Imperial County *Agricultural Briefs*

University of California
Agriculture and Natural Resources

Features from your Advisors

May 2020 (Volume 23 Issue 5)

Table of Contents

Table of Contents (continued)

BEST IRRIGATION MANAGEMENT PRACTICES IN THE LOW DESERT CARROTS – PART I

Ali Montazar, Irrigation & Water Mgmt Advisor, UCCE Imperial and Riverside Counties

Figure 1. Carrot fields under furrow (top) and solid set sprinkler (bottom) irrigation systems in the Imperial Valley.

Introduction. California fresh market and processing carrots comprise an area of 68,000 acres with gross sales of nearly 702 million dollars per year (California Agricultural Statistics Review 2016-2017, CDFA, data associated with 2016 crop season). While carrots have been one of the ten major commodities in Imperial County, the average acreage of carrots was nearly 16,000 over the past five years (2014-2018 Imperial County Agricultural Crop & Livestock Reports). The farm gate value of fresh market and processing carrots was more than 61 million dollars in 2018.

Carrots have been grown on different soil types, although best root development is obtained with sandy textured to silty loam soils. In California, most carrots are typically grown in sandy soils and are sprinkler irrigated, except in the Imperial Valley where carrots are typically sprinkler irrigated for stand establishment and subsequently furrow irrigated for the remainder of the growing season. However, there are fields that are irrigated by solid set sprinkler systems the entire crop season. This article aims to provide science-based irrigation management recommendations for the low desert carrot production system. This work is part of an ongoing research project funded by California Fresh Carrot Advisory Board which intends to fully understand the viability and applicability of current nitrogen and irrigation management practices, and to quantify the best irrigation and nitrogen management practices in the low desert carrots. The study is being conducted in a 2.5-acre research trial at UC Deseret Research and Extension Center located in Holtville, and in five commercial fields in the Imperial Valley.

Field experiment. This part of the field experiment was carried out in four commercial fields in the Imperial Valley. One of the fields was irrigated by solid set sprinkler irrigation the entire crop season (field 1) and in the other three fields, stand establishment was accomplished by sprinkler irrigation and thereafter furrow irrigated for the remainder of the season (field 2-4). The cultivar in field 1 and 4 was fresh-market carrots and was processing carrots in fields 2 and 3. The dominant soil type in field 1 is silty clay loam, in field 2 is silty loam and in field 3 and 4 is sandy loam, respectively.

The actual crop water use (actual crop ET; ET stands for crop evapotranspiration) was measured using the residual of the energy balance method with a combination of surface renewal and eddy covariance equipment (fully automated ET tower showed in Figure 2, left). As an affordable tool to estimate actual crop ET, Tule Technology sensors (www.tuletechnologis.com) were also set up at all experimental sites. The Tule ET data were verified using the ET estimates from the fully automated ET station. Soil moisture sensors were installed at multiple depths to monitor soil water potential on a continuous basis (Figure 2, right). The water delivered by IID to the experimental fields (reported by the cooperative growers as irrigation water) and the rain gauge data of the ET tower were used to determine the applied water (irrigation water + rain).

Figure 2. Fully automated ET tower (left) and a multi depths soil moisture sensor monitoring station equipped along with Tule and NDVI sensors at one of the experimental fields in Westmorland.

Results. A wide range in the length of the crop season (seeding through harvest) was observed, ranging from a 128-day period in a processing carrot (field 3) through a 177-day period in a fresh-market carrot (field 1). The cumulative crop actual ET (crop water use) varied between 11.0-in (field 3) and 16.5-in (field 1) in the experimental fields. As an example, the actual daily and cumulative crop water consumptions were presented for field 1 in Figure 3. A minimum and maximum daily crop water use of 0.008-in and 0.203-in was observed in this carrot field, respectively.

The common irrigation practice in carrot stand establishment is to irrigating field every other day during the first two-three weeks after seeding. Carrots germinate slowly, and hence, the beds need to be kept moist to prevent crusting. The cumulative ET of these three fields during the stand establishment was between 1.8 and 2.8-in which indicates we could overirrigate carrot fields about three times of the water requirements to compensate water loss by ET early for the period (Figure 4a). While high frequent irrigation events in this period is recommended, we might be able to apply less irrigation water in each event and still keep the beds moist as much as needed.

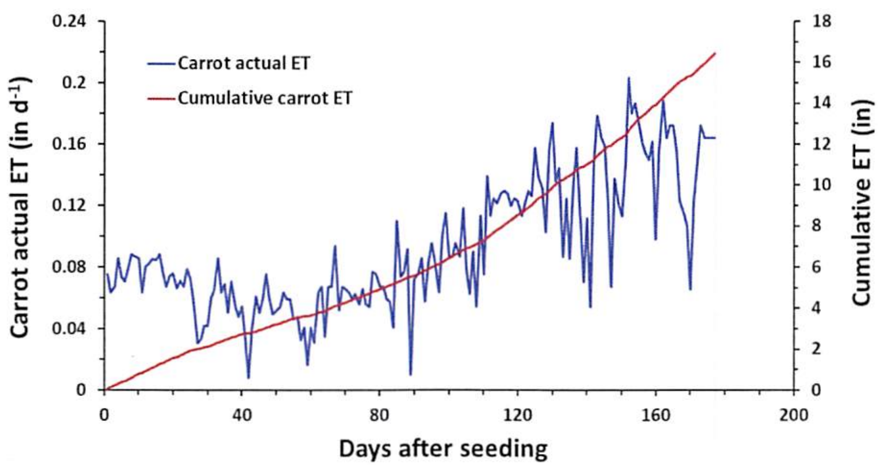

Figure 3. Daily and cumulative actual crop ET in carrot field 1.

The results indicate that growers could underirrigate carrot fields during the period of days 35 through 60 after seeding when the cultivation practices need to be implemented and it causes delay following irrigation event (Figure 4a and 4b). The soil moisture sensors data at multiple depths and sites confirmed this conclusion. An average soil water tension of 120 cb (centibars) at the top 12-in of the soil (field 4 with a dominant sandy loam soil) demonstrates a potential crop water stress in this period when the root development is not yet completed. In field 1 with a silty clay loam soil type, the soil moisture content did not decline as low as in field 4, which means the severity of water stress in this period is highly depending upon the soil type. One irrigation event over this one-month period may be a management tool to prevent possible water stress in fields with dominant light soil type. It is unclear what exact effect this temporary stress could have on carrot crop production quality, particularly on processing carrots with a shorter growing season than fresh-market carrots.

