RESOURCE
CONSERVATION DISTRICT
OF SANTA CRUZ COUNTY

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A. Project Information:

CDFA-FREP Grant Agreement No: 18-0535-000-SA
Report Type: FINAL REPORT
Total Grant Period: January 1st 2019 - Dec 31st 2020
Project Title: Promoting the adoption of soil nitrogen quick tests by Spanish-speaking operators on strawberry ranches in Santa Cruz and Monterey Counties.
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B. Abstract:

Over-application of nitrogen fertilizer in strawberry production on the Central Coast of California reduces the profitability of the crop and results in nitrate leaching and negative effects on the environment. Studies have indicated substantial potential for nitrate leaching due to rains during winter months and during spring and summer due to over-irrigation. Local efforts have been made to educate growers on limiting fertilizer over-application, however, most of the management tools that have been developed target an English-speaking audience and presume certain skills and knowledge that are not necessarily present among Spanish-speaking field operators who are typically in charge of executing fertilizer application and nitrogen management decisions. This has resulted in limited adoption of best management practices. The goal of this project was to promote and facilitate adoption of management practices that optimize nitrogen fertilization in strawberry production. Specifically, the project focused on the Soil Nitrate Quick Test (SNQT), which has proven to be an accessible, fast and reliable field method to measure the amount of soil nitrate available to the crop and to improve nitrogen fertilization management in strawberry and coastal vegetable production. The project produced well-illustrated practical guidelines printed in English and Spanish and provided individual and group in-field trainings along with equipment and hands-on demonstrations to facilitate adoption of the SNQT as a management tool.

C. Introduction:

Strawberry and cool season vegetable production is one of the main economic drivers on the California central coast (particularly, the Pajaro and Salinas valleys in Santa Cruz and Monterey Counties). This high-value crop industry requires continuous and reliable nitrogen availability for crop uptake to achieve high yield and quality (Hartz 2012). Unfortunately, over-application of nitrogen-based fertilizer in strawberry production is widespread throughout the region, which reduces crop profitability and contributes to severe nitrate pollution of water resources, causing detrimental effects to human health and the natural environment (RWQCB 2010). Not all growers are aware of these regional problems and some are unaware that they over-fertilize. There is a need for on-going technical assistance and education resources to help growers improve their on

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farm practices. The consequences of nitrogen mismanagement include foregone profits and penalties from increasingly stringent water quality regulations.

In strawberry, the establishment phase of the crop cycle occurs during the rainy season, when high soil nitrate concentrations can easily lead to high rates of leaching because crop uptake is still relatively low (Cahn 2012, Bottoms et al 2013 and 2014). During the production phase crop uptake grows exponentially, requiring constant N application, but then it is critical to strike a balance between irrigation and nitrogen application schedules to maintain sufficient levels of soil N while avoiding leaching (Bottoms et al 2013 and 2014). Many growers apply nitrogen based on a fixed schedule, instead of calculating a crop nitrogen balance and/or adjusting application based on regular measurements of changing soil N levels. The Soil Nitrate Quick Test (SNQT) has been shown to be an accessible, fast and reliable field method to assess the amount of nitrate available to the crop and to improve nitrogen management in strawberry and cool season vegetables (Hartz 2010, Hartz 2012, Murphy et al 2014, Cahn and Smith 2019). The SNQT can be performed in the field in minutes and has the potential to inform and improve nitrogen application practices.

Many strawberry growers and the majority of field operators are Spanish speakers (a recent Strawberry Commission survey indicated that 29% of all growers and 90% of all irrigators only speak Spanish). As a result, most fertilizer application decisions are made or executed by Spanish speakers. However, management tools that have been developed to support efficient on-farm practices are either written in English, presume knowledge and skills that are often non-existent, or are too long to be practically adopted (e.g. Kortman 2014, Hartz 2010, Hartz 2011, Cahn and Smith 2019), which has resulted in limited adoption amongst the Spanish speaking demographic.

Some of the barriers to the adoption of Soil Nitrogen Quick Tests include:

a) Lack of succinct and simplified guidelines written in Spanish on how to collect, process and analyze a soil N sample.
b) The existing published guides require following mathematical equations and unit conversions to interpret the soil test results and to calculate the amount of nitrogen fertilizer that one needs to apply, which is challenging for many operators.
c) To effectively adopt the tool, operators must invest time and go through a learning period with enough repetition to gain confidence and develop capacity.
d) The current recommended management practice involves dividing the strawberry crop cycle into two phases (roughly corresponding to vegetative and production stages) and managing nitrogen fertilization differently depending on the phase. Different thresholds of soil nitrate concentration are recommended depending on the crop stage, but many growers manage nitrogen in the same manner throughout the year. Lack of time and cultural resistance to changing management practices are both important barriers, as testing soil nitrogen and making fertilization decisions based on test results

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requires more effort on the part of farm operators who are already very busy with day-to-day operations.

This project aimed at removing some of these identified barriers for Spanish speakers to apply nitrate quick tests in strawberry and coastal vegetable crops.

D. Objectives:

The project goal was to promote the adoption of management practices that can optimize nitrogen fertilization in commercial strawberry production. Specifically, the project focused on the Soil Nitrate Quick Test (SNQT) and aimed to remove known barriers for Spanish speaking farm operators to adopt this practice.

To achieve the desired goal this project developed educational materials and provided practical training to growers and irrigators.

Project objectives as written in the original proposal included:

1. Produce a printed guide for taking soil nitrate quick tests in Spanish.

2. Provide in-field technical assistance to irrigators on how to perform and interpret soil nitrate quick tests.

3. Organize hands-on demonstration workshops and present at well-established grower outreach events to share grower experience and to encourage peer-to-peer learning.

4. Conduct project evaluation to assess practice adoption and trends in behavior or perception related to nitrogen management.

E. Methods:

Objective 1. Produce a printed guide for taking soil nitrate quick tests in Spanish

Methods and Activities: RCDSCC staff compiled available scientific literature and technical management guidelines from local experts related to nitrogen use management in strawberry production, as well as previously published SNQT guidelines (in English). Updated and simplified step-by-step guidelines were then produced in Spanish and English, vetted with project cooperators from UCANR, and laid out in a graphic format (trifold brochure) with ample visual representations, diagrams and brief explanatory text on how to collect and process a soil sample and how to perform and interpret a Nitrate Quick Test. The new guide was designed and printed for easy use in the field and it provides the user with a direct guideline in terms of the number of

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pounds of nitrogen per acre required by the crop based on the test results. The recommendations are given in tables and charts and no calculations are required by the user. Guidelines recommend nitrogen management based on soil nitrate availability for the first management phase (winter-early spring months) and based on crop nitrogen uptake curves for the production months (March to October). The guide also indicates where to buy the necessary tools and materials and how to prepare the test solution.

Objective 2. Provide in-field technical assistance to irrigators on how to perform and interpret soil nitrate quick tests

Methods and Activities: The key elements in achieving this objective and encouraging adoption of the SNQT tool were a) one-on-one instruction, b) field-based practical demonstration, and c) repetition. RCDSCC leveraged some of its on-going relationships with the Spanish-speaking agricultural community of the Pajaro Valley and pursued new partnerships to enroll project participants. Technical assistance was to be offered in Spanish to at least 10 ranches in Santa Cruz and Monterey Counties. And at least five subsequent visits would be provided to each ranch with the objective of gradually training irrigators (building their confidence) to correctly take a soil sample, conduct the test and interpret it. As part of the training, participants received a copy of the printed guidelines in their preferred language (English or Spanish), and a kit with tools and supplies to conduct the soil nitrate quick test. The kit included a soil probe, 6-8 plastic centrifuge tubes, one gallon of calcium chloride solution and a pack of nitrate test strips. Participants were offered a “refill” of calcium chloride solution and nitrate test strips if/when they run out.

Objective 3. Organize workshops to share grower experience and to encourage peer-to-peer learning

Methods and Activities: In addition to the individual technical assistance provided to participating growers and irrigators, several outreach events including hands-on workshops and/or presentations in group settings were organized during the first year. These events offered empirical information and guidelines promoting the adoption of the SNQT, facilitated grower-to-grower exchange, and allowed growers who have already adopted and regularly use this tool to share their experience. In-person group outreach events were not possible during the second year due to COVID 19, so the outreach strategy shifted and instead a series of demonstration videos in Spanish was produced and published on a YouTube channel.

