March 4, 2021

To: Doug Whitener, Dewhops Enterprises LLC

Fr: Tracy D. Miller, CCA, PCA
Mid Valley Ag Services Agronomist & Independent PCA with ValleyAg Consulting Services

RE: Summary report of a 3-year trial investigating the use of Twin N microbes in commercial organic almond production.

Trial Summary Report

Evaluation of Twin N microbes in Organic Almond Production

Background: Mid Valley Agricultural Services was introduced to Twin N from Mapleton Agri Biotec Pty Ltd in Queensland, Australia in the fall of 2017 by Doug Whitener with Dewhops Enterprises LLC in Yakima, WA. Twin N microbes are selected from high-performance *Diazotroph* bacteria that fix atmospheric nitrogen gas into plant-available nitrogen. The product is made for both conventional and organic crop production. It is OMRI listed. The manufacturer claims that it is well-suited for use in conventional farming in situations where growers want to reduce nitrogen inputs while maintaining or increasing profits, or organic production where growers want to improve their nitrogen nutrition and enhance crop growth and yield. The manufacturer states that Twin N microbes improve crop performance by three main mechanisms:

1. Converting N_2 gas from the air into a steady supply of plant available N through the entire crop season. The manufacturer states that nitrogen fixation provided by Twin N microbes occurs through two processes. First, some of these nitrogen fixing microbes reside in the soil environment within the rhizosphere and will fix atmospheric nitrogen as air is pushed into the soil root zone through pore spaces. Second, other microbes are absorbed by the plant roots, and are then mobilized through the xylem tissues to the leaves where they live as endophytes. As a plant's leaves exchange gases with the outside environment, these endophytes extract N_2 from the atmosphere and convert it into usable plant nitrogen in an ammonic form that can readily be converted to amino acids and proteins.
2. Produces larger, more efficient root systems due to the production of Plant Growth Factors (PGFs) that give improved capture of applied N fertilizers, aka improved N use efficiency.
3. Improvement of soil health and soil structure. That is, long-term use of Twin N lowers soil disease pressure and builds soil carbon. Twin N microbes also assist in mobilizing fixed soil Phosphorus.

Trial Summary: Mid Valley Ag's Agronomic Services team felt that such a product could be a real game-changer in organic production, and believed that establishing a trial in this type of crop ecosystem would

provide the best opportunity to see what Twin N could actually do. In the spring of 2018, we located a mature, organic almond orchard site in southwestern Merced County located near Gustine, CA to conduct this trial. The orchard is a 35-acre site that was divided into two separate irrigation sets – one to irrigate the west 17.5 acres and the other to irrigate the east 17.5 acres. The orchard was approximately 12 or 13 years old at the initiation of the trial in April 2018, and it is made up of three varieties within the planting: Nonpareil (50%), Aldrich (25%) and Monterey (25%). All varieties within this almond orchard are being grown on Viking rootstock, which is a complex peach x almond hybrid that also includes some apricot and plum parentage. The orchard spacing is 22 feet by 16 feet, and there are approximately 124 trees per acre. At the start of the trial, the orchard was irrigated only with Fan-Jet micro-sprinklers. Later in 2018, the grower also installed double-line drip irrigation tubing, which has become the primary method of irrigation and fertigation of the Twin N microbes since that time.

The UC Davis web soil survey information for this location reveals that the entire orchard is of the same soil type. It is made up of 85% Stanislaus Clay Loam formed through alluvial fans, along with five other soil types that evenly make up the remaining 15% of this soil. This soil is well drained, and contains gravel in some areas. Most of the gravel was found in the west half of this orchard. The grower had informed us before we began the trial that the west half of the field was the weaker half, and that the yields from that side of the orchard were historically lower than those from the east half of the orchard. It was suggested that we treat the west side of the orchard with the Twin N to see if the product could increase the yields to be more "on par" with the eastern half. The grower stated that if the yield in the west half could be increased to match that of the east half, he would know for sure that the product had made a difference. Visually, one can see that the trees are slightly smaller in the west half of the orchard than the east half, confirming that what the grower told us was likely true.

The grower's standard fertilization program that was applied to the entire orchard throughout the trial period consisted of fall-applied organic chicken compost, followed by in-season soil applications of an organic 3-2-2 protein hydrolysate, and semi-frequent in-season foliar applications of a 16-0-0 plant protein hydrolysate nitrogen. Soil applications also included organic sulfate of potash applications. In-season micronutrient fertilizers were also applied to the foliage and the soil as needed across the entire field.