The carrot fields comparatively practiced more effective irrigation management for the remainder of the growing season and soil moisture was maintained in a desired level in the experimental fields (Figure 4b). Sprinkler irrigation may be considered as a more effective irrigation tool when compared with furrow irrigation. More frequent and light irrigation events are possible by sprinkler irrigation. Over-irrigation of carrot fields increases the incidence of hairy roots; and severe drying and wetting cycles result in significant splitting of roots. Sprinklers reduce salinity which is important since carrots are very sensitive to salt accumulation. On the other hand, improving nitrogen use efficiency is closely associated with the effectiveness of irrigation management and water use efficiency. While nitrogen/water use efficiency is another topic that will be addressed in another article soon, the preliminary results of this study illustrate a significant enhancement in nitrogen and water use efficiency of carrots using sprinkler irrigation.

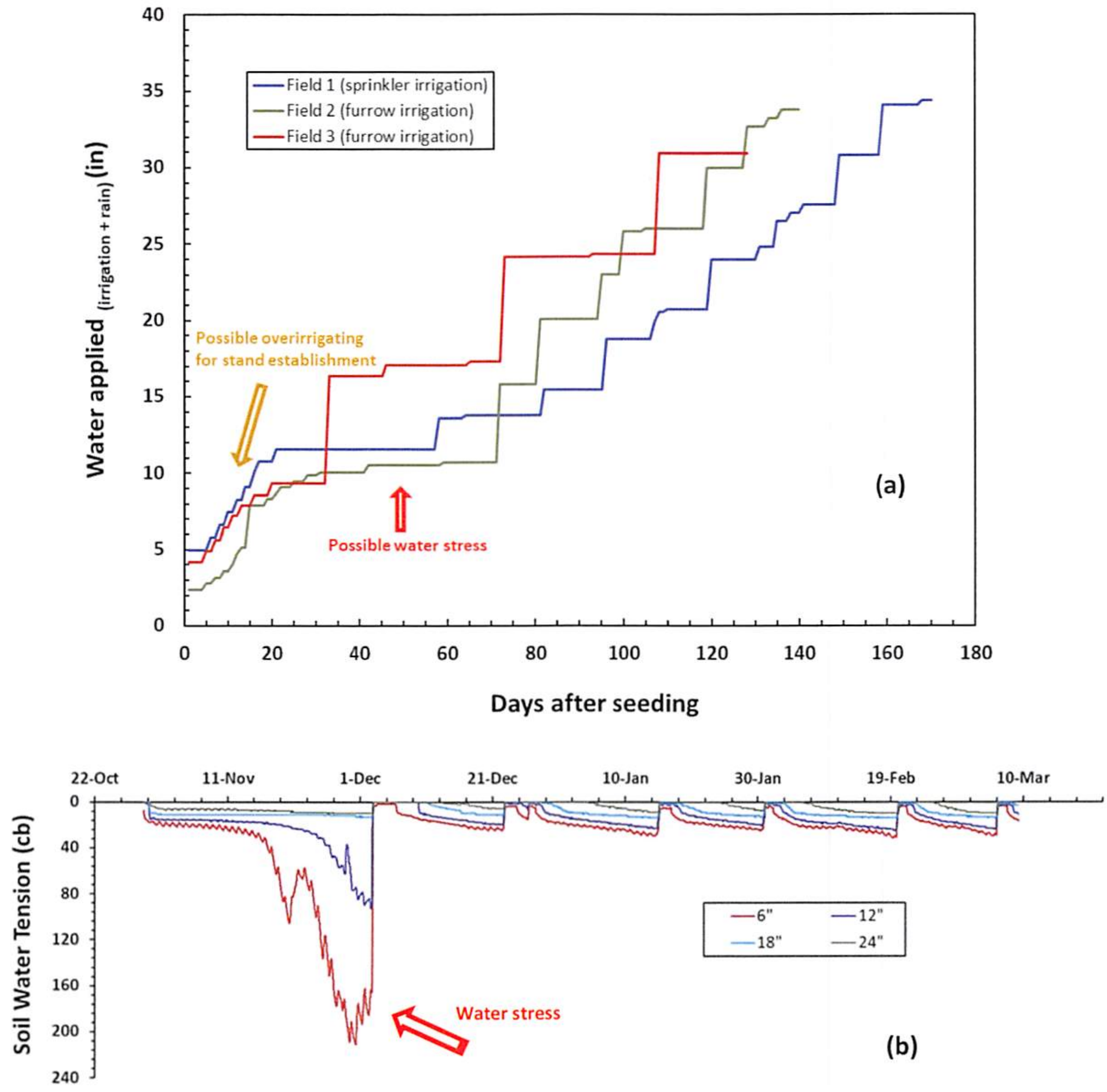

Figure 4. Water applied in carrot fields 1-3 over the growing season (a). Overirrigation during the stand establishment and water stress during the second-third month after seeding are possible I carrot fields. Soil water tension in multiple depths (6-in to 24-in) in carrot field 4 over the growing season (b). This field was planted on October 3rd, 2019. Soil water tension data at the depth of 6 and 12-in shows possible water stress between November 24 and early December. In other words, one-week delay in irrigation event was occurred in this this specific field and period.

If you have any question regarding this article and the ongoing study or soil - water related issues of carrot production, please feel free to contact me at (442) 265-7707 or amontazar@ucanr.edu.

HEALTHY SOILS GRANT OPPORTUNITY
ZOOM WORKSHOP

Cosponsored by
UCCE-Imperial County, UCANR, and
Imperial County Farm Bureau

The Healthy Soils Grant Funding Program provides financial assistance for the implementation of conservation management practices that improve soil health, sequester carbon and reduce greenhouse gas (GHG) emissions. Applications will be open on a rolling bases online at https://www.cdfa.ca.gov/oefi/healthysoils/, and applicants are eligible to receive up to $100,000 in grant funding. Applications will be accepted through 5:00 pm on June 26th.

Imperial County Farm Bureau, UCCE-Imperial County, and UCANR will be hosting another Healthy Soils Workshop to provide information and assistance to growers who are interested in applying. Potential applicants are encouraged to attend at least one workshop.