Objective 4. Conduct project evaluation

Methods and Activities: A follow up interview was conducted over phone with a subset of the project participants to gather feedback on the educational materials (printed guidelines) and trainings, and to evaluate the degree of adoption and/or the persistence of challenges and barriers.

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F. Data/Results:

1. Material Deliverables:

a. Printed soil nitrate quick test guide for strawberry (English and Spanish).
RCDSCC produced the SNQT practical guide in English and Spanish with simple and well-illustrated instructions to perform the test in the field and interpret its results to inform N fertilizer management. The guide content was first written and edited in English, and it was discussed with project cooperators Dr. Michael Cahn and Dr. Richard Smith from UCCE and eight collaborating growers. Once the final draft was completed, a Spanish translation was produced, and graphic design layout was completed for both English and Spanish versions. 50 copies of each version were printed in September 2019 and continue to be distributed among interested users (Figure 1).

b. Soil nitrate quick test field sheet (English and Spanish).
This field sheet is intended for recording information as the SNQT is conducted in the field and it provides a step-by-step sequence for entering the soil N measurement numbers and conversion factors, calculating the test results, and put results in the context of desired nitrate concentrations and lbs of N needed for different crops and crop stages (Figure 2).

c. N contribution from irrigation water sheet (English and Spanish).
This is a printed table to quickly estimate the nitrogen contribution from irrigation water applied, based on a quick nitrate test of the irrigation water and the amount of water applied. For users who may not have measured the amount of water applied, the table also offers N contribution estimates based on nitrate concentration and the average total amount of water applied for some of the most common crops in our area (Figure 3).

d. Common fertilizers recommendation sheets for lettuce sidedress (English and Spanish).
At the request of participating growers, field sheets were produced relating the quantity of fertilizer to be applied to the quick test result color. This approach provides only a rough estimate of the nitrogen application required, since it doesn't consider the contribution from irrigation water, mineralization etc., and it is preferable only when the grower would otherwise apply a fixed quantity of nitrogen without calculating a nitrogen balance. Field sheets were produced for lettuce, indicating the quantity of fertilizer required to increase the soil nitrate content to 20 ppm at sidedress, and for the four most used fertilizers: CAN-17, UAN-32, AN-20 and 27-0-0 (Figure 4).

e. Articles published in the Santa Cruz Farm Bureau newsletter.
Two short articles were published in 2019 on the Santa Cruz County Farm Bureau newsletter. The articles introduced the SNQT as a practical tool to improve nitrogen fertilization management and advertised the services and resources available through this project, seeking to enroll new participants (Figure 5).

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RECURSOS

Resource Conservation District of Santa Cruz County (RCD)
820 Bay Ave, Ste 136
Capitola, CA 95010
(831) 464-2950
www.rcdsantacruz.org
Servicios: Asistencia tecnica y financiera prestamo de equipo, evaluaciones de riego, y mas.

Natural Resources Conservation Service (NRCS)
820 Bay Ave, Ste 136
Capitola, CA 95010
(831) 475-1967
Servicios: Asistencia tecnica y financiera para agricultura - programa EQIP.

Esta guía fue financiada por el Departamento de Alimentos y Agricultura de California, mediante su Programa de Educación e Investigación en Fertilizantes (FREP) y la Junta Consultora de Inspección de Fertilizantes. FREP ofrece financiamiento para realizar proyectos de investigación y educación que orienten el uso y manejo de fertilizantes de manera agronómicamente optima y segura para el ambiente.

PRUEBA RAPIDA DE NITRATO EN EL SUELO GUÍA PARA FRESA

GUÍA PARA TOMAR MUESTRAS DE NITRÓGENO DEL SUELO

Esta guía práctica da instrucciones paso-a paso para tomar una muestra de suelo y medir el nitrógeno mediante la prueba rápida de nitratos. La guía es una referencia rápida para usar directamente en el campo, que NO pretende reemplazar herramientas mas precisas como pruebas de laboratorio, o CropManage, etc.

Cuando y Donde Tomar La Muestra: Se recomienda cada dos semanas o cada mes, entre Febrero y Septiembre, cuando el cultivo necesita más nitrógeno. Se debe tomar tierra de muchos puntos en el campo. Se recomienda tomar una muestra a un pie de profundidad, porque las raíces de fresa alcanzan hasta el primer pie de suelo, y la muestra nos dice si hay suficiente nitrógeno para las plantas. También se puede tomar una muestra más profunda a dos pies que nos dice si perdimos nitrógeno por drenaje.

Materiales Requeridos: *materiales en la foto

1. Varilla para muestrear suelo 7/8" x 33" - *(www.ams-samplers.com/7-8-x-33-sst-soil-probe-w-handle.html)
2. Un balde (3-5 galones)
3. Seis tubitos de centrifuga de 50 ml con gradilla para los tubitos *(www.amazon.com/SPL-Conical-Centrifuge-Racks-Sterile/dp/B01M04HGPJ)
4. Botella de chorro - *(www.amazon.com/Plastic-Squirt-Bottle-Lid-16/dp/B004BNC80C)
5. Cronometro o reloj con cronometro
6. Solución de cloruro de calcio - ***gratis con el RCD**
7. Tiras de papel con reactivo ("tiras reactivas") para la prueba rápida de nitratos - ***gratis con el RCD**

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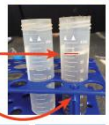
COMO COLECTAR EL SUELO

1. Tomar muestras en 10 puntos al azar en el campo. **Si se toman muestras a dos profundidades, marcar los baldes para no confundir ni mezclar las muestras de distintas profundidades.** Insertar la varilla cerca de las planta hacia el centro de la cama a un ángulo para evitar de muestrear en la banda de fertilizante.

2. Mezclar las muestras en el balde hasta que todo el suelo de cada muestra esté uniforme. Si el suelo es muy arcilloso y no se mezcla, tomar una pizca de cada muestra de suelo.

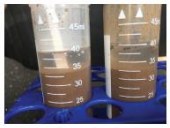
COMO PROCESAR LA MUESTRA

3. Llenar 4 tubitos con solución de cloruro cálcico hasta los **30 mL.** Dos tubitos son para cada profundidad.



4. Añadir suelo de cada muestra a los dos tubitos correspondientes, hasta que la solución llegue a los **40 mL.**

5. Sacudir vigorosamente hasta que todo el suelo esté disuelto.



6. Dejar los tubitos en la gradilla hasta que todo el suelo se haya depositado en el fondo y una capa de solución clara se desarrolle arriba. Normalmente este proceso tarda unos minutos, pero en suelos arcillosos puede tardar hasta media hora.

7. Mojar brevemente una tira reactiva en la solución de cada tubito y sacudirla para que se seque. Esperar un minuto y comparar el color del cuadrado más próximo al extremo de la tira con la escala de colores en el tubo de las tiras. Utilizar los números de arriba (ppm of NO_3^-), no los de abajo (ppm of NO_3-N).

La lectura de la muestra en la foto de abajo es aproximadamente 35 ppm de NO_3^- ya que el color del papelito esta entre 25 y 50 ppm de NO_3^- en la escala de arriba

COMO USAR LOS RESULTADOS

Multiplicar por dos el resultado de la muestra a 12 pulgadas le da un estimado general de las libras de nitrógeno que hay en un acre de suelo hasta 12 pulgadas de profundidad. Por ejemplo, si el resultado es 25 ppm de NO_3^-, quiere decir que hay más o menos 50 libras de nitrógeno por acre en la capa de suelo de 0 a 12 pulgadas.

La Fresa absorbe menos que 25 libras por acre desde la siembra hasta finales de Marzo, y alrededor de una libra por acre por día desde Abril hasta la mitad de Septiembre. Así que las necesidades de la planta para toda la temporada son alrededor de 200 lb de nitrógeno por acre.

Manejo durante el invierno:
Se recomienda tomar una muestra de invierno al principio de Febrero.