At the start of the trial, we determined that we wanted to measure the effects of Twin N on soil nitrogen content (e.g., NO_3-N, NH_4-N), total leaf tissue nitrogen, overall tree health/vigor, foliar disease susceptibility, kernel size and weight, shriveled nuts, "double" nuts, and total harvested yields. We selected 40 trees from each half of the orchard to collect soil and leaf samples from on a regular basis throughout each year of the trial. These 40 trees were divided into 4 groups of 10 trees that were selected in the NW, NE, SW, and SE quadrants of each half of the orchard.

The first application of Twin N took place in April 2018, using the recommended rate of 0.2 grams per acre. (Each gram of product contains 75 billion colony forming units (cfu's) or 7.5×10^{10} cfu's.) The freeze-

dried microbes were was mixed up in a 1-quart bottle of clean water, and then added to another batch tank of approximately 100 gallons for injection by fertigation. The first application in April 2018 was applied through the Fan-Jet sprinklers, but all later applications were applied through the double-line drip hoses. The product was applied alone each time it was applied. One application of Twin N was applied at this rate every spring and fall from April 2018 through the fall post-harvest period of 2020.

Trial Results:

- Soil Analytical Results: Soil samples were collected each spring and fall of 2018 and 2019, and in the spring of 2020 from each of 10 ten trees located within the four quadrants of each half of the orchard for the purpose of measuring soil nitrate-nitrogen and ammoniacal-nitrogen present within the top 13.3 inches. There were no significant numerical differences in the levels present, as seen below. On average for each period of soil sampling at any given time, there was only a difference of 3.08 lbs. of nitrogen per acre between the treatments with the greater number being in the Twin N treatment. We do not feel this is enough of a measurable difference to necessarily attribute the increase to the Twin N microbes.

Average of 40 soil samples collected over 3-year trial period.

	Avg. NO_3-N	Avg. NH_4-N	Avg. Total N	Avg. Lbs. of N present in the top 13.3" of soil
Twin N:	6.31	4.69	10.99	43.96
UTC:	5.79	4.43	10.22	40.88

However, in the 3rd year of the trial, we did see some interesting soil nitrogen levels that might argue that Twin N microbes will build soil nitrogen levels over time. The following is a comparison of 4 soil samples from the Twin N treatment and 4 from the untreated half of the orchard:

Average of 8 soil samples collected on April 21, 2020

	Avg. NO_3-N	Avg. NH_4-N	Avg. Total N	Avg. Lbs. of N present in the top 13.3" of soil
Twin N:	6.00	5.30	11.30	45.2
UTC:	4.50	4.05	8.55	34.2

- Leaf Tissue Analytical Results: Leaf sample collection began just over 2 months after the first application of Twin N was applied. Samples were collected 10 times over the course of this trial from June of 2018 through the summer of 2020 from four locations (quadrants) within each half of the orchard. Each quadrant had 10 designated trees from which samples were collected. A total of 80 individual leaf samples were collected in all for the purpose of measuring leaf nitrogen levels and observing what effect, if any, the Twin N microbes may have had on any other plant nutrients. The following is a list of nutrients analyzed in the leaf tissues for each collection: N, S, P, K, Mg, Ca, Na, Fe, Al, Mn, Cu, and Zn. From the beginning of the sampling in June 2018, we observed leaf nitrogen levels to be about 0.1 – 0.15% greater in the Twin N treated side of the

orchard compared to the control. In the end, Twin N treated trees had about 7% more nitrogen in them than untreated trees over the entire trial period. This probably is not significant, but what gives credible support that Twin N was making a difference was the fact that the combined average of all four samples from each of the 10 sample periods was never lower in the Twin N treatment than in the untreated part of the field. Twin N treated trees showed higher leaf nitrogen levels 100% of the time.

	Total Avg. N
Twin N	2.58
UTC	2.41

Twin N trees average 0.17% more N in leaf tissues over 3 years.

