A. Project Information:

Report type: Final

FREP grant number: 20-0963-000-SA

Time covered by the grant period: January 1, 2021 – December 31, 2022

Project title: University of California Nursery and Floriculture Alliance Fertilizers and Plant Nutrition Workshops for Greenhouse and Nursery Growers

Project leaders:
Dr. Lorence Oki, Specialist in Cooperative Extension (CE), Department of Plant Sciences, UC Davis, lroki@ucdavis.edu, (530) 754-4135.
Dr. David Fujino, Executive Director, California Center for Urban Horticulture, UC Davis, dwfujino@ucdavis.edu, (530) 754-7739.
Dr. Don Merhaut, Associate Specialist in Cooperative Extension, Department of Botany and Plant Sciences, UC Riverside, donald.merhaut@ucr.edu, (909) 560-0038.
Dr. Maria de la Fuente, Director UC CE Monterey County and CE Advisor Monterey, San Benito, and Santa Cruz Counties, medelafuente@ucanr.edu, (831) 759-7358.
Dr. Gerardo Spinelli, Advisor UC CE San Diego County, gspinelli@ucdavis.edu, (530) 304-3738.

B. Abstract:

Fertilizers are an essential part of greenhouse and nursery plant production. Crops in these systems are grown in substrates that are “synthetic” in that they contain little to no natural mineral soils. Due to the limited fertility provided by these substrates, nutrition must be provided, mostly with fertilizers, for healthy and productive growth.

Another challenge to greenhouse and nursery production in California is that the majority of these crops are grown in containers, although there is some field production of specific nursery and floriculture crops. In either case, since these crops are grown in highly intensive systems, high plant densities and shortened crop times, there is also a high demand for resources including water, energy, labor, and nutrients.

Improper management of plant nutrition can affect crop health. Both under- and over-applying fertilizers can result in poor crop quality, which not only has negative economic impacts, but also can result in polluting surface and groundwater.

This project will utilize workshop programs and materials developed under Agreement Number 16-0678-000-SA. That project presented 8 workshops in English and Spanish. This project provided up to 8 additional short courses (4 in English, 4 in Spanish) to respond to the requests we have received for additional workshops on this topic.

C. Introduction:
This project builds upon prior work by the University of California Nursery and Floriculture Alliance (UCNFA) and a previously awarded CDFA FREP grant (Agreement Number 16-0678-000-SA). UCNFA is an outreach and extension program of the UC Agricultural and Natural Resources Division (UCANR) that provides technical and educational training for nursery and greenhouse growers.

As part of a long-term project, the UCNFA team has been providing half-day English and Spanish workshops on plant nutrition and fertilizer management since 2011. Over the years, these workshops have been revised, expanded, and offered to growers throughout California. A listing of previous workshops can be found at https://UCNFA.UCANR.edu.

In the previously awarded CDFA FREP grant titled "University of California Nursery and Floriculture Alliance Fertilizers and Plant Nutrition Education Program," 8 half-day workshops (4 in English and 4 in Spanish) were offered during the 2017-2018 project period. These workshops included new topics and demonstrations incorporated by the UCNFA team in response to feedback from attendees on previous events. This grant also provided funding for the production of educational nutrient management YouTube videos.

The success of the workshops led to numerous requests for more events. This project will provide 8 additional workshops (4 in English, 4 in Spanish) to meet grower demand. Workshops will be held throughout California in locations of high concentrations of nursery and greenhouse growers such as San Diego, Ventura, the San Joaquin Valley, and Salinas/Watsonville. The workshops will be modified from half-day events to full-day events. This will accommodate the incorporation of more content and demonstrations and greater discussion amongst attendees.

The earlier workshops delivered content in 2 half-day sessions. On the first day, Part 1 of the workshop series described the roles of plant nutrients. Content was provided in English in the morning and to a different audience in Spanish in the afternoon. About 1 month later, Part 2 of the series discussed operational topics related to fertilizer use and management, again in English in the morning and Spanish in the afternoon. This format was used based on surveys of attendees of the pilot workshop conducted in the previous project. However, we found that the audiences of Parts 1 and 2 were different, so few attendees received the entirety of the information presented by the program.

This project provided all of the content in a single day so that attendees will receive all of the relevant information on plant nutrition and fertilizer management. This format also reduces travel costs since the transportation costs per workshop were reduced.