Si los resultados de la muestra están por arriba de 15 ppm NO_3^-, no se necesita fertilizante.

Si los resultados de la muestra están por debajo de 15 ppm NO_3^-, se recomienda 10 o 20 lb/ac divididas en dos aplicaciones.

Manejo durante primavera y verano:
El tiempo y frecuencia de muestreo recomendados para fertilizar durante Primavera y Verano es cada dos semanas o cada mes, entre Abril y Septiembre, cuando el cultivo toma 1 lb N/ac por día. Durante este periodo la fresa usa 7 lb N/ac cada semana o 14 lb N/ac cada dos semanas. Con base en los resultados del test, se puede ajustar cuanto N hace falta aplicar para satisfacer las necesidades del cultivo. **La tabla y figura abajo da recomendaciones según los resultados de la prueba de nitrato.**

El agua de riego y la mineralización de materia orgánica del suelo también añaden nitrato al suelo. Un suelo más pesado con más materia orgánica mineraliza más N por acre por día que un suelo arenoso. Un suelo con más materia orgánica puede aportar bastante N solo por mineralización. Esto más el nitrato en el agua de riego (dependiendo de la cantidad) pueden dar suficiente N a su cultivo.

CUANTO FERTILIZANTE DE NITRÓGENO APLICAR (ABRIL-SEPTIEMBRE)

Si la muestra es (ppm de NO_3^-)	Aplicar libras de nitrógeno por acre por semana
0	14
5	12
10	10
15	8
20	7
25	6
30	5
40	4
50	2
>50	No fertilizante

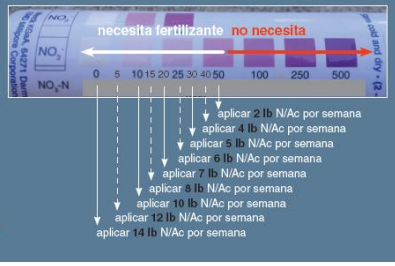


Figure 1. Guide to collect, process and interpret a soil nitrogen quick test for strawberry.

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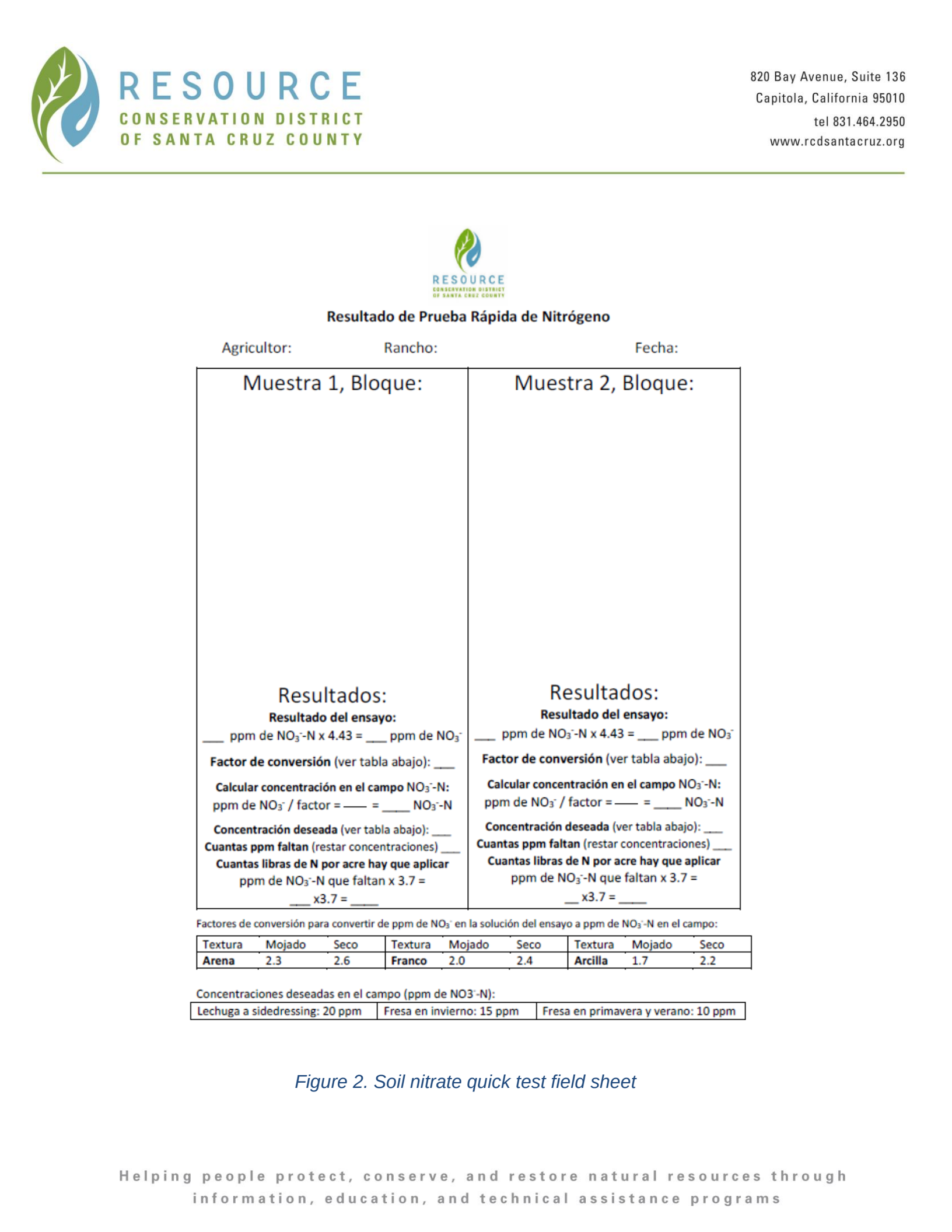

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Resultado de Prueba Rápida de Nitrógeno

Agricultor: Rancho: Fecha:

Muestra 1, Bloque:	Muestra 2, Bloque:
Resultados: **Resultado del ensayo:** ___ ppm de NO_3^--N x 4.43 = ___ ppm de NO_3^- **Factor de conversión** (ver tabla abajo): ___ **Calcular concentración en el campo** NO_3^--N: ppm de NO_3^- / factor = —— = ____ NO_3^--N **Concentración deseada** (ver tabla abajo): ___ **Cuantas ppm faltan** (restar concentraciones) ___ **Cuantas libras de N por acre hay que aplicar** ppm de NO_3^--N que faltan x 3.7 = ___ x3.7 = ____	Resultados: **Resultado del ensayo:** ___ ppm de NO_3^--N x 4.43 = ___ ppm de NO_3^- **Factor de conversión** (ver tabla abajo): ___ **Calcular concentración en el campo** NO_3^--N: ppm de NO_3^- / factor = —— = ____ NO_3^--N **Concentración deseada** (ver tabla abajo): ___ **Cuantas ppm faltan** (restar concentraciones) ___ **Cuantas libras de N por acre hay que aplicar** ppm de NO_3^--N que faltan x 3.7 = __ x3.7 = ____

Factores de conversión para convertir de ppm de NO_3^- en la solución del ensayo a ppm de NO_3^--N en el campo:

Textura	Mojado	Seco	Textura	Mojado	Seco	Textura	Mojado	Seco
Arena	2.3	2.6	**Franco**	2.0	2.4	**Arcilla**	1.7	2.2

Concentraciones deseadas en el campo (ppm de $NO3^-$-N):

Lechuga a sidedressing: 20 ppm	Fresa en invierno: 15 ppm	Fresa en primavera y verano: 10 ppm

Figure 2. Soil nitrate quick test field sheet

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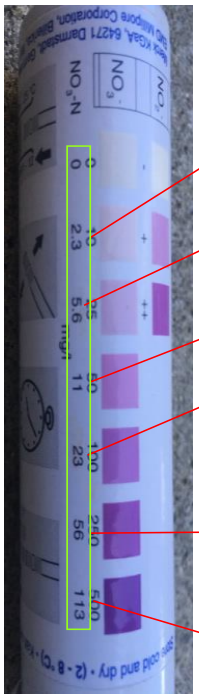
Libras de nitrógeno en el agua de riego

Libras totales de nitrógeno añadida por el agua de riego al cultivo para diferentes concentraciones de nitrato en el agua del pozo y para diferentes cantidades de agua de riego aplicada.