Avg. % Leaf Nitrogen for each tissue sample period

	6/21/18	7/26/18	8/30/18	10/22/18	4/1/19	6/24/19	7/24/19	9/16/19	4/21/20	7/14/20
Twin N (Avg)	2.55	2.44	1.96	1.84	4.01	2.72	2.45	1.72	3.08	3.02
UTC (Avg)	2.45	2.31	1.86	1.74	3.89	2.65	2.38	1.66	2.79	2.37

Three other nutrients showed moderate average differences between the treatments:

- ➔ **Potassium:** Twin N treated trees were about 2.5% greater than the UTC.
- ➔ **Magnesium:** Twin N treated trees were about 14% less than the UTC.
- ➔ **Zinc:** Twin N treated trees were about 10% less than the UTC.

All other nutrient levels were very close to each other between the treatments and showed no significant numerical differences. We did not observe an increase in leaf tissue phosphorus levels to support the notion that these microbes help with phosphorus solubilization or mobilization.

- Overall Tree Health/Vigor: We did not observe significant differences in tree growth during this trial in terms of shoot growth or overall tree vigor. However, we did notice that the leaf size was generally larger and of better color in the Twin N treatment each time we collected leaf samples.

- Foliar Disease Observations: No disease was observed in 2018 or 2019, but in 2020 there was a significant outbreak of Leaf Rust disease. Twin N treated trees did not show any greater resistance or tolerance to this disease; in fact, there may actually have been greater incidence of rust disease in the part of the field treated with Twin N.

- Harvest Quality Measurements: When this trial began in April 2018, the crop set was already determined so we did not believe that an application Twin N at that time was likely to make a significant difference in that year's yield. Instead, it seemed most logical that an improvement in yield would most likely be seen in year 2 or 3. For harvest 2018, we planned to simply count the number of Jackrunner shuttle/bank-out loads by variety that were taken from each side of the orchard during harvest to give us a rough comparison. Unfortunately, this data was not collected.

As harvest approached in 2019, we again attempted to measure yield differences by either counting bank-out loads or by literally weighing each bank-out load using a set of DOT scales that we had on hand. Unfortunately, the 2019 harvest happened once again without any data collection. In 2020, we were determined to collect the data as best we could, and we did.

The standard harvest process for this grower and this orchard begins with shaking the Nonpareil variety in mid-August. After the nuts have dried on the ground for sufficient time, they are swept into windrows. Next, each windrow is conditioned to remove as much dirt, organic residue, and sticks as possible; what is left behind is a clean windrow of inshell almonds with or without the hull. Once the windrows were conditioned, we collected a full 3-gallon bucket of almonds from the Twin N treated side and the untreated side of the orchard. This was done by walking a diagonal pattern across the entire field while sampling a couple handfuls of nuts from every couple tree rows. These 3-gallon samples of nuts were then split into 4 separate subsamples that were then analyzed to determine 1) percent meat weight or crack-out %, 2) kernel weight, 3) percent double kernels, and 4) percent shriveled nuts. This process was repeated again at the time of the Aldrich and Monterey varieties' harvests. Below is a summary of this data:

Mid Valley Agricultural Svc, INC

[2020 Nonpareil var. subsample harvest data]

Twin N 2020

Trial ID: mva2020.twinn Location: Santa Nella Trial Year: 2020
Protocol ID: mva2020.twinn Investigator: Ben Duesterhaus
Project ID: Almond Fertility Study Director:
Sponsor Contact:

Trt No.	Treatment Name	Rate	Rate Unit	Plot	1	2	3	4
	Crop Type, Code				C PRNDU	C PRNDU	C PRNDU	C PRNDU
	Crop Name				Sweet almond	Sweet almond	Sweet almond	Sweet almond
	Description				% Meat Weight	Kernel Weight	Doubles	Shrivels
	Rating Date				Aug-26-2020	Aug-26-2020	Aug-26-2020	Aug-26-2020
	Part Rated				NUT C	NUT C	NUT C	NUT C
	Rating Type				WEDRCL	WEDRCL	WEDRCL	WEDRCL
	Rating Unit				%	g	%	%
	Number of Subsamples				4	4	4	4
	Data Entry Date				Aug-26-2020	Aug-26-2020	Aug-26-2020	Aug-26-2020
1				101	21.590	1.060	0.198	3.280
				Mean =	21.590	1.060	0.198	3.280
2	Twin N	1pt/100 gal		102	21.035	1.093	0.390	1.358
				Mean =	21.035	1.093	0.390	1.358