Wednesday, May 13, 2020, 10:00 am – 12:00 pm
Zoom Conference Call

Please register in advance for this meeting at:
https://ucanr.zoom.us/meeting/register/tJlqdO-oqz4oHtIW6QSGE1ONluxwtaQFayPM

After registering, you will receive a confirmation email containing information about joining the meeting. If you need assistance or have questions regarding the program, please email kmsalgado@ucanr.edu.

Please feel free to contact us if you need special accommodations.

LIVESTOCK RESEARCH BRIEF

UC CE | University of California Agriculture and Natural Resources | Cooperative Extension

1050 E. Holton Rd.
Holtville, CA, 92250
(442) 265-7700

Hello,

This month examines a study looking at the effect of replacing steam flaked corn with extruded corn meal in the diet on the performance of calf-fed Holstein steers.

If you have any comments, questions, recommendations, or know someone who would like to be included on the mailing list, please feel free to contact me.

Best wishes,

Brooke Latack
Livestock Advisor
UC Cooperative Extension – Imperial, Riverside, and San Bernardino counties
1050 E Holton Rd
Holtville, CA 92250
442-265-7712
bclatack@ucanr.edu
http://ceimperial.ucanr.edu/Livestock/

EFFECT OF REPLACING STEAM FLAKED CORN WITH EXTRUDED CORN MEAL ON FEEDLOT HOLSTEIN STEER PERFORMANCE

Brooke Latack
Livestock Advisor

Introduction

Extruded corn, produced by forcing steamed, ground grain through a perforated die, has been proposed to be comparable to steam flaked corn as a feedlot diet ingredient. The benefits of extruded corn meal have differed between studies. This study aimed to evaluate the potential positive benefits of extruded corn meal as a partial replacement for steam flaked corn on calf-fed Holstein production and digestive function.

Methods

64 calf-fed Holstein steers (247 ±4 kg) housed at UC DREC were sorted into 16 pens (4 animals per pen) for a 70-d trial. Steers were fed a steam flaked corn based finishing diet. Four treatments were applied, replacing steam flaked corn with extruded corn meal. Treatments were:

1. 0% extruded corn meal, replacing 0% of steam flaked corn
2. 10% extruded corn meal, replacing 15% of steam flaked corn
3. 20% extruded corn meal, replacing 30% of steam flaked corn
4. 30% extruded corn meal, replacing 45% of steam flaked corn

Treatment diets are shown in Table 1.

Results and Implications

Treatment effects are shown in Table 2. Crude protein, NDF, and starch content for extruded corn meal was similar to steam flaked corn, but soluble starch was 359% greater for extruded cornmeal compared to steam flaked corn. Inclusion of extruded corn meal didn't affect ADG, DMI, gain efficiency, and dietary net energy. Dietary net energy was 99% of expected for diets containing 10% and 20% extruded corn meal. Dietary net energy was 94% of expected for diets containing 30% extruded corn meal.

Overall, as long as inclusion of extruded corn meal does not exceed 20% of the diet, the feeding values of extruded corn meal and steam flaked corn are similar. Extruded corn meal was not beneficial to ruminal microbial efficiency and digestive function.

Table 1.
Ingredient composition of experiment diet

Ingredient Composition	Extruded crude protein, % (DM basis)			
Item	0	10	20	30
Sudan hay	12	12	12	12
Yellow grease	3	3	3	3
Cane molasses	4	4	4	4
DDGs	10	10	10	10
Steam flaked corn	67.53	57.53	47.53	37.53
Extruded corn meal	0	10	20	30
Urea	1.3	1.3	1.3	1.3
Limestone	1.7	1.7	1.7	1.7
Rumensin	0.0184	0.0184	0.0184	0.0184
Magnesium oxide	0.15	0.15	0.15	0.15
TM salt	0.30	0.30	0.30	0.30

Table 2.
Growth performance treatment effects

	Extruded crude protein, % (DM basis)			
Item	0	10	20	30
Weight, kg				
Initial	246	247	244	251
Final	340	346	338	343
ADG, kg	1.34	1.42	1.35	1.32
DMI, g/d	6.50	6.69	6.37	6.74
ADG/DMI	0.21	0.21	0.21	0.19
Dietary NE, Mcal/kg				
Maintenance	2.15	2.18	2.19	2.09
Gain	1.48	1.51	1.51	1.42

References

Buenabad, L., Jacinto, A. Y., Montano, M, and Zinn, R.A. Extruded corn meal as a partial replacement for steam flaked corn in finishing diets för feedlot cattle: growth performance and digestive function of feedlot cattle. 2019. Open Journal of Animal Sciences, 9, 196-206.

PROMOTING HEALTHY PEOPLE AND COMMUNITY THROUGH GARDENING

Yu Meng, Ph.D, Youth, Family, and Community Advisor, UCCE Imperial County

The New York Times article titled 'Food Supply Anxiety Brings Back Victory Gardens' has been reposted widely through social media during the COVID-19 pandemic. The victory garden movement began during World War I and called on all Americans to grow food for self-sustainability. Panicking with the pandemic, shoppers emptied shelves and further raised food anxiety to the virus. Basic foods like eggs, tomatoes and potatoes are quickly gone. In the meantime, people frequently visited the University of California (UC) Master Gardener Program website. In response to our community needs, a survey was conducted by an UC Cooperative Extension (UCCE) advisor. Half of the respondents asked for gardening advice. It must be noted that there are various good things in gardening, at an individual level, inter-personal level, and social ecological level.

1. Increase in food security

At an individual level, gardening isn't just about making a house look good. It is also an excellent way of reducing grocery bills if you are growing a food garden. 'A well-maintained food garden yields 1/2 pound of produce per square foot per growing season. According to the National Grocers' Association, an American household that spend an average of $70 per year, could churn out 300 pounds of fresh produce worth about $600 annually.

Access to food has been an issue for people living in rural areas. Twenty-five (25) % of Imperial County residents live with high access to healthy food sources in their environment, within 1 mile (for urban) or 10 miles (for rural residents) of a supermarket, compared to 53% statewide. Thirty- three percent of children are food insecure compared to 19% statewide.