Prueba de nitrato ppm de NO_3-N	Pulgadas de agua de riego aplicada														Pulgadas estimadas para un ciclo de cultivo			
	1	2	3	4	5	6	7	8	9	10	12	15	20	25	Fresa 26	Lechuga 8	Mora 20	Broccoli 20
0	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac
1	0 lb N/ac	0 lb N/ac	1 lb N/ac	1 lb N/ac	1 lb N/ac	1 lb N/ac	2 lb N/ac	2 lb N/ac	2 lb N/ac	2 lb N/ac	3 lb N/ac	3 lb N/ac	5 lb N/ac	6 lb N/ac	6 lb N/ac	2 lb N/ac	5 lb N/ac	5 lb N/ac
2	0 lb N/ac	1 lb N/ac	1 lb N/ac	2 lb N/ac	2 lb N/ac	3 lb N/ac	3 lb N/ac	4 lb N/ac	4 lb N/ac	5 lb N/ac	5 lb N/ac	7 lb N/ac	9 lb N/ac	11 lb N/ac	12 lb N/ac	4 lb N/ac	9 lb N/ac	9 lb N/ac
3	1 lb N/ac	1 lb N/ac	2 lb N/ac	3 lb N/ac	3 lb N/ac	4 lb N/ac	5 lb N/ac	5 lb N/ac	6 lb N/ac	7 lb N/ac	8 lb N/ac	10 lb N/ac	14 lb N/ac	17 lb N/ac	18 lb N/ac	5 lb N/ac	14 lb N/ac	14 lb N/ac
4	1 lb N/ac	2 lb N/ac	3 lb N/ac	4 lb N/ac	5 lb N/ac	5 lb N/ac	6 lb N/ac	7 lb N/ac	8 lb N/ac	9 lb N/ac	11 lb N/ac	14 lb N/ac	18 lb N/ac	23 lb N/ac	24 lb N/ac	7 lb N/ac	18 lb N/ac	18 lb N/ac
5	1 lb N/ac	2 lb N/ac	3 lb N/ac	5 lb N/ac	6 lb N/ac	7 lb N/ac	8 lb N/ac	9 lb N/ac	10 lb N/ac	11 lb N/ac	14 lb N/ac	17 lb N/ac	23 lb N/ac	28 lb N/ac	29 lb N/ac	9 lb N/ac	23 lb N/ac	23 lb N/ac
6	1 lb N/ac	3 lb N/ac	4 lb N/ac	5 lb N/ac	7 lb N/ac	8 lb N/ac	10 lb N/ac	11 lb N/ac	12 lb N/ac	14 lb N/ac	16 lb N/ac	20 lb N/ac	27 lb N/ac	34 lb N/ac	35 lb N/ac	11 lb N/ac	27 lb N/ac	27 lb N/ac
7	2 lb N/ac	3 lb N/ac	5 lb N/ac	6 lb N/ac	8 lb N/ac	10 lb N/ac	11 lb N/ac	13 lb N/ac	14 lb N/ac	16 lb N/ac	19 lb N/ac	24 lb N/ac	32 lb N/ac	40 lb N/ac	41 lb N/ac	13 lb N/ac	32 lb N/ac	32 lb N/ac
8	2 lb N/ac	4 lb N/ac	5 lb N/ac	7 lb N/ac	9 lb N/ac	11 lb N/ac	13 lb N/ac	15 lb N/ac	16 lb N/ac	18 lb N/ac	22 lb N/ac	27 lb N/ac	36 lb N/ac	45 lb N/ac	47 lb N/ac	15 lb N/ac	36 lb N/ac	36 lb N/ac
9	2 lb N/ac	4 lb N/ac	6 lb N/ac	8 lb N/ac	10 lb N/ac	12 lb N/ac	14 lb N/ac	16 lb N/ac	18 lb N/ac	20 lb N/ac	24 lb N/ac	31 lb N/ac	41 lb N/ac	51 lb N/ac	53 lb N/ac	16 lb N/ac	41 lb N/ac	41 lb N/ac
10	2 lb N/ac	5 lb N/ac	7 lb N/ac	9 lb N/ac	11 lb N/ac	14 lb N/ac	16 lb N/ac	18 lb N/ac	20 lb N/ac	23 lb N/ac	27 lb N/ac	34 lb N/ac	45 lb N/ac	57 lb N/ac	59 lb N/ac	18 lb N/ac	45 lb N/ac	45 lb N/ac
15	3 lb N/ac	7 lb N/ac	10 lb N/ac	14 lb N/ac	17 lb N/ac	20 lb N/ac	24 lb N/ac	27 lb N/ac	31 lb N/ac	34 lb N/ac	41 lb N/ac	51 lb N/ac	68 lb N/ac	85 lb N/ac	88 lb N/ac	27 lb N/ac	68 lb N/ac	68 lb N/ac
20	5 lb N/ac	9 lb N/ac	14 lb N/ac	18 lb N/ac	23 lb N/ac	27 lb N/ac	32 lb N/ac	36 lb N/ac	41 lb N/ac	45 lb N/ac	54 lb N/ac	68 lb N/ac	91 lb N/ac	113 lb N/ac	118 lb N/ac	36 lb N/ac	91 lb N/ac	91 lb N/ac
25	6 lb N/ac	11 lb N/ac	17 lb N/ac	23 lb N/ac	28 lb N/ac	34 lb N/ac	40 lb N/ac	45 lb N/ac	51 lb N/ac	57 lb N/ac	68 lb N/ac	85 lb N/ac	113 lb N/ac	142 lb N/ac	147 lb N/ac	45 lb N/ac	113 lb N/ac	113 lb N/ac
30	7 lb N/ac	14 lb N/ac	20 lb N/ac	27 lb N/ac	34 lb N/ac	41 lb N/ac	48 lb N/ac	54 lb N/ac	61 lb N/ac	68 lb N/ac	82 lb N/ac	102 lb N/ac	136 lb N/ac	170 lb N/ac	177 lb N/ac	54 lb N/ac	136 lb N/ac	136 lb N/ac
35	8 lb N/ac	16 lb N/ac	24 lb N/ac	32 lb N/ac	40 lb N/ac	48 lb N/ac	56 lb N/ac	63 lb N/ac	71 lb N/ac	79 lb N/ac	95 lb N/ac	119 lb N/ac	159 lb N/ac	198 lb N/ac	206 lb N/ac	63 lb N/ac	159 lb N/ac	159 lb N/ac
40	9 lb N/ac	18 lb N/ac	27 lb N/ac	36 lb N/ac	45 lb N/ac	54 lb N/ac	63 lb N/ac	73 lb N/ac	82 lb N/ac	91 lb N/ac	109 lb N/ac	136 lb N/ac	181 lb N/ac	227 lb N/ac	236 lb N/ac	73 lb N/ac	181 lb N/ac	181 lb N/ac
45	10 lb N/ac	20 lb N/ac	31 lb N/ac	41 lb N/ac	51 lb N/ac	61 lb N/ac	71 lb N/ac	82 lb N/ac	92 lb N/ac	102 lb N/ac	122 lb N/ac	153 lb N/ac	204 lb N/ac	255 lb N/ac	265 lb N/ac	82 lb N/ac	204 lb N/ac	204 lb N/ac
50	11 lb N/ac	23 lb N/ac	34 lb N/ac	45 lb N/ac	57 lb N/ac	68 lb N/ac	79 lb N/ac	91 lb N/ac	102 lb N/ac	113 lb N/ac	136 lb N/ac	170 lb N/ac	227 lb N/ac	283 lb N/ac	295 lb N/ac	91 lb N/ac	227 lb N/ac	227 lb N/ac
60	14 lb N/ac	27 lb N/ac	41 lb N/ac	54 lb N/ac	68 lb N/ac	82 lb N/ac	95 lb N/ac	109 lb N/ac	122 lb N/ac	136 lb N/ac	163 lb N/ac	204 lb N/ac	272 lb N/ac	340 lb N/ac	354 lb N/ac	109 lb N/ac	272 lb N/ac	272 lb N/ac
70	16 lb N/ac	32 lb N/ac	48 lb N/ac	63 lb N/ac	79 lb N/ac	95 lb N/ac	111 lb N/ac	127 lb N/ac	143 lb N/ac	159 lb N/ac	190 lb N/ac	238 lb N/ac	317 lb N/ac	397 lb N/ac	413 lb N/ac	127 lb N/ac	317 lb N/ac	317 lb N/ac
80	18 lb N/ac	36 lb N/ac	54 lb N/ac	73 lb N/ac	91 lb N/ac	109 lb N/ac	127 lb N/ac	145 lb N/ac	163 lb N/ac	181 lb N/ac	218 lb N/ac	272 lb N/ac	363 lb N/ac	453 lb N/ac	471 lb N/ac	145 lb N/ac	363 lb N/ac	363 lb N/ac
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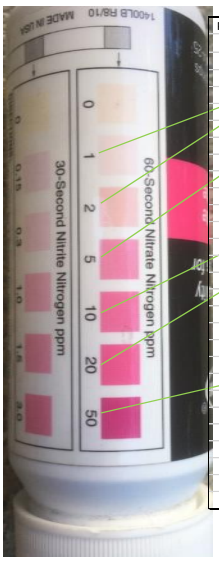
110	25 lb N/ac	50 lb N/ac	75 lb N/ac	100 lb N/ac	125 lb N/ac	150 lb N/ac	175 lb N/ac	199 lb N/ac	224 lb N/ac	249 lb N/ac	299 lb N/ac	374 lb N/ac	499 lb N/ac	623 lb N/ac	648 lb N/ac	199 lb N/ac	499 lb N/ac	499 lb N/ac
120	27 lb N/ac	54 lb N/ac	82 lb N/ac	109 lb N/ac	136 lb N/ac	163 lb N/ac	190 lb N/ac	218 lb N/ac	245 lb N/ac	272 lb N/ac	326 lb N/ac	408 lb N/ac	544 lb N/ac	680 lb N/ac	707 lb N/ac	218 lb N/ac	544 lb N/ac	544 lb N/ac