D. Objectives:
Objective 1: Review and improve the workshops that were provided by the previous CDFA FREP grant (Agreement Number 16-0678-000-SA). Workshops will be modified from half-day events to full-day events to allow for grower schedule accommodation, more content and demonstrations, greater discussion amongst attendees, and minimization of travel for project staff. Improvements will be made based on grower-attendee feedback from previous post-workshop surveys and instructor insight. Content will be expanded and may include demonstrations of how to monitor irrigation water and media conditions.

Objective 2: Provide 8 new workshops (4 in English, 4 in Spanish) for growers on plant nutrition and fertilizer management. Workshop locations may include areas with high concentrations of nursery and greenhouse production such as San Diego, Ventura, the San Joaquin Valley, and Salinas/Watsonville. At each location, day 1 will be the English workshop and day 2 will be the Spanish workshop. Workshop attendees will be surveyed to determine if workshops on additional topics regarding managing plant nutrition and the use of fertilizers would be helpful to growers for efficiently using fertilizers to optimize crop growth and minimize environmental impacts.

Objective 3: Continue to monitor the plant nutrition YouTube videos produced under the previous grant (Agreement Number 16-0678-000-SA). These videos were announced at the UCNFA website (https://ucnfa.ucanr.edu/), included a link to the list of the videos (https://ucnfa.ucanr.edu/Fertilizers_and_Plant_Nutrition_Videos), and posted on the UCNFA YouTube channel (https://www.youtube.com/channel/UC7OYtL9PEKN4CzcJLBYoFdg) and the UCANR YouTube channel: https://www.youtube.com/playlist?list=PLLjlfxpbNglZdZQ04CiB0ipW7i-WdzIvy for easy access by growers and their personnel. Viewership totals and video comments will be monitored. Videos will be assessed and improvements to the existing videos may be proposed. Additional topics for future videos may also be proposed.

E. Methods: Explain project activities pertaining to each objective. Summarize project activities, methods, and materials in enough detail to provide an in-depth understanding of how each task was conducted.

These workshops will provide in-depth training on essential plant nutrients and the use of fertilizers for the floriculture and container nursery industries. Understanding when and how to use fertilizer will not only produce a healthier crop but also reduce cost of production and excess fertilizer and pesticides in runoff. Plant health is also a key component of an Integrated Pest Management Program and optimizes the efficacy of pesticides and reduces the damage caused by insects and diseases.

Participants will be able to:
- Identify and understand the role of plant nutrients and their role in plant growth
- Determine the appropriate fertilizer program for individual nurseries

- Describe and identify fertilizer types and how to incorporate them into a fertilizer program
- Customize fertilizer application programs to individual needs to optimize nutrient uptake and reduce damage from over or under fertilization

Workshop title: Optimizing Plant Nutrition of Containerized Crops Through Fertilizer, Water, and Media Management

The program is broken down into 5 sections:

1) Essential plant nutrients. (45 minutes)
   Macronutrient, micronutrients and nonessential nutrients. We will provide a list of the nutrients, briefly state their role in plant growth and their mobility in the plant, and their role in plants. Understanding this area of plant physiology specific to plant nutrition will aid in diagnosing field problems and properly collecting tissue samples and keeping proper records.

2) Determining the fertilizer program for your nursery. (2 hours)
   This section of the program is broken down into three parts: water, media and crop. We will discuss what parameters are crucial and not crucial to plant nutrition in container production. We will also demonstrate how to measure and correct some of these parameters.
   a) Irrigation water quality and nutrients derived from water. We will describe pH, alkalinity, EC, bicarbonates, and other aspects of water that impact fertility status. Topics will include management methods to reduce environmental impacts. Portable equipment will be demonstrated to easily monitor water quality on site.
   b) Planting Media Quality. We will highlight what to look for in planting media, both physical and chemical properties of substrates that are used to make growing media. In this section we will demonstrate some methods to monitor media performance.
   c) Crop Type. What type(s) of crop will be grown? There are different crops, and many nurseries are growing long-term crops such as woody ornamentals, and short-term color and succulents. These crops have different water and nutrient requirements and we will point out aspects to improve this - separating crops out by these specific needs. We will also point out some fertilizer differences to meet the needs of pH preferences (acid vs. slightly neutral.