Access to healthy, safe, and affordable food choices is crucial to achieve a healthy eating pattern. Growing food in backyard gardens saves trips to thebgrocery stores and increases healthy access to food. Shown below is a picture of one of the garden beds' harvest at a low-income housing site with which the UCCE is partnered.

2. Promotes healthy eating

One great challenge for fighting obesity is eating more fruits and vegetables. According to Center for Disease Control and Prevention, only 1 in 10 adults eat enough fruits and vegetable (5 servings a day). Thirty-eight (38) % of Imperial County residents are obese compared to 28% statewide. Garden-based nutrition education programs showed an increased fruits and vegetable consumption by Latino Children, as well as their preference to use fruits and vegetables as healthy snacks. The study also showed that gardening decreased children's body mass index. (Castro et al., 2012; Gatto et al., 2014)

3. Increases outdoor time

Nowadays, too much screen time is a problem not only for adults but also for children. Gardening provides a reason to go outside and burn some calories, lower stress levels, lower blood pressure, strengthen bones, and bring a family together. Growing fresh food brings sustainability and also connects us back to nature. In a study that interviewed people why they garden (Kingsley et al, 2019), one participant stated:

"with gardening, you put something in the ground, you nurture it, and you get a result... a sense that I was contributing, that I was reconnecting... with the land and people...there is no better way for me to regain a sense of self and calm"

4. Increases agriculture literacy

UCCE Imperial County is committed to support gardening through expanding knowledge to individuals, schools, and communities. Our CalFresh Healthy Living program offers garden-based nutrition curriculum to schools. The k-3 grade school students also have opportunities to visit our Farm Smart program as a field trip and learn about the various gardening techniques and nutritional values. We further teach the youth about carbon footprint and how to reduce it through gardening practices, sustainable food choices, and composting skills. Below are pictures taken during one of our garden kickoffs where our community education specialist teaches about nutrition curriculum and vegetable planting activity.

5. Community garden brings the community together

Community gardens can forge bonding experiences for families and community members, provides a space to befriend neighbors, supports people in food security with extra food, and builds a sense of identity and ownership. The building of a local connection through educating others gives a sense of belonging and promotes relationships with similarly interested neighbors. According to Kingsley et al, 2019, some of the reasons people are interested in gardening are described as:

1. *"I've recently retired... If I didn't have a plot (gardening field) here, I'd probably be... sitting at home... it really gives me a focus... an opportunity to find people that I can relate to"*

2. *"gardens are... important, in terms of community development... being able to access fresh, healthy... produce, especially for groups that are facing disadvantage... the more we can grow, the more they can access"*

The picture shown below is a vegetable harvesting event at Harding Elementary school, where children, community members, and UCCE staff were gathering, harvesting, and demonstrated cooking on site. We have created three videos in English and Spanish on how to start your home garden, seek gemmation, and desert climate gardening. The video will be released soon and be available on UCCE Imperial County website and 4-H and CalFresh social medias.

To learn more about the UC Master Gardener program, you may want to access http://mg.ucanr.edu/ and UCCE programs at http://ceimperial.ucanr.edu/. If you have any further questions about gardening and this particular article, please call our office at (442)265-7700 or email Yu Meng at ucmeng@ucanr.edu

References:

1. Castro D. C., Samuels M., Harman A. E. (2012). Growing healthy kids: A community garden-based obesity prevention program. American J of Prev Md, 44(3), S193-199. https://doi.org/10.1016/j.amepre.2012.11.024
2. Gatto, N. M., Martinez, L. C., Spruijt-Metz, D., & Davis, J. N. (2015). LA sprouts randomized controlled nutrition and gardening program reduces obesity and metabolic risk in Latino youth. *Obesity (Silver Spring, Md.)*, *23*(6), 1244–1251. https://doi.org/10.1002/oby.21077 (Retraction published Obesity (Silver Spring). 2015 Dec;23(12):2522)
3. Kingsley, J., Foenander, E., & Bailey, A. (2019). "You feel like you're part of something bigger": exploring motivations for community garden participation in Melbourne, Australia. *BMC public health*, *19*(1), 745. https://doi.org/10.1186/s12889-019-7108-3

UC COOPERATIVE EXTENSION UPDATE, IN THE CONTEXT OF COVID-19

Oli Bachie, Director, UCCE Imperial County &
Agronomy Advisor, UCCE Imperial, Riverside & San Diego Counties

First, I would like to extend my wish for your health and safety to all of you and loved ones at this difficult time. While this unprecedented epidemic is impacting our daily activities, productivity of our farms, the health and livelihood of our community and the economy of the country, I would like to re-assure you that it has not caused the CE to be closed for business, although limited our capacity of clientele and industry face to face contact. As soon as we were told of a "stay home" order both from the county and the university:

1. We classified our staff as essential and non-essential, in which case the essential workers must work in office or in the field or laboratory research projects. The non-essential workers perform 8 hours daily activity as usual, but through telecommuting. In recent weeks, we implemented monitoring our staff and anyone coming to the CE office for body temperatures using infra-red thermometer following county recommendation.

2. Our essential staff working in the office answer phones and emails and direct incoming calls or emails to concerned telecommuting advisors and/or Community Education Specialists.

3. Our staff working in the fields and lab research projects travelled to research project fields and collected data.

4. We issued (issue) the monthly Ag Brief articles without any interruption

5. We responded to phone calls through phone or zoom meetings if a one on one or group discussion is desired. To this effect, the UCANR allowed us to lease university zoom service to our clientele. If anyone (individually or as a group) would like to hold a zoom meeting with us, or want to organize something of your own, please feel free to contact us for zoom service.

6. Our staff, in cooperation with the Farm Bureau conducted one in person and another zoom workshop on Healthy Soil (HS) incentive Program for potential applicants.

In the area of pest management, we would like to inform you that a UCR specialist, Dr. Putman detected what may be a "white rust of spinach" in his spinach research field at Desert Research and Extension Center. White rust is said to have not been spotted in California. A group of people from county Ag commission, UCR and Cooperative Extension are working on confirming the pathogen and the spinach variety that was affected. When all is confirmed we will provide a written article, preferably through the Ag Brief and our website.

With our recent search for Integrated Pest Management (IPM) advisor, the established selection committee screened 16 applicants to three potential candidates. As soon as offices open and regular working conditions resume, we will invite the candidates for onsite (in person) interviews and bring selected candidate onboard.