Libras de nitrógeno en el agua de riego

Libras totales de nitrógeno añadida por el agua de riego al cultivo para diferentes concentraciones de nitrato en el agua del pozo y para diferentes cantidades de agua de riego aplicada.



Prueba de nitrato ppm de NO_3-N	Pulgadas de agua de riego aplicada														Pulgadas estimadas para un ciclo de cultivo			
	1	2	3	4	5	6	7	8	9	10	12	15	20	25	Fresa 26	Lechuga 8	Mora 20	Broccoli 20
0	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac	0 lb N/ac
1	0 lb N/ac	0 lb N/ac	1 lb N/ac	1 lb N/ac	1 lb N/ac	1 lb N/ac	2 lb N/ac	2 lb N/ac	2 lb N/ac	2 lb N/ac	3 lb N/ac	3 lb N/ac	5 lb N/ac	6 lb N/ac	6 lb N/ac	2 lb N/ac	5 lb N/ac	5 lb N/ac
2	0 lb N/ac	1 lb N/ac	1 lb N/ac	2 lb N/ac	2 lb N/ac	3 lb N/ac	3 lb N/ac	4 lb N/ac	4 lb N/ac	5 lb N/ac	5 lb N/ac	7 lb N/ac	9 lb N/ac	11 lb N/ac	12 lb N/ac	4 lb N/ac	9 lb N/ac	9 lb N/ac
3	1 lb N/ac	1 lb N/ac	2 lb N/ac	3 lb N/ac	3 lb N/ac	4 lb N/ac	5 lb N/ac	5 lb N/ac	6 lb N/ac	7 lb N/ac	8 lb N/ac	10 lb N/ac	14 lb N/ac	17 lb N/ac	18 lb N/ac	5 lb N/ac	14 lb N/ac	14 lb N/ac
4	1 lb N/ac	2 lb N/ac	3 lb N/ac	4 lb N/ac	5 lb N/ac	5 lb N/ac	6 lb N/ac	7 lb N/ac	8 lb N/ac	9 lb N/ac	11 lb N/ac	14 lb N/ac	18 lb N/ac	23 lb N/ac	24 lb N/ac	7 lb N/ac	18 lb N/ac	18 lb N/ac
5	1 lb N/ac	2 lb N/ac	3 lb N/ac	5 lb N/ac	6 lb N/ac	7 lb N/ac	8 lb N/ac	9 lb N/ac	10 lb N/ac	11 lb N/ac	14 lb N/ac	17 lb N/ac	23 lb N/ac	28 lb N/ac	29 lb N/ac	9 lb N/ac	23 lb N/ac	23 lb N/ac
6	1 lb N/ac	3 lb N/ac	4 lb N/ac	5 lb N/ac	7 lb N/ac	8 lb N/ac	10 lb N/ac	11 lb N/ac	12 lb N/ac	14 lb N/ac	16 lb N/ac	20 lb N/ac	27 lb N/ac	34 lb N/ac	35 lb N/ac	11 lb N/ac	27 lb N/ac	27 lb N/ac
7	2 lb N/ac	3 lb N/ac	5 lb N/ac	6 lb N/ac	8 lb N/ac	10 lb N/ac	11 lb N/ac	13 lb N/ac	14 lb N/ac	16 lb N/ac	19 lb N/ac	24 lb N/ac	32 lb N/ac	40 lb N/ac	41 lb N/ac	13 lb N/ac	32 lb N/ac	32 lb N/ac
8	2 lb N/ac	4 lb N/ac	5 lb N/ac	7 lb N/ac	9 lb N/ac	11 lb N/ac	13 lb N/ac	15 lb N/ac	16 lb N/ac	18 lb N/ac	22 lb N/ac	27 lb N/ac	36 lb N/ac	45 lb N/ac	47 lb N/ac	15 lb N/ac	36 lb N/ac	36 lb N/ac
9	2 lb N/ac	4 lb N/ac	6 lb N/ac	8 lb N/ac	10 lb N/ac	12 lb N/ac	14 lb N/ac	16 lb N/ac	18 lb N/ac	20 lb N/ac	24 lb N/ac	31 lb N/ac	41 lb N/ac	51 lb N/ac	53 lb N/ac	16 lb N/ac	41 lb N/ac	41 lb N/ac
10	2 lb N/ac	5 lb N/ac	7 lb N/ac	9 lb N/ac	11 lb N/ac	14 lb N/ac	16 lb N/ac	18 lb N/ac	20 lb N/ac	23 lb N/ac	27 lb N/ac	34 lb N/ac	45 lb N/ac	57 lb N/ac	59 lb N/ac	18 lb N/ac	45 lb N/ac	45 lb N/ac
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110	25 lb N/ac	50 lb N/ac	75 lb N/ac	100 lb N/ac	125 lb N/ac	150 lb N/ac	175 lb N/ac	199 lb N/ac	224 lb N/ac	249 lb N/ac	299 lb N/ac	374 lb N/ac	499 lb N/ac	623 lb N/ac	648 lb N/ac	199 lb N/ac	499 lb N/ac	499 lb N/ac
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Figure 3. Field sheets to estimate the contribution of irrigation water to the crop nitrogen balance from the strip test color and from the irrigation applied in a crop cycle. The table was produced for MQuant and for Hach Aquachek strips.