Crop Type, Code
C = EPPO species (Bayer) codes
PRNDU, BSTO, Prunus dulcis, Sweet almond = US
Part Rated
NUT = nut
C = Crop is Part Rated
Rating Type
WEDRCL = weight dried and cleaned
Rating Unit
% = percent
g = gram

Twin N Almond Trial 2020 Aldrich sub-sample Harvest Data

2020 Aldrich variety sub-sample harvest data

Sample	Gross Wt. (grams)	Kernel Count	Kernel Wt. (g)	# of Shrivels	# of Doubles	# insect damage	% Kernel Wt.	Kernel Wt. in Grams	% Shrivels	% Doubles	% Insect damage
UTC 1	671.1	265	217.5	2	3	2	32.4	0.8	0.8	1.1	0.8
UTC 2	679.4	276	222.9	2	3	0	32.8	0.8	0.7	1.1	0.0
UTC 3	679.8	271	231.5	3	2	0	34.1	0.9	1.1	0.7	0.0
UTC 4	680	269	231.1	4	3	1	34.0	0.9	1.5	1.1	0.4
Twin N 1	680.2	251	217.5	4	2	1	32.0	0.9	1.6	0.8	0.4
Twin N 2	677.7	266	232	5	4	1	34.2	0.9	1.9	1.5	0.4
Twin N 3	679.4	246	213.9	7	3	1	31.5	0.9	2.8	1.2	0.4
Twin N 4	678.3	246	216.3	0	1	2	31.9	0.9	0.0	0.4	0.8

Monterey Twin N Data

2020 Monterey variety sub-sample harvest data

Treatment	Subsample	Gross	Net Wt	% Nut Wt.	Kernels	Avg. Kernel Weight in Grams	% Shrivel	% Double	% Insect	#Shrivels	# Doubles	# Insect
Twin N	1	456.4	127.6	27.96	74	1.7	5.4	8.1	1.4	4	6	1
Twin N	2	455.5	125.7	27.60	74	1.7	2.7	8.1	4.1	2	6	3
Twin N	3	451.2	138.9	30.78	83	1.7	4.8	8.4	2.4	4	7	2
Twin N	4	452	118.4	26.19	71	1.7	1.4	8.5	2.8	1	6	2
UTC	1	456	102.8	22.54	64	1.6	4.7	7.8	3.1	3	5	2
UTC	2	457.3	113.9	24.91	71	1.6	4.2	8.5	2.8	3	6	2
UTC	3	458.8	116.4	25.37	66	1.8	1.5	9.1	1.5	1	6	1
UTC	4	458	129.3	28.23	78	1.7	6.4	10.3	3.8	5	8	3

Below is a chart showing a summary of the mean harvest quality values taken from the 4 individual sub-samples for each variety. The values do not appear to indicate that Twin N made a significant impact on % meat weight (aka % kernel weight or crack-out %), kernel wt., % doubles, % insects. The Nonpareil data does suggest that Twin N may have possibly reduced the % shrivels compared to the untreated trees.

Mean Harvest Quality Values

	% Meat Wt.	Kernel Wt. (g)	% Doubles	% Shrivels	% Insects
Nonpareil (TwinN)	21.035	1.093	0.390	1.358	No Data
Nonpareil (UTC)	21.590	1.060	0.198	3.280	No Data
Aldrich (TwinN)	32.40	0.90	0.975	1.575	0.50
Aldrich (UTC)	33.33	0.85	1.000	1.025	0.30
Monterey (TwinN)	28.1325	1.700	8.275	3.575	2.675
Monterey (UTC)	25.2625	1.675	8.925	4.200	2.800

- Harvest Yield Measurements: For the Nonpareil and Aldrich variety harvests, the crop from the treated and untreated sides of the orchard were picked up separately, put into separate hopper trailers, and then trucked to the huller/sheller facility where individual gross weights were taken for the individual trailers in order to separate the crop by each treatment. Trailer tare weights were then subtracted from these gross weights to determine the net weight of the incoming un-hulled/unshelled crop. The percent kernel weights determined from the sub-samples (see chart above) were then multiplied by these net weights to provide a calculated estimate of the total kernel yield for each side of the field. The estimated total kernel yield values were then divided by the number of acres in each half of the field to determine the estimated per acre kernel yield.