3) Fertilizer Types. (1.5 hours).
   We will describe the different types of fertilizers available and highlight how they work. Specifically, we will review different types of granular and liquid fertilizers and micronutrient chelates. We will also review how to calculate fertilizer applications.
   a) Soluble Fertilizers – We will describe special formulations, winter/vs. summer issues, and general BMPs regarding the mixing and management of solutions.
   b) Controlled Release Fertilizers – We will describe types, release characteristics, performance, and general BMPs when using these products.

c) Organic Fertilizers – We will describe some types currently available, how nutrients are released from these products, and BMPs.

4) Monitoring Crop Fertility Status. (1.5 hours)
This portion of the workshop will review how to monitor fertility status through media, water and tissue analyses. We will describe what should be monitored, how to monitor, and how to interpret lab reports. We will have a samples lab report for media, water, and tissue, and review them. The final part of this section will discuss the essentials of proper record keeping.

5) Measuring Nitrate and Nitrate-Nitrogen in water
This section of the workshop will discuss the differences between nitrate and nitrate-nitrogen and how to measure those parameters. There will be a hands-on session where attendees will use several methods to measure those parameters and understand the results.

F. Data/Results:
For projects that are outreach and education focused, the data/results section shall include the following:
a. Material deliverables – any outreach or educational materials published and/or printed over the course of the project

Presentations
Plant Nutrition and Fertilizer Management in Nursery Operations by Dr. Don Merhaut
https://ucanr.edu/sites/UCNFA/files/369992.pdf

Measuring Nitrate in Water by Dr. Gerry Spinelli
https://ucanr.edu/sites/UCNFA/files/369993.pdf

Videos on Fertilizers and Plant Nutrition at the
UCNFA YouTube Channel
https://www.youtube.com/channel/UC7OYtL9PEKN4CzcJLBYoFdg
And the UCANR YouTube channel:
https://www.youtube.com/playlist?list=PLLjlfxpbNglZdZQ04CiB0ipW7i-WdzIvy

Essential Plant Nutrients and Fertilization in Nursery Production
Learn the fundamentals of plant nutrition and fertilization in nursery production systems, including macronutrient -- nitrogen, phosphorus, potassium -- and micronutrient requirements, nutrient uptake processes, and the allocation of mobile and immobile nutrients in the plant.
Published on the UCNFA channel Feb 8, 2019. 1,403 views
Published on the UCANR channel July 16, 2020. 1,160 views for a total of 2,563 views

Nitrogen in Plant Nutrition in Nursery Production
Nitrogen is an essential plant nutrient. Learn about nitrogen uptake, metabolism and mobility in plants.
Published on the UCNFA channel Feb 8, 2019. 239 views
Published on the UCANR channel July 16, 2020. 252 views for a total of 491 views

Nitrogen Deficiency and Toxicity Issues in Nursery Production
Learn how to identify and fix nitrogen deficiency and nitrogen toxicity problems in nursery production systems.
Published on the UCNFA channel Feb 8, 2019. 198 views
Published on the UCANR channel July 16, 2020. 223 views for a total of 421 views

Phosphorus in Plant Nutrition in Nursery Production
Learn about phosphorus uptake and mobility in nursery production systems, and how to identify and address phosphorus deficiency and phosphorus toxicity problems.
Published on the UCNFA channel Feb 8, 2019. 310 views
Published on the UCANR channel July 16, 2020. 906 views for a total of 1,216 views

Potassium in Plant Nutrition in Nursery Production
Learn about potassium uptake and mobility in nursery production systems, and how to identify and address potassium deficiency and potassium toxicity problems.
Published on the UCNFA channel Feb 8, 2019. 188 views
Published on the UCANR channel July 16, 2020. 212 views for a total of 400 views

There were a total of 5,091 views of the English videos.