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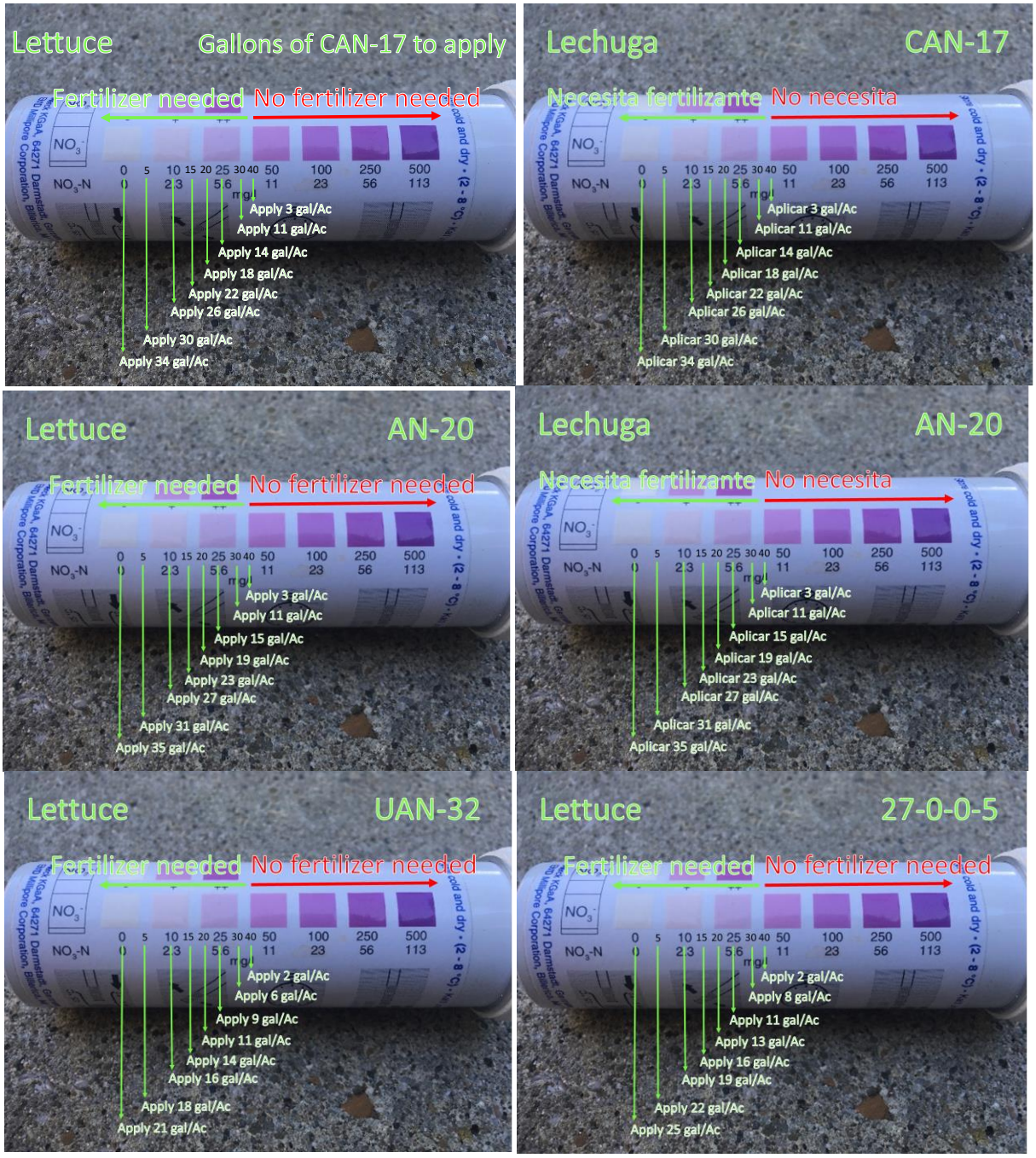

Figure 4. Examples of quick recommendation sheets in English and Spanish (estimated application rate needed based on SNQT results) for common fertilizers used in lettuce at sidedressing.

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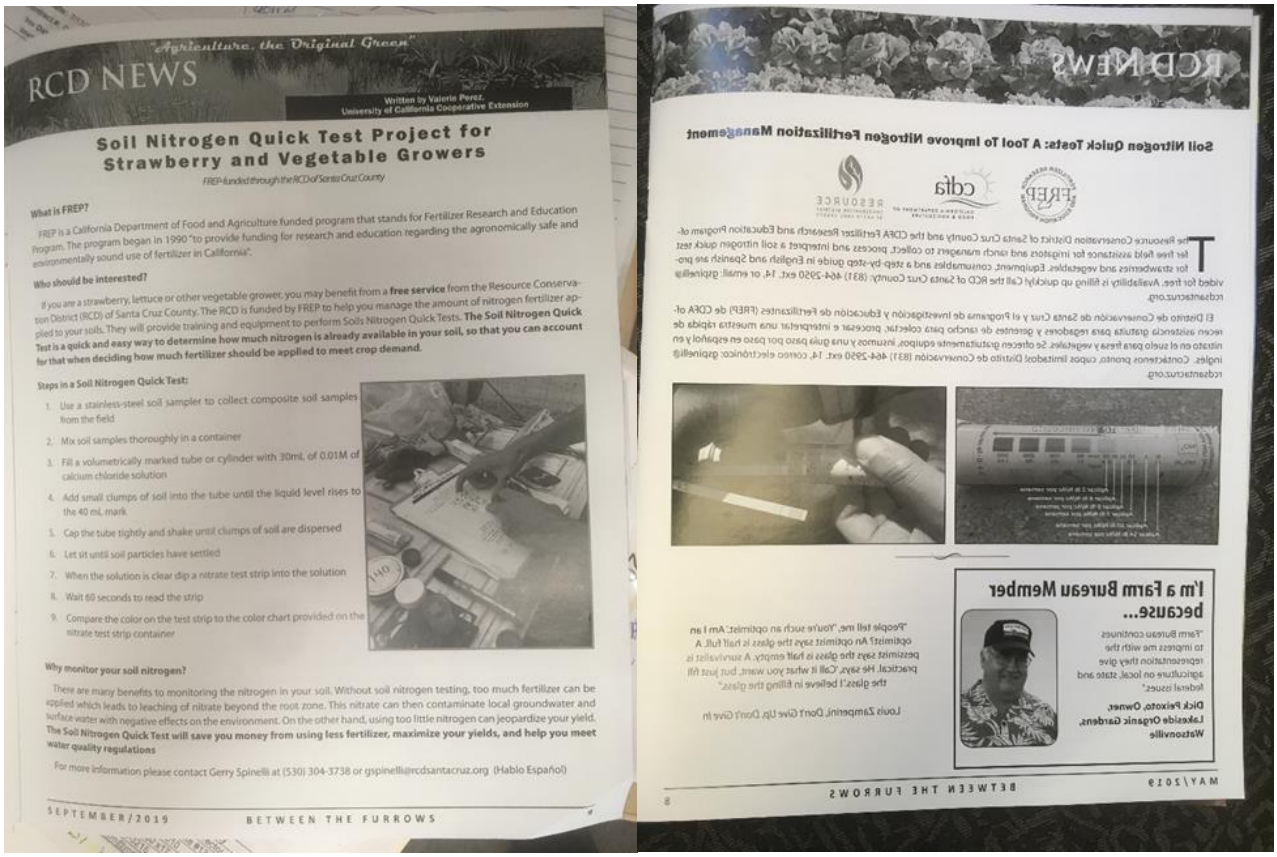

"Agriculture, the Original Green"

RCD NEWS

Written by Valerie Perez, University of California Cooperative Extension

Soil Nitrogen Quick Test Project for Strawberry and Vegetable Growers

FREP-funded through the RCD of Santa Cruz County

What is FREP?

FREP is a California Department of Food and Agriculture funded program that stands for Fertilizer Research and Education Program. The program began in 1990 "to provide funding for research and education regarding the agronomically safe and environmentally sound use of fertilizer in California".

Who should be interested?

If you are a strawberry, lettuce or other vegetable grower, you may benefit from a **free service** from the Resource Conservation District (RCD) of Santa Cruz County. The RCD is funded by FREP to help you manage the amount of nitrogen fertilizer applied to your soils. They will provide training and equipment to perform Soils Nitrogen Quick Tests. **The Soil Nitrogen Quick Test is a quick and easy way to determine how much nitrogen is already available in your soil, so that you can account for that when deciding how much fertilizer should be applied to meet crop demand.**

Steps in a Soil Nitrogen Quick Test:

1. Use a stainless-steel soil sampler to collect composite soil samples from the field
2. Mix soil samples thoroughly in a container
3. Fill a volumetrically marked tube or cylinder with 30mL of 0.01M of calcium chloride solution
4. Add small clumps of soil into the tube until the liquid level rises to the 40 mL mark
5. Cap the tube tightly and shake until clumps of soil are dispersed
6. Let sit until soil particles have settled
7. When the solution is clear dip a nitrate test strip into the solution
8. Wait 60 seconds to read the strip
9. Compare the color on the test strip to the color chart provided on the nitrate test strip container

Why monitor your soil nitrogen?