  After the huller/sheller facility weighed the incoming crop, they then mixed the crop from both sides of orchard and processed the crop as a single lot to provide a Total Actual Shelled Weight (Lbs. of Kernels) for the entire orchard. To determine the actual yield for each half of the orchard, the total kernel weight was then multiplied by the calculated percent of yield for each half of the orchard that was previously determined when calculating the estimated yield. See charts on the following page that show estimated yields and actual yields, and the yield differences between the treatments.

Nonpareil Variety, Harvest 2020	Gross Wt. (lbs)	Tare Wt. (lbs)	Net Wt. (lbs)	% Kernel Weight	Calculated Shelled Wt. (lbs)	Percent of Yield (W vs. E)	Est. Meat Wt. per Ac.
Twin N (8.75 Ac):	180,820.00	77,300.00	103,520	21.035%	21,775.43	55.45%	2488.6
UTC (8.75 Ac):	135,720	54,700.00	81,020	21.590%	17,492.22	44.55%	1999.1
		Total Calculated Shelled Wt. (lbs):			39,267.65	**Diff:**	**489.5**

Total Actual Shelled Nonpareil Wt. (kernel lbs.)	x Percent of Yield (W vs. E)	Calculated Shelled Wt. (lbs.)	Actual Meat Wt. per Ac.	
47,156.0	55.45%	26,149.8	2988.6	← Twin N
	44.55%	21,006.2	2400.7	← UTC
		Yield Diff:	**587.8**	

Nonpareil Yield: Our harvest weight estimates for this variety were 2,488.6 lbs./acre for the Twin N treated side of the orchard and 1,999.1 lbs./acre for the untreated side, bringing a difference of +489.5 lbs./acre in favor of the Twin N treatment. However, the processor reported that there were actually 47,156 total Nonpareil kernel pounds harvested from this orchard. After multiplying the calculated "Percent of Yield (W vs. E)" values by the total actual kernel pounds from the processor, we determined the actual yields to be 2,988.6 lbs./acre for the Twin N treatment and 2,400.7 lbs./acre for the untreated side. This is a difference of +587.8 lbs./acre in favor of the Twin N treatment.

In December of 2020, shelled Nonpareil almond crop prices to the grower were between $1.60 - $2.10 per kernel pound, or an average of $1.85/kernel pound. Organic almond crop prices are usually about double that of conventional crop prices, meaning that organic crop prices were probably around $3.70/kernel pound for this same period. At this grower price, the use of Twin N increased the grower's gross income on this variety by $2,175 per acre. This amounts to a return on investment of 3,525%.

Aldrich Variety, Harvest 2020	Gross Wt. (lbs)	Tare Wt. (lbs)	Net Wt. (lbs)	% Kernel Weight	Calculated Shelled Wt. (lbs)	Percent of Yield (W vs. E)	Est. Meat Wt. per Ac.
Twin N (3.85 Ac):	66,540	26,720	39,820	0.33325	13,270.02	51.68%	3,446.8
UTC (4.375 Ac):	64,440	26,140	38,300	0.324	12,409.20	48.32%	2,836.4
		Total Calculated Shelled Wt. (lbs):			25679.2	**Diff:**	**610.4**

Total Actual Shelled Wt. (kernel lbs.)	x Percent of Yield (W vs. E)	Calculated Shelled Wt. (lbs.)	Actual Meat Wt. per Ac.	
23,994.00	51.68%	12,399.2	3,220.6	← Twin N
	48.32%	11,594.8	2,650.2	← UTC
		Yield Diff:	**570.3**	

Aldrich Yield: Our harvest weight estimates for this variety were 3,446.8 lbs./acre for the Twin N treated side of the orchard and 2,836.4 lbs./acre for the untreated side, bringing a difference of +610.4 lbs./acre in favor of the Twin N treatment. However, the processor reported that there were actually 23,994 kernel pounds harvested from this orchard for this variety. After multiplying the calculated "Percent of Yield (W vs. E)" values by the total actual kernel pounds from the processor, we determined the actual yields to be 3,220.6 lbs./acre for the Twin N treatment and 2,650.2 lbs./acre for the untreated side. This is a difference of +570.3 lbs./acre in favor of the Twin N treatment.

In December of 2020, shelled 'California' variety almond crop prices to the grower were between $1.57 - $1.64 per kernel pound, or an average of $1.605/kernel pound. Organic almond crop prices are usually about double that of conventional, meaning that organic crop prices were probably around $3.21/kernel pound for the same period for this variety. At this grower price, the use of Twin N increased the grower's gross income on the Aldrich variety by $1,830.66 per acre. This amounts to a return on investment of 2,951%.