Our CalFresh and 4-H staff, youth and volunteers working from home to support community needs virtually. Our 4-H County Young Ambassadors are making 1000 face masks for community. Our 4-H CES host daily Facebook Cooking Lives for members. In picture is a demonstration of cooking skills by a 4-H All Stars and her mom, who is also 4-H volunteer.

The university and the county are independently discussing potentially easing the stay home requirement and opening businesses and industry. If that becomes effective, we look forward to seeing you soon in person when it's safe to do so and hope to provide the needed services. Until then, you can continue to connect with us by email, phone or video conference—and that includes all our advisors and CES staff. If necessary, our staff will travel to grower fields or shops, discuss with you over the phone or organize a zoom conferencing for a face to face online meeting.

Thank you and stay safe and healthy

BACTERIAL WHEAT STREAK / BLACK CHAFF

Michael D. Rethwisch, Crop Production & Entomology Advisor, UCCE Riverside County – Palo Verde Office

The wet, cool winter weather conditions have also been contributing to diseases in our local durum wheat. The majority of disease noted thus far has been caused by the bacteria *Xanthomonas translucens* pathovar (pv.) *undulosa*. The scientific name of this disease was recently changed from *Xanthomonas campetris* pathovar (pv.) *translucens*.

This disease actually has two different names, depending upon wheat structures being attacked. The name early in the season when leaves are attacked is 'bacterial leaf streak'. This is characterized by streaks that ooze yellow colored bacteria (Fig. 1) that results in leaves that often appear orange in color (Fig. 2). The dried bacteria ooze results in a scale-like appearance on leaves.

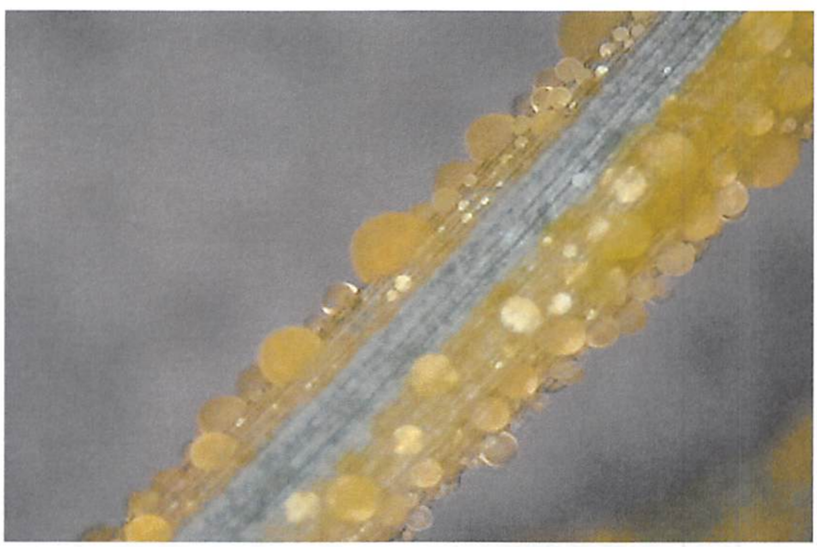

Fig. 1. Yellow-colored bacterial exudates that ooze from infected wheat plants are indicative of the bacterial disease Bacterial leaf streak.

Fig. 2. Wheat flag leaves showing yellowing/ orange colored areas from bacterial wheat streak infestation (photo courtesy of Rich Wellman).

Leaf rust and stem rust can also result in wheat having an orange appearance. In contrast to bacterial wheat streak, the orange color associated with rust diseases on wheat are circular or oval pustules. The spores within these pustules are easily dislodged and cover hands and clothing with an orange dust. This will not occur with bacterial wheat streak.

As bacterial leaf streak progresses up the plant it can next affect the peduncles (stem area between head and top (flag) leaf). The dried bacteria ooze results in a dried, yellowed exudate clumps on wheat (Fig. 3).

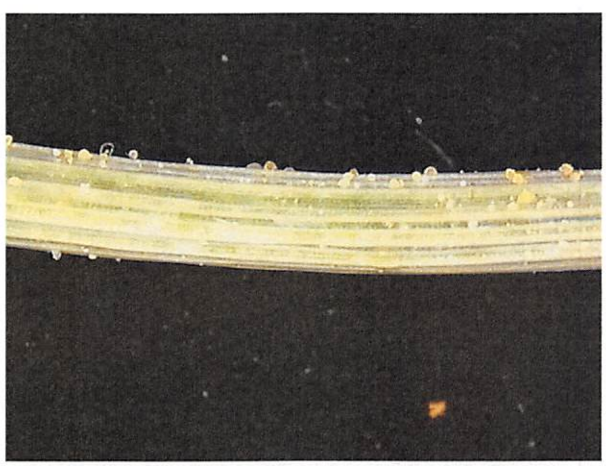

Fig. 3. Wheat peduncle with dried Xanthomonas bacterial exudates. Affected peduncle areas are also often slightly misshapen and curved.

Local PCAs have been finding heads that are yellowing (Fig. 4), prior to the finding dis-colored awns, with this being almost always associated with an infected peduncle.

Fig. 4. Yellowed awns are usually found locally on wheat plants with peduncles that are infected with Xanthomonas prior to black chaff development on awns and glumes (photo courtesy of Richard Wellman).

When *Xanthomonas* moves up and affects the head and glumes, the disease is known as black chaff as the glumes turn a dark color. Bands of necrotic and healthy tissue on awns, resulting in what is referenced as a 'barber pole' appearance, are indicative of black chaff.

Yield loss is a linear function of the percent infected flag leaf area, and even a small-infected leaf area has an effect on yield. The disease mainly affects grain fill, with grain number significantly correlated with bacterial leaf streak severity levels two out of three years in experiments conducted in Mexico. These data also indicated that an average loss below 5 percent could be expected when the percent infected flag leaf area is less than 10 percent.

Yield losses as high as 40 percent have occurred in the most severely diseased fields in Idaho, however, area PCAs experienced with this disease have indicated losses much greater than this in the low desert.

The primary source of inoculum for long distance spread of this disease is through contaminated seed. Secondary source of inoculum is through the exudates and populations on volunteer cereals and grassy plants. Short distance spread is through splashing water, plant-to-plant contact, and insects.