Nutrientes Esenciales de las Plantas y Fertilización en la Producción de Viveros
Conozca los fundamentos de la nutrición y la fertilización de las plantas en los sistemas de producción de viveros, incluidos los procesos de absorción de macronutrientes y micronutrientes, y la asignación de nutrientes móviles e inmóviles en el planta.
Published on the UCNFA channel Feb 12, 2019. 377 views
Published on the UCANR channel July 22, 2020. 4,601 views for a total of 4,978views

Nitrógeno en la Nutrición de las Plantas en la Producción de Viveros
El nitrógeno es un nutriente esencial para las plantas. Aprenda sobre la absorción de nitrógeno, su metabolismo y movilidad en las plantas.
Published on the UCNFA channel Feb 8, 2019. 316 views
Published on the UCANR channel July 22, 2020. 1,494 views for a total of 1,810 views

Problemas de Deficienciay Toxicidad de Nitrógeno en la Producción de Viveros
Aprenda a identificar y corregir los problemas de deficiencia y toxicidad de nitrógeno en los sistemas de producción de viveros.
Published on the UCNFA channel Feb 8, 2019. 1,254 views
Published on the UCANR channel July 22, 2020. 695 views for a total of 1,949 views

Fósforo en la Nutrición de las Plantas en la Producción de Viveros
Aprenda sobre la absorción de fósforo y la movilidad en los sistemas de producción de viveros, y cómo identificar y abordar los problemas de deficiencia de fósforo y toxicidad de fósforo.
Published on the UCNFA channel Feb 12, 2019. 2,363 views
Published on the UCANR channel July 22, 2020. 1,928 views for a total of 4,291 views

El Potasio en la Nutrición Vegetal en la Producción de Viveros
Aprenda sobre la absorción y la movilidad del potasio en los sistemas de producción de viveros, y cómo identificar y abordar los problemas de deficiencia de potasio y toxicidad de potasio.
Published on the UCNFA channel Feb 11, 2019. 140 views
Published on the UCANR channel July 22, 2020. 1,232 views for a total of 1,372 views

There were a total of 14,400 views of the Spanish videos.

b. Information on Event(s)

July 11, 2022 (English) 15 attend
Center for Applied Horticulture Research at Altman's Nursery
Vista, CA

August 9 (English) and 9 attend
August 10 (Spanish) 7 attend
Ventura County Cooperative Extension
Ventura, CA

August 23 (English) and 7 attend
August 24 (Spanish) 4 attend
Stanislaus County Cooperative Extension
Modesto, CA

November 9 (English) and 7 attend
November 10 (Spanish) 16 attend
Monterey County Cooperative Extension
Salinas, CA

4. Presentation title(s):
Plant Nutrition and Fertilizer Management in Nursery Operations by Dr. Don Merhaut
https://ucanr.edu/sites/UCNFA/files/369992.pdf

Measuring Nitrate in Water by Dr. Gerry Spinelli
https://ucanr.edu/sites/UCNFA/files/369993.pdf

5. Number of participants: See entries in b. above

6. Type of audience: Growers, grower consultants, and technical and sales representatives.

7. Supporting documentation (e.g. flyers, program, etc.)
UC Nursery and Floriculture Alliance (UCNFA)

See **UCNFA website pages.docx** as an appendix showing all of the webpages promoting the events.
See **MailChimp Fertilizers and Plant Nutrition all.pdf** as an appendix showing email announcements sent to the UCNFA email list.
See **UC Davis Registration pages all.pdf** file as an appendix showing screenshots of the inline registration pages for all events.

8. CCA CEUs/Grower CEUs offered:
CCA- 8 hours
Irrigated and Nitrogen Management Training Program- 5 hours

c. Impact Measures
Informal evaluations were made at the end of the workshops asking about what was learned. Attendees appreciated several aspects of the workshops including the hands-on activities on measuring nitrate in water, using different methods to measure nitrate, and measuring pH and EC. They also appreciated explanations regarding nutrition that were easy to understand. There were at least four event presenters present at the workshops (except at Salinas where Loren was absent due to illness) that enabled constructive discussions of topics and personal attention during the hands-on demonstrations.

Opinions of attendees was sought to explain low attendance. The most common explanations provided were that although business has been good as a result of COVID stay-at-home policies that increased activities inside and outside the home regarding plant use but there is also an inability to fill positions which means that there is less time available for activities outside of on-site work.

The YouTube videos produced in the previous FREP-supported project continue to be utilized. There were a total of 5,091 views of the videos in English. But there 14,400 views of the videos on Spanish! This demonstrates the need for more educational and technical training and support materials in that language.