There are many benefits to monitoring the nitrogen in your soil. Without soil nitrogen testing, too much fertilizer can be applied which leads to leaching of nitrate beyond the root zone. This nitrate can then contaminate local groundwater and surface water with negative effects on the environment. On the other hand, using too little nitrogen can jeopardize your yield. **The Soil Nitrogen Quick Test will save you money from using less fertilizer, maximize your yields, and help you meet water quality regulations**

For more information please contact Gerry Spinelli at (530) 304-3738 or gspinelli@rcdsantacruz.org (Hablo Español)

SEPTEMBER/2019 BETWEEN THE FURROWS

RCD NEWS

Soil Nitrogen Quick Tests: A Tool To Improve Nitrogen Fertilization Management

I'm a Farm Bureau Member because...

Dick Peixoto, Owner, Lakeside Organic Gardens, Watsonville

MAY/2019 BETWEEN THE FURROWS

Figure 5. Articles published in the Santa Cruz County Farm Bureau Newsletter to advertise the project

2. In-field one-on-one technical assistance to irrigators on how to perform and interpret soil nitrate quick tests:

   Over the two-year project period RCDSCC staff identified and enrolled fifty-two (52) growers, ranch managers and other agricultural personnel to participate in the project. RCDSCC staff distributed the SNQT guide in both English and Spanish and provided supplies and one-on-one training and assistance for participants to correctly use the nitrate test and interpret its results to inform N fertilizer management on their fields. This result surpassed the project's original target of at least ten ranches/growers trained, with each participating grower receiving at least five subsequent trainings in the field during the crop fertilization season/period. Not all participants received follow up trainings, either because in certain cases these were not necessary, or because participant enrollment occurred toward the end of the project term and there was not enough time to complete subsequent visits. Follow up visits and trainings were conducted based on participant's request or project staff's assessment of the trainee's skillset and confidence. Repetition allowed

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participating growers and/or irrigators to gradually develop and reinforce their capacity to adopt the SNQT as part of their management. In January and February 2020, RCDSCC staff provided group trainings to all the ranch managers and irrigators of two additional farming operations (total 10 people). One was a large strawberry grower and the other one was a blackberry/raspberry producer.

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With more growers interested in the project, different tools were developed integrating solutions from other researchers in the state, in order to make the soil test more accessible and less expensive. In particular, the use of food-grade calcium chloride (Pickle Crisp) as a flocculant instead of the more expensive research-grade product. Research conducted by Laura Murphy and Dr. Michael Cahn (Murphy et al 2014) showed that Hach Aquachek nitrate strips give comparable results to the more expensive MQuant strips (made by Merck now Millipore-Sigma). The Hach strips

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were adopted by the program and additional field sheets were produced in order to be used with the Hach strips. Also, given the increased interest in the project, a “train-the-trainers” format was applied and some of the trainees were not directly growers or ranch managers but were practitioners that are thought to be able to train growers in the future. We trained an NRCS soil conservationist, the personnel of the Cabrillo Community College Student Farm and the sustainability coordinator of one large food processor in Salinas.

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3. Education and outreach events:

Four outreach and education events were organized in 2019 for large group settings in the field. The first one was organized at the facilities of the Agricultural Land-based Training association (ALBA) in Salinas, as part of their training program in Spanish for beginning growers. The second event was hosted at the ranch of a successful adopter of the soil nitrate quick test and included a comprehensive discussion of nitrogen management in strawberry, with the participation of UCANR field advisors Mark Bolda and Dr. Michael Cahn. The third event was a module within the annual CropManage workshop, organized as part of the Pajaro Valley Water conservation program. The fourth event was conducted at Coke Farms facililities in San Juan Bautista, as part of their Fall grower meeting.

In March 2020, due to the COVID-19 pandemic, the field operations of the project were interrupted, and the education and outreach strategy shifted to producing on-line accessible materials such as YouTube videos and field sheets to facilitate the use of the quick test. Five different videos were produced in Spanish and posted on YouTube. In June 2020 RCDSCC staff trained an outreach staff member of the Strawberry Commission who interacts with numerous growers. This training included how to input the SNQT results into CropManage and obtain recommendations.

Outreach and education event #1:
Date: 9/26/19,
Location: ALBA, 1700 Old Stage Rd, Salinas.
Event Name: Taller de prueba rapida de nitrato (Nitrate quick test workshop)
Presentation Title: Taller de prueba rapida de nitrato
Number of participants: 25
Type of audience: Beginning organic Spanish-speaking small farmers
Evaluation tools: based on interviews the workshop gave a good idea of how to collect and process a quick test, but field visits are still required to train the growers in the field.
Improvements made based on feedback: cheaper tools were developed for beginning farmers to adopt the quick test.

Outreach and education event #2:
Date: 10/11/19,
Location: Ramos Farms, 880 Airport Blv, Watsonville.
Event Name: Mariscada y platica sobre nitrogeno para crecedores de Fresa (Seafood feast and talk about nitrogen management for strawberry growers)
Presentation Title: Strawberry N management
Number of participants: 18
Type of audience: Advanced and beginning, conventional and organic strawberry farmers
Evaluation tools: based on attendance it is better to organize workshops for strawberry growers in November after new plantings.

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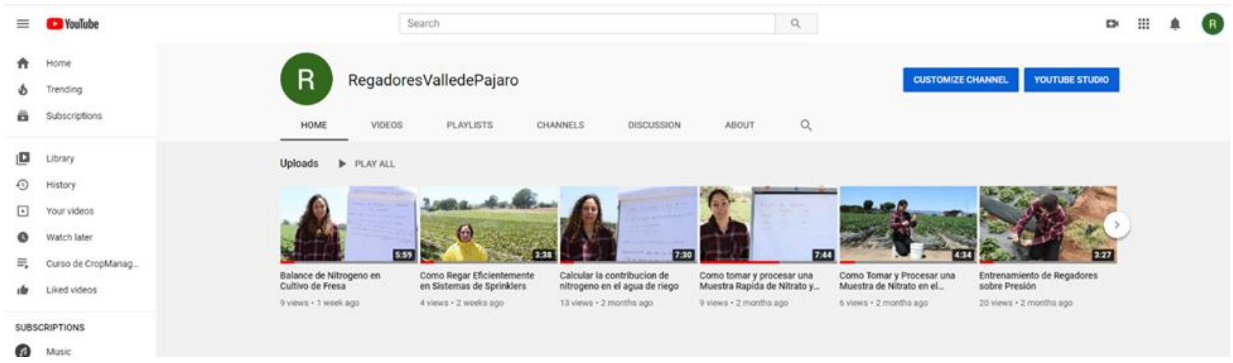
Outreach and education event #3:
Date: 11/20/19,
Location: UC Cooperative Extension, Freedom Blv, Watsonville.
Event Name: CropManage Workshop
Presentation Title: Bringing CropManage to the field
Number of participants: 31
Type of audience: Growers, ranch managers, irrigators and agricultural operators.
Evaluation tools: based on interviews it is recommended to organize a dedicated workshop for Spanish-only speakers.

Outreach and education event #4:
Date: 11/5/19
Location: Coke Farms, 1681 San Justo Rd, San Juan Bautista
Event Name: Coke Farms grower meeting
Presentation Title: Prueba rapida de nitrato
Number of participants: 42
Type of audience: Small Spanish-only-speaking organic growers.