During the growing season it is capable of living on the plant surface without causing any symptoms. Cool and moist conditions allow *Xanthomonas* to proliferate. It enters plants through their stomata and through wounds.

Usually the winter weather conditions in the low desert are not generally conducive for bacterial wheat streak outbreaks and high levels of damage. The cool, wet conditions noted this past winter were atypical and have provided optimal conditions for bacterial wheat streak to proliferate and cause yield loss.

Management of bacterial leaf streak is very limited. Being a bacterial disease rather than a fungal disease, fungicides are ineffective in providing control of *Xanthomonas*. Registered bactericides are not systemic, thus control of this disease once inside the wheat plant cannot currently be achieved by bactericides.

Management options are usually exercised prior to wheat seed being planted. These options are using varieties with bacterial leaf streak resistance (which may or may not be readily available for low desert durum varieties), and/or by planting seed that has low levels of bacterial infestation. There is limited research data on bacterial wheat streak infestation levels and resulting infections, but available data have indicated that a minimum of 1,000 cfu (colony forming units) per milliliter of seed wash was needed for field infections under Idaho conditions. There are antagonistic bacteria that kill *Xanthomonas* bacteria on seeds, but it is unknown if these bacteria are available for commercial use to control black leaf streak bacteria on wheat seed.

WHITE BLISTER RUST OF SPINACH FOUND IN IMPERIAL COUNTY

Alex Putman, Assistant Cooperative Extension Specialist, UC Riverside

- White blister rust of spinach was observed in a research trial in Holtville
- There are no previous reports of spinach white blister rust in California
- Disease development is favored by cool air temperatures, leaf wetness and high relative humidity, and rain events
- The pathogen can survive in the soil as oospores, its sexual reproductive structures
- White blister rust is best managed by crop rotation and a fungicide rotation program

Observation in Imperial County

White blister rust of spinach was observed in April 2020 in a downy mildew trial located at the University of California Desert Research and Extension Center outside Holtville. This disease has not been previously observed west of the Rocky Mountains, making it the first detection in Imperial County and California.

The first observation of white blister rust was made on April 9. The plots were planted with cultivar Viroflay on January 25, and by April 9 the plots were overgrown but were still receiving irrigation. Due to the COVID-19 pandemic, the trial had last been treated on March 5 and last scouted on March 17. Therefore, the disease first appeared sometime after March 17. Judging from the progression of symptoms observed on April 9, it is likely the outbreak began 1 to 2 weeks prior to April 9.

The portion of the trial affected was small relative to the size of the trial. The outbreak likely originated from a single focus or starting point and was limited to about 30 bed-ft. of one bed and part of the adjacent bed. To stop the outbreak, the trial was cultivated on April 21, and spinach will not be planted in this area until the Fall of 2023 at the earliest. Furthermore, monitoring and sanitation of volunteer spinach and closely related weeds will be performed in this area.

White blister rust of Spinach

Symptoms. White blister rust of spinach (also called "white rust") first appears as chlorotic (yellow) lesions on the upper leaf surface (Figure 1A). Although these lesions are similar to the symptoms of downy mildew on the upper leaf surface, individual white blister rust lesions are generally smaller and restricted in size. A cluster of small, white pustules (the "blisters") up to 0.1 inches in diameter form on the underside of the leaf opposite these lesions (Figure 1A, B). The pustules may not form immediately with the appearance of the chlorotic lesions. These pustules burst when mature to release sporangia, the asexual spore of the pathogen. Later, a dense collection of tiny black specks often forms within the lesion, sometimes in a ring pattern (Figure 1D). These are oospores, the sexual spore of the pathogen. Some pustules can emerge on the upper leaf surface (Figure 1C). Lesions can coalesce as the disease progresses, and then affected areas become necrotic (brown and dead) and produce more oospores (Figure 1D).

Disease Cycle and Epidemiology. The sporangia produced in the white pustules are carried by wind or water splash and are the primary way the pathogen is dispersed within a season. These sporangia can cause repeated cycles of infection as long as conditions are favorable. The oospores are produced as infected leaf tissue dies and are the structure that survival in the soil during periods with no host or unfavorable environmental conditions. In other parts of the United States where white blister rust has occurred for many years, oospores in the soil are believed to be responsible for starting epidemics at the beginning of the season. The pathogens that cause white blister rust of other crops such as Brassica crops or sunflower have been shown to be seedborne, but this has not been reported for spinach white blister rust.

Development of white blister rust disease is favored by cool and moist conditions. The optimal air temperatures for infection and disease development have been reported to be about 53°F to 65°F, with a range of 46°F to 79°F. Leaf wetness is required for infection. A leaf wetness duration of 3 hours was reported to be sufficient for disease, and longer durations led to more severe disease and allowed disease development over a wider range of temperatures. Disease outbreaks in the central United States are often associated with rain events.

The Pathogen. White blister rust of spinach is caused by *Albugo occidentalis*. This pathogen is a member of the Oomycota (also known as the water molds), a group of organisms that also includes the downy mildew pathogens, *Phytophthora*, and *Pythium*. Therefore, *A. occidentalis* is not a true fungus. Like the downy mildew pathogens, the *A. occidentalis* is an obligate parasite, meaning it needs a living host to grow and reproduce. However, it can survive dormant as oospores for several years.

The pathogen causing white blister rust of spinach is hostspecific. In addition to spinach, the only plants that have been reported as hosts of *A. occidentalis* are Mexican tea (*Chenopodium ambrosioides*), strawberry blite or blite goosefoot (*Chenopodium capitatum*), and red goosefoot (*Chenopodium rubrum*). The genus *Chenopodium* belongs to the same subfamily as spinach. Nettle-leaved goosefoot (*Chenopodiastrum murale*), a common weed in Imperial County, has not been reported as a host of the spinach white blister rust pathogen.

Like the downy mildew pathogens, the "white blister rusts" are a group of separate species, each of which infects a specific host plant or group of host plants. For example, *Albugo candida* causes white blister rust of crops in the Brassica family including vegetables (cole crops), mustards, and oilseeds, but does not affect spinach. Sunflower and sweetpotato are examples of crops that are each affected by different host-specific pathogens. More broadly, note that these diseases are called "white blister rust" or sometimes simply "white blister" to distinguish them from the true rusts that cause disease on crops such as cereal grains, onion, almonds, peaches, and caneberries.

