dye to reach the furthest point of block is equal to the travel time of the fertilizer.

At the end of the slow injection, the participants replace their cup with an empty second cup. The second cup is removed when clear water is collected for a period of time equal in length of the travel time. This represents flush time. Participants compare all the paired cups by contrasting color intensity and by reading electrical conductivity values of the water. The following observations and conclusions were discussed with workshop participants at the conclusion of the exercise:

- The injected dye traveled at a rate that was dependent on the flow of water in the drip tape and not on the rate of injection.
- The injected fertilizer travels rapidly at the head of the field but then moves progressively slower towards the tail end of the field.

These two observations illustrate the concept of travel time, the time span it takes injected fertilizer to reach the farthest point in the field. Travel time is independent of the rate of fertilizer injection. This is because fertilizer moves at a speed dictated by speed of water movement in the drip lines. Emitter discharge rate lateral lines will determine the speed of water in the drip tape. As water approaches the end of the tape, there are fewer emitters providing flow and, subsequently, lower flow rates in this region of the tape.

- As flush time approaches or exceeds travel time, fertilizer distribution in the field improved dramatically.

- For both rates of injection, the fertilizer was poorly distributed when flush time was shorter than travel time.

Flush time is the time it takes to clean the lateral lines of any injected material. Flush time is correlated to travel time. When lateral lines are cleaned for a time equal or greater than travel time, participants observed equal distribution of fertilizer as indicated by color intensity in the discharged liquid in the cups. EC readings in different cups also supported this observation. Collected discharged solution during travel time only (cup one) resulted in intense color and higher EC levels (0.74 – 0.82 mmohs/cm) at the front-end of the field. Water collected from the tail end of the field was almost clear, and the EC was close to background level of the irrigation water (0.4 – 0.44 mmohs/cm). Collected solutions during flushing alone (cup 2) reversed the trend and ranged from 0.44 mmohs/com at the front of the field to more than 0.80 mmohs/cm at the tail end. However, the overall cup average EC of the combined travel/flush times (cups 1 and 2) was around 0.66 mmohs/cm.

The third concept that was demonstrated is that of injection time. Attendees observed that whenever injection time was shorter than travel time, fertilizer distribution was less than satisfactory.

When injection time, travel time, and flush time were all equal, relative fertilizer distribution was improved.

The principal derived from this discussion can be summarized bythe following recommendations. After injecting, irrigators should allow enough time to flush the system completely of fertilizer. Conversely, the worst thing an irrigator can do when fertigating is to shut off the system when the fertilizer tank is empty.

However, flush time should be at least one to two times longer than the travel time, so as not to exceed the critical point beyond which mobile nutrients, such as nitrates, would leach beyond the root zone and eventually pollute groundwater.

Conclusions

Fertigation is a very useful tool for applying nutrients to drip-irrigated crops if steps are taken to ensure that the distribution is uniform. The hands-on sessions emphasize two principal concepts, irrigation uniformity as expressed by distribution uniformity (DU) and fertilizer distribution in the field.

DU can be assessed indirectly via pressure readings at the head and tail end of the field, or directly by collecting water discharges from emitters at different points in the field. High DU of 85% or more is required to effectively utilize fertigation.

To successfully achieve fertilizer distribution uniformity, growers need more than just a uniform delivery system. They need to take into account three additional factors: injection time, travel time, and flush time. By allowing time for the fertilizer to travel to the tail end of the field and using it as time-base-unit for injection and flushing, they would increase the level of uniform fertilizer distribution in their field. By using careful flush time that is based on travel time, they will also avoid deep leaching of mobile nutrients beyond the plant root zone. Such actions provide efficient use of nutrients, spare the environment, save precious resources, and minimize cost on inputs.

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