Virtual outreach and education materials during 2020:



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Due to the Covid-19 pandemic, large group outreach activities for year 2020 were canceled. Instead, the project developed a series of YouTube videos in Spanish that are available at the links below:

How to collect soil and process a nitrate quick test:
https://www.youtube.com/watch?v=FkCt-QDGNx8

How to interpret the results of a nitrate quick test:
https://www.youtube.com/watch?v=PoMA2I1GSv4

How to measure the nitrogen contribution of irrigation water:
https://www.youtube.com/watch?v=KdjE7U3yuw4

Complete nitrogen balance in strawberry and how to adjust N application to yield:
https://www.youtube.com/watch?v=Rrcu_id9c5o

How to use different colorimetric strips with different units for a nitrate quick test
https://youtu.be/opXxxGIXzYk

4. Impact Measures: Project evaluation and improvements based on feedback

Participant feedback was informally gathered during the entire project duration and several improvements and additional resources were developed in response. For instance, throughout the project, it became clear that many growers lack the knowledge to make a complete nitrogen balance, including contributions from organic matter mineralization, irrigation water, crop residue etc. Additional outreach materials were produced to estimate the contribution of irrigation water to the nitrogen balance and the training provided in the field included a discussion of various sources of nitrogen to the crop and how to estimate the contribution of each. Also, at the request of some participants, additional field sheets were produced with recommendations for lettuce, indicating (roughly) the quantity of fertilizer required (for the four most used fertilizers) to increase the soil nitrate content to 20 ppm at sidedress, based on SNQT results. A more formal evaluation was conducted through phone interviews with a subset of participants. Survey responses demonstrated a positive impact from this project and a fair amount of practice adoption (Figure 6), while some growers indicated they still need more practice to gain enough confidence with the tool. RCDSCC will continue to provide one-on-one technical assistance, training and supplies for growers to adopt this practice.

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Figure 6. Participant evaluation survey responses (n=11)

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Feedback from growers focused on the need for tools that provide usable recommendations without requiring complicated calculations. This input was incorporated to the project by producing very visual field guides with a quick and actionable interpretation that do not require users to conduct any math. For example, a table was produced to estimate the contribution of the irrigation water to the crop nitrogen balance by estimating the water nitrate concentration from the colorimetric test strip. Another input from growers was that the MQuant strips and the research grade calcium chloride are too expensive and hard to find. To address this issue, cheaper materials to perform the test were found, adopting Hach strips and more accessible calcium chloride.

G. Discussion and conclusions:

The results of the project are positive, all objectives were met and even surpassed, and there is good interest in learning the technique and adopting the practice among independent growers and large companies. Providing training in Spanish was critical, as was the ability of training farm personnel directly in the field. Many have heard about the soil nitrate quick test but there seems to be an almost insatiable thirst for questions like “where do I buy the strips?”, “what kind of centrifuge bottles do I need?”, “what’s calcium chloride?” etc. The project provided answers these questions, and offered participants the necessary supplies, which was well received by growers.
The resulting printed guidelines were well documented, vetted and easy to follow and interpret, as intended. An effort was made to make the recommendations from the quick test very practical and usable for the main fruiting season of a strawberry crop (Mar-Oct) and this perhaps caused a partial loss of accuracy. However, this seems acceptable for a method like the quick test, which is not very accurate to begin with. Persistence and repetition in the outreach, training and technical assistance is key to develop confidence and capacity to successfully adopt and use the SNQT tool.

H. Challenges

The main challenge encountered in training growers and irrigators on the use of the SNQT, was adapting the materials, explanations, calculations and concepts to overcome low levels of literacy and numeracy among many of the participants. Many Spanish speaking irrigators and growers have limited scholar or academic attainment (elementary school in many cases). Therefore, even seemingly basic and simple arithmetic operations and unit conversions can be a big hurdle for them, which creates a barrier to independently use the tool. Deciding how much fertilizer to apply requires basic math skills and a general understanding of the principles of nitrogen management, which many operators lack. Many growers and irrigators experience considerable difficulty calculating how many pounds of fertilizer are needed to apply a given number of pounds of N because this requires previous foundational concepts (in the learning scaffold) such us N content percentage and/or density in a particular type of fertilizer (how to convert between lb of N and lb of fertilizer, or between pounds and gallons).

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The project addressed these challenges by simplifying concepts as much as possible and developing work sheets and guidelines that shielded the end user from having to conduct too many complex calculations. At a higher level of complexity there was the concept of calculating a nitrogen balance and considering all the potential sources (inputs), including the nitrogen contribution in irrigation water, relative to the crop N uptake, in order to adjust nitrogen application rates and timing. Although the project goal was limited to training growers on collecting and interpreting the soil nitrate quick test, in some cases the project expanded into providing advice on calculating a crop nitrogen balance to support fertilization decisions.

Soil nitrate testing requires following a specific protocol. Although our guide has simplified the process and offered clear step-by-step instruction, the tool is only useful if implemented correctly. Therefore, irrigators must pay adequate attention to detail and also must adjust nutrient management practices according to test results. Most irrigators lack time for taking on additional responsibilities such us regularly conducting the SNQT on their fields. But many of them regularly sample the soil, walking through different parts of the field and poking with soil probes like the ones used in this test, to check for moisture. Perhaps, if the SNQT is tagged on to this common and seemingly established practice, it will more likely be adopted. An alternative is to persuade growers/ranch managers of the need to have a different field person at the farm who can be responsible of sampling soil nitrogen.

I. Project Impacts:

This project provided direct one-on-one training and technical assistance to 52 irrigators, growers and/or agriculturalists, plus a number of outreach materials and large group education events to help advance adoption of the soil nitrate quick test as a relatively simple solution to improve nitrogen management and prevent water pollution in agricultural systems on the California central coast. The materials and training provided addressed several known adoption barriers including knowledge, confidence, language, low levels of school attainment, and understanding of practical interpretation and use. The project achieved its objectives by simplifying the guidelines to conduct the test, interpret and use its results, facilitating repetition and practice to gradually develop grower and irrigator's capacity, and by providing highly visual, step-by-step and easy to follow instruction materials in English and Spanish.

J. Outreach Activities Summary:

Outreach and education events are summarized in the Data and Results section. The photos below highlight the various events conducted during the project.

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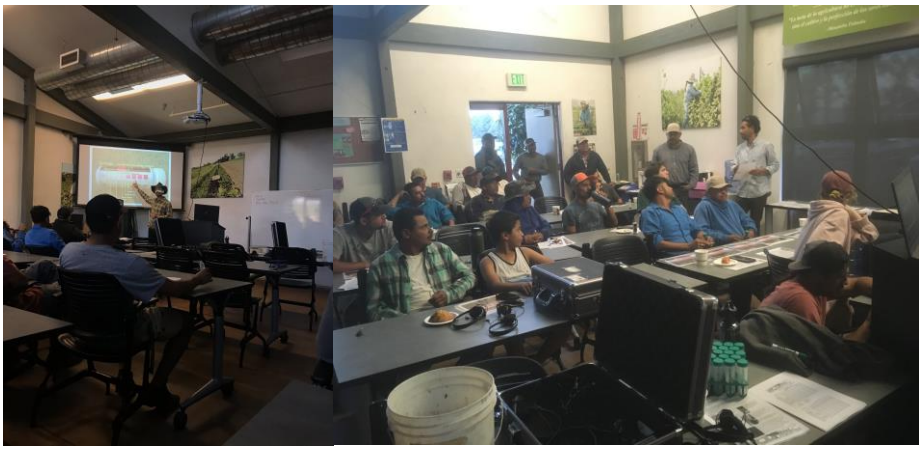

Figure 7. Workshop at ALBA for beginning Spanish-speaking growers on 9/26/1

Figure 8. Outreach event organized at the CropManage workshop in Watsonville on 11/20/19

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Figure 9. Training the Cabrillo College student farm personnel on 10/31/2019

Figure 10. The Strawberry Nitrogen Management outreach event organized on 10/11/19 at the ranch of a strawberry grower that joined the project with the participation of Dr. Cahn and Mark Bolda.

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Figure 11. Soil nitrogen quick test demonstration at the Coke Farm Meeting on 10/5/2019

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Figure 12. Trainings for ranch managers and irrigators of two additional farming operations (Jan & Feb 2020)

K. References

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L. Appendix

N/A

M. factsheet/Database Template

N. Copy of the Product/Result

Copies of the SNQT brochure have been previously submitted. Please indicate if more copies are needed.