Management. In other areas of the United States such as Texas where the disease has been a recurring problem, management of white blister rust of spinach has been accomplished with an integrated approach of host resistance, crop rotation, sanitation of volunteers and weeds, and fungicides.

The type of resistance to white blister rust available in spinach cultivars is quantitative, also known as incomplete or partial. This type of resistance is responsible for a partial reduction, but not elimination, in the amount of disease compared with susceptible cultivars. This quantitative resistance is generally effective against all strains of the pathogen that may be encountered. In contrast, the more familiar qualitative (also known as major gene) resistance in spinach to downy mildew is conferred by a series of resistance sources corresponding to pathogen races. A cultivar that possess a resistance source will not be infected by the corresponding pathogen race. It should be noted that this observation of white blister rust in Imperial County was on cultivar Viroflay, a heirloom cultivar from 1866 that likely does not have any resistance to white blister rust. Breeding spinach for white blister rust resistance has been undertaken in Texas and Arkansas since 1960. Although these programs have produced cultivars with varying levels of resistance, these cultivars are likely adapted to conditions and production systems in those areas, and it is unclear if any of this resistance is present in cultivars grown in the conditions and production systems of California and Arizona.

The primary cultural method to manage spinach white blister rust is crop rotation. The objective is to avoid the hardened oospores which are adapted to surviving in the soil or in crop residue for long periods. While it is not known how long the oospores survive, various sources recommend a crop rotation with at least 2 or 3 years between spinach crops to allow the oospores to degrade. These recommendations align with those for white blister rust of Brassicas, for which more research has been performed. Additional cultural practices that are recommended include burying infested spinach residue as deeply as possible and performing sanitation of volunteer spinach and possible weed hosts of the pathogen.

While some of the fungicides that are effective against downy mildew are also active against white blister rust, the most efficacious fungicides for managing each disease are not the same. The most consistently efficacious fungicides for managing spinach white blister rust in trials in Oklahoma have been pyraclostrobin (FRAC Group 11) and fluopicolide (43). Fungicides with good to moderate performance in these trials include azoxystrobin and fenamidone (11), cyazofamid (21), and rotations that include acibenzolar-S-methyl (P01), or fosetyl-Al or phosphonates (P07). An application of mefenoxam (4) at planting as a soil-applied spray or as a granular in-furrow has been shown to provide extended control of white blister rust, and the latter is part of the standard white blister rust management program in Texas. Mainstays for a downy mildew management program including oxathiapiprolin (49), mandipropamid (40), or dimethomorph (40) should not be relied upon in a management program as little information is available on the performance of these fungicides against white blister rust. Similar to other diseases, always check the label and practice fungicide rotation among different FRAC Groups to reduce the risk of fungicide resistance emerging in the pathogen.

Future Outlook. The source of the outbreak we observed is unknown, and it is unknown if the pathogen will become established in Imperial County. The number of fields with spinach remaining in the ground was relatively low by the time the outbreak occurred. Hopefully, the measures that we are employing at the UC Desert Research and Extension Center, including cultivation, a 3-year rotation away from spinach, and monitoring and sanitation of volunteer and weeds, will be sufficient to prevent recurrence. Even if these methods are successful, however, it is possible that spinach white blister rust will be re-introduced into Imperial County or nearby production areas in the future. This pathogen was first discovered on blite goosefoot in Colorado in 1901, and then became an economically significant disease in Texas, Oklahoma, and Arkansas in the late 1930's and early 1940's. After this, spinach white blister rust remained confined to the United States until it was found in Greece in 2012, Mexico in 2015, and Turkey in 2017. These recent detections suggest that further expansion is likely.

Research to confirm identity and pathogenicity of the pathogen is underway and will be published in the near future.