2. Any improvements made based on feedback
Two half-day, instead of full-day, workshops may be more attractive for attendees. But in past workshops held were half-day, it was found that the attendees differed between the two days and meant that attendees did not receive the full content of the program. Perhaps in the future, the lecture component could be provided as an online workshop (e.g., via Zoom or prerecorded) and the hands-on demonstrations be held in person. That would allow attendees to have to leave work and travel for only one half-day period.

G. Discussion and Conclusions:
Objectives were met, but minimally. We provided a total of 7 workshops in four locations missing the target of 8 workshops. More attendees at each workshop event would have been more impactful, of course. It was hoped that there would be at least 15 to 20 in

attendance at each event. This number was achieved only at the Vista English and Salinas Spanish events. There were no registrations for the Spanish event in Vista.

The YouTube videos continue to be viewed. One set of videos was released through UCNFA in 2019, and a revision was released by UCANR in 2020. There were a combined total of 5,091 views of the videos in English. But there 14,400 views of the videos on Spanish! This demonstrates the need for more educational and technical training and support materials in that language.

H. Challenges:
Challenges due to COVID restricted in-person meetings until 2022. But there seemed to be reluctance to participate as reflected in low attendance at the workshops that occurred earlier in the year. The first workshop was initially planned in Salinas in late June, but very low registrations caused it to be cancelled and rescheduled to November. Attendance then was better, but still much lower than expectations. Other issues seemed to affect attendance including business being very good, but hiring to fill open positions was an obstacle to achieving better attendance.

I. Project Impacts:
The content of this project focuses directly on improving fertilizer use efficiency to reduce over use and potential contamination of surface and ground waters. There was a section devoted specifically on nitrate that discussed how to measure it in water and included a hands-on activity using several methods. The number of views of the YouTube videos on plant nutrition topics in Spanish (14,400) compared to English (5,091) supports the need for more educational and technical training in nursery and greenhouse topics in this language.

J. Outreach Activities Summary:
Seven workshops on Fertilizers and Plant Nutrition Workshops for Greenhouse and Nursery Growers were provided in English and Spanish in four locations. Topics covered included 1) The essential plant nutrients, 2) Determining that fertilizer program for your nursery, 3) Fertilizer types, 4) Monitoring crop fertility status, and 5) Measuring nitrate in water. Information on these topics was presented followed by a hands-on session when attendees were able to measure nitrate and other parameters (pH and EC) using different methods.

YouTube videos produced for nursery production in a previous FREP-supported project were monitored for use. There are 5 videos in both English and Spanish covering the topics of 1) Essential plant nutrients, 2) Nitrogen in plant nutrition, 3) Nitrogen deficiency and toxicity issues, 4) Phosphorus in plant nutrition, and 5) Potassium in plant nutrition.

A detail of the activities conducted is this is an outreach project this information is presented in section F above.

K. References: No citations

L. Appendix:

UCNFA website pages.docx as an appendix showing all of the webpages promoting the events.
MailChimp Fertilizers and Plant Nutrition all.pdf as an appendix showing email announcements sent to the UCNFA email list.
UC Davis Registration pages all.pdf file as an appendix showing screenshots of the inline registration pages for all events.

M. Factsheet/Database Template: Grantees are required to complete a factsheet template (no more than two pages). The information entered in the template should provide a summary of the work performed by the grantee, demonstrating the significance of the research and its contribution towards advancing the environmentally safe and agronomically sound use of fertilizing materials. Information should be written as a practical guide with growers and certified crop advisors in mind. Please include the following sections:

1. **Project Title:** University of California Nursery and Floriculture Alliance Fertilizers and Plant Nutrition Workshops for Greenhouse and Nursery Growers
2. **Grant Agreement Number:** 20-0963-000-SA
3. **Project Leaders:**

Lorence R. Oki, Ph.D.
Cooperative Extension (CE) Specialist
and Co-Director UC Nursery and
Floriculture Alliance (UCNFA)
University of California, Davis
Department of Plant Sciences, MS6

Don Merhaut, Ph.D.
Associate CE Specialist, Nursery and
Floriculture Crops
University of California, Riverside
Department of Botany and Plant
Sciences

Dave Fujino, Ph.D.
Executive Director
California Center for Urban Horticulture
and Co-Director UCNFA
University of California, Davis
College of Agriculture and
Environmental Sciences
Davis, CA 95616-8570

Maria de la Fuente, Ph.D.
Director UC CE Monterey County and
CE Advisor Monterey, San Benito, and
Santa Cruz Counties

Gerardo Spinelli, Ph.D.
Production Horticulture Advisor UC CE
San Diego County

4. **Start Year/End Year:** 2021/2022
5. **Locations:** Vista, Ventura, Modesto, Salinas
6. **Counties:** San Diego, Ventura, Stanislaus, Monterey
7. **Highlights:**
    - Workshops on plant nutrition and fertilizers in nursery production were provided in English and Spanish.
    - Hands-on activities included learning how to measure nitrates, pH, and electrical conductance (EC) in water.