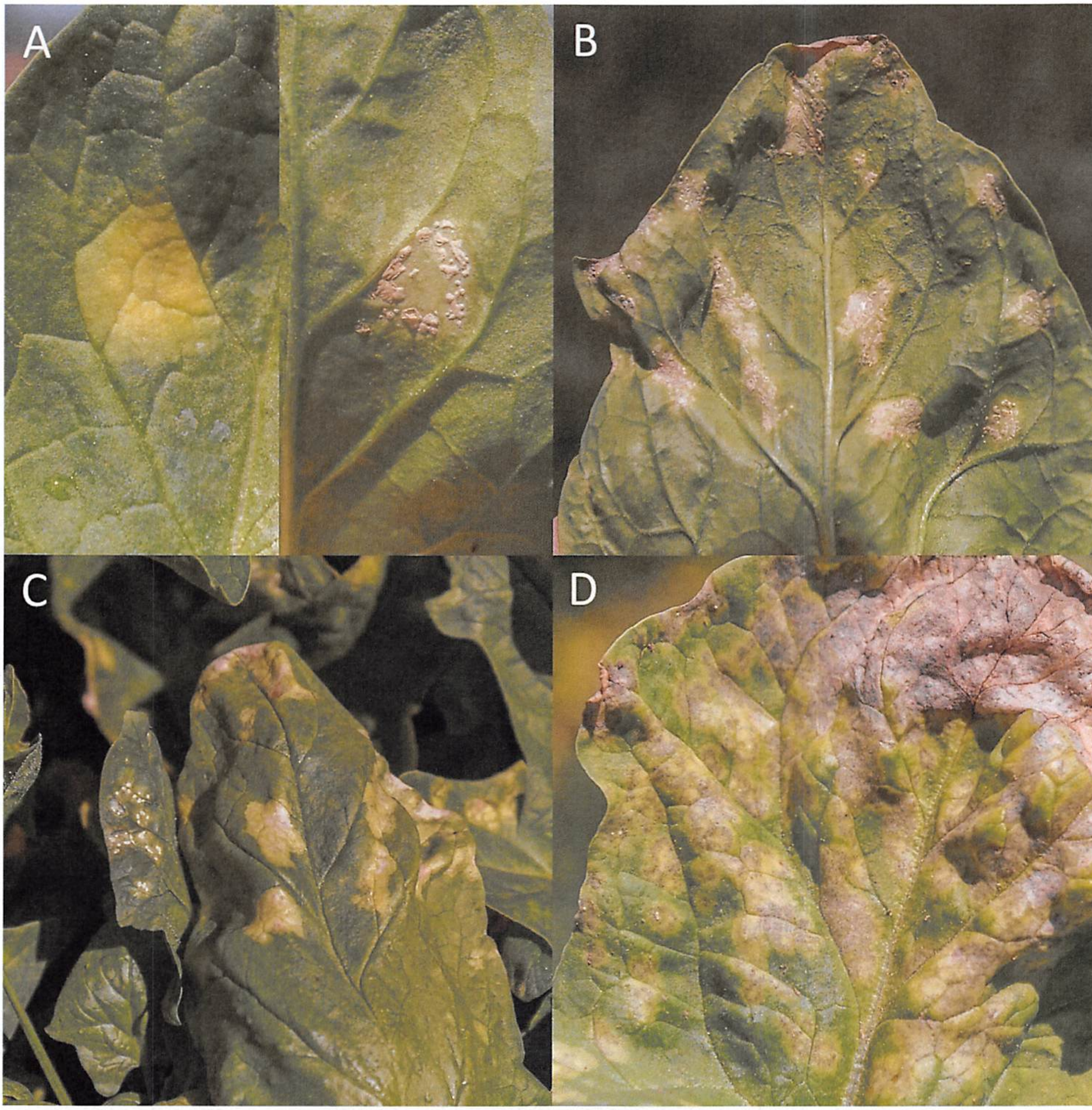

Figure 1. Symptoms of white blister rust of spinach observed near Holtville, CA. **A**, view of a single lesion from the upper surface and of the pustules from the lower leaf surface. **B**, large leaves can harbor multiple lesions, each with numerous pustules. **C**, as time passes, pustules can emerge from the upper leaf surfaces or lesions can turn white to brown. **D**, oospores (dark specks) are produced in abundance as affected tissue dies.

References

Awika, H.O., T.G. Marconi, R. Bedre, K.K. Mandadi, and C.A. Avila. 2019. Minor alleles are associated with white rust (*Albugo occidentalis*) susceptibility in spinach (*Spinacia oleracea*). Horticulture Research 6:129.

Brandenberger, L.P., J.C. Correll, T.E. Morelock, and R.W. McNew. 1994. Characterization of resistance of spinach to white rust (*Albugo occidentalis*) and downy mildew (*Peronospora farinosa* f. sp. *spinaciae*). Phytopathology 84:431-437.

Correll, J.C., C.D. Feng, and B. Liu. First report of white rust (*Albugo occidentalis*) of spinach in Mexico. Plant Disease 101:511.

Correll, J.C., T.E. Morelook, M.C. Black, L.P. Brandenberger, and F.J. Dainello. 1994. Economically important diseases of spinach. Plant Disease 78:653–660.

Dainello, F.J., and R.K. Jones. 1986. Evaluation of use-pattern alternatives with metalaxyl to control foliar diseases of spinach. Plant Disease 70:240-242.

Damicone, J. and T. Pierson. 2011. Evaluation of fungicides for control of foliar diseases in spring-cropped spinach, 2010. Plant Disease Management Reports 5:V053.

Damicone, J. and T. Pierson. 2016. Evaluation of fungicides for control of white rust on fall-cropped spinach, 2015. Plant Disease Management Reports 10:V045.

Lava, S.S., A. Heller, and O. Spring. 2013. Oospores of Pustula helianthicola in sunflower seeds and their role in the epidemiology of white blister rust. IMA Fungus 4:251–258.

Soylu, S., M. Kara, S. Kurt, A. Uysal, H.D. Shin, Y.J. Choi, and E.M. Soylu. 2018. First report of white blister rust disease caused by *Albugo occidentalis* on spinach in Turkey. Plant Disease 102:826.

Stein, L.A. 2018. Development of a spinach white rust management strategy in Texas (Abstr.). Proceedings of the International Spinach Conference, February 14-15, 2018, Murcia, Spain.

Sullivan, M.J., J.P. Damicone, and M.E. Payton. 2002. The effects of temperature and wetness period on the development of spinach white rust. Plant Disease 86:753-758.

Thomas, C.E. 1970. Epidemiology of spinach white rust in South Texas (Abstr). Phytopathology 60:588.

Trent, M.A. 2004. Etiology and management of spinach white rust. M.S. Thesis. Department of Entomology and Plant Pathology, Oklahoma State University, Stillwater.

Vakalounakis, D.J., and A.G. Doulis. First record of white rust, caused by *Albugo occidentalis*, on spinach in Greece. Plant Disease 97:1253.

Voglmayr, H., and A. Reithmüller. 2006. Phylogentic relationships of *Albugo* species (white blister rusts) based on LSU rDNA sequence and oospore data. Mycological Research 110:75–85.

IMPERIAL VALLEY CIMIS REPORT AND UC WATER MANAGEMENT RESOURCES

Ali Montazar, Irrigation and Water Management Advisor, UCCE Imperial and Riverside Counties

The reference evapotranspiration (ET_o) is derived from a well-watered grass field and may be obtained from the nearest CIMIS (California Irrigation Management Information System) station. CIMIS is a program unit in the Water Use and Efficiency Branch, California Department of Water Resources that manages a network of over 145 automated weather stations in California. The network was designed to assist irrigators in managing their water resources more efficiently. CIMIS ET data are a good guideline for planning irrigations as bottom line, while crop ET may be estimated by multiplying ET_o by a crop coefficient (K_c) which is specific for each crop.

There are three CIMIS stations in Imperial County include Calipatria (CIMIS #41), Seeley (CIMIS #68), and Meloland (CIMIS #87). Data from the CIMIS network are available at: http://www.cimis.water.ca.gov/. Estimates of the average daily ET_o for the period of May 1st to July 31th for the Imperial Valley stations are presented in Table 1. These values were calculated using the long-term data of each station.

Table 1. Estimates of average daily potential evapotranspiration (ET_o) in inch per day

Station	May		June		July	
	1-15	16-31	1-15	16-30	1-15	16-31
Calipatria	0.27	0.29	0.31	0.32	0.32	0.31
El Centro (Seeley)	0.29	0.31	0.34	0.36	0.33	0.31
Holtville (Meloland)	0.29	0.31	0.33	0.34	0.32	0.31

For more information about ET and crop coefficients, feel free to contact the UC Imperial County Cooperative Extension office (442-265-7700). You can also find the latest research-based advice and California water & drought management information/resources through link below:

http://ciwr.ucanr.edu/.