- Presentation slides are posted at: https://ucanr.edu/sites/UCNFA/files/369992.pdf and https://ucanr.edu/sites/UCNFA/files/369993.pdf.
- Views of YouTube videos produced in a previous project were monitored on the UC ANR (https://www.youtube.com/playlist?list=PLLjlfxpbNglZdZQ04CiB0ipW7i-WdzIvy) and UCNFA (https://www.youtube.com/channel/UC7OYtL9PEKN4CzcJLBYoFdg) channels.

8. **Introduction**

Fertilizers are an essential part of greenhouse and nursery plant production. Crops in these systems are grown in substrates that are “synthetic” in that they contain little to no natural mineral soils. Due to the limited fertility provided by these substrates, nutrition must be provided, mostly with fertilizers, for healthy and productive growth.
Another challenge to greenhouse and nursery production in California is that the majority of these crops are grown in containers, although there is some field production of specific nursery and floriculture crops. In either case, since these crops are grown in highly intensive systems, high plant densities and shortened crop times, there is also a high demand for resources including water, energy, labor, and nutrients. Improper management of plant nutrition can affect crop health. Both under- and over-applying fertilizers can result in poor crop quality, which not only has negative economic impacts, but also can result in polluting surface and groundwater.

This project will utilize workshop programs and materials developed under Agreement Number 16-0678-000-SA. This project provided 7 additional short courses (4 in English, 3 in Spanish) to respond to the requests we have received for this workshop.

9. **Methods/Management**

Full day workshops were planned in four locations, in English followed by a repeat in Spanish. The plan nutrient program was presented in five sections: 1) The essential plant nutrients. The macronutrients and the micronutrients; 2) Determining the fertilizer program for your nursery; 3) fertilizer types; and 4) monitoring crop fertility status. This was followed by a discussion of nitrogen, monitoring nitrate in water, and a hands-on activity learning how to measure nitrate in water.

10. **Findings**

Since this is an outreach project, no findings were generated.

N. Copy of the Product/Result:

Presentations
Plant Nutrition and Fertilizer Management in Nursery Operations by Dr. Don Merhaut
https://ucanr.edu/sites/UCNFA/files/369992.pdf

Measuring Nitrate in Water by Dr. Gerry Spinelli
https://ucanr.edu/sites/UCNFA/files/369993.pdf

Videos on Fertilizers and Plant Nutrition at the UCANR YouTube channel:
https://www.youtube.com/playlist?list=PLLjlfxpbNglZdZQ04CiB0ipW7i-WdzIvy

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Learn the fundamentals of plant nutrition and fertilization in nursery production systems, including macronutrient -- nitrogen, phosphorus, potassium -- and micronutrient requirements, nutrient uptake processes, and the allocation of mobile and immobile nutrients in the plant.

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Nitrogen is an essential plant nutrient. Learn about nitrogen uptake, metabolism and mobility in plants.

Nitrogen Deficiency and Toxicity Issues in Nursery Production
Learn how to identify and fix nitrogen deficiency and nitrogen toxicity problems in nursery production systems.

Phosphorus in Plant Nutrition in Nursery Production
Learn about phosphorus uptake and mobility in nursery production systems, and how to identify and address phosphorus deficiency and phosphorus toxicity problems.

Potassium in Plant Nutrition in Nursery Production
Learn about potassium uptake and mobility in nursery production systems, and how to identify and address potassium deficiency and potassium toxicity problems.

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Conozca los fundamentos de la nutrición y la fertilización de las plantas en los sistemas de producción de viveros, incluidos los procesos de absorción de macronutrientes y micronutrientes, y la asignación de nutrientes móviles e inmóviles en el planta.

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