Monterey Yield: When it was time to harvest this variety, there was some confusion by the ranch foreman in that he thought he only needed to count the number of Jackrunner bank-out carts from each half of the field. Consequently, the crop did not get put into separate trailers to be weighed separately, but it was mixed. However, in speaking to the grower and others in the industry, we

determined that each full load of a Jackrunner bank-out would hold an estimated 1,750 kernel pounds of crop in addition to the other harvested material (hulls, shells, sticks, and other field debris). This value was determined in this manner:

> *Jackrunner carts hold approximately 7,000 gross pounds of harvested crop, which includes hulls, shells, kernels, sticks, rocks, etc. Applying a kernel crack-out percentage of 20 – 30% to this 7,000 lb. gross total, this amounts to 1,400 – 2,100 kernel pounds of meats per cart. We took the average of this range or 1,750 kernel pounds of almond meats as the number to use in our calculations.*

Using this 1,750-lb. value, we took the number of bank-out loads, compared it to the planted acres of Monterey trees in each side of the field, and calculated the following yield estimates for the Twin N and untreated sides of this orchard:

									Diff.
Monterey var.:	Est. Wt/Cart	Units	Twin N Carts	Twin N Total Wt.	Twin N Yield	UTC Carts	UTC Total Wt.	UTC Yield	**(lbs/A)**
West (4.9 Ac):	1750	Lbs	5	8750	1786	---	---	---	**266**
East (4.375 Ac):	1750	Lbs	---	---	---	3.8	6650	1520	

A total of 5 Jackrunner bank-out carts of un-hulled/unshelled Monterey crop was removed from the Twin N treated side of the orchard, while 3.8 bank-out carts were removed from the untreated side. Using the predetermined value of 1,750 kernel pounds per cart, we estimated the yields to be 1,786 lbs./acre for the Twin N treatment and 1,520 lbs./acre for the untreated side. This amounts to a positive difference of 266 lbs./acre in favor of the Twin N treatment. Although this yield advantage is about half of that shown in the Nonpareil and Aldrich varieties, it is proportional to the total lbs./acre of harvested kernels. This variety had a large crop in 2019 that put a significant strain on the carbohydrate reserves within the trees, so it was expected that there would be a lighter crop yield in 2020.

In December of 2020, shelled Monterey variety almond crop prices to the grower were between $1.57 - $1.64 per kernel pound, or an average of $1.605/kernel pound. Organic almond crop prices are usually about double that of conventional, meaning that organic crop prices were probably around $3.21/kernel pound for the same period. At this grower price, the use of Twin N increased the grower's gross income on the Monterey variety by $853.86 per acre. This amounts to a return on investment of 1,323%.

Twin N was also applied to another nearby organic almond orchard in March of 2020 to observe if it was possible for these nitrogen-fixing microbes to increase yield following just a single spring application. This is a mature orchard that is approximately 17 years old. It has three varieties (Nonpareil, Sonora, Monterey) that are planted on Brights 5 rootstock, a peach x almond hybrid. We estimated yield in this block by once again counting Jackrunner carts. We collected data for

the Nonpareil and Monterey varieties, but overlooked getting the data from the Sonora variety. Yields were estimated as follows:

Variety:	Est. Wt/Cart	Units	Twin N Carts	Twin N Total Wt.	Twin N Yield/A	UTC Carts	UTC Total Wt.	UTC Yield/A	Diff. (lbs/A)
Nonpareil (7.5Ac):	1750	Lbs	16	28000	3733	14	24500	3267	**467**
Sonora (3.75Ac):	1750	Lbs	---	#VALUE!	#VALUE!	---	#VALUE!	#VALUE!	---
Monterey (3.75Ac):	1750	Lbs	5	8750	2333	4.5	7875	2100	**233**

After just one application, the Twin N treated Nonpareil trees produced 467 kernel lbs./acre more than the untreated Nonpareils, while the Twin N treated Monterey trees produced 233 more kernel lbs./acre than the untreated Monterey trees. If the single spring application of Twin N is truly the reason for these yield increases, then this amounts to an ROI of 5,660% for the Nonpareil variety and a 2,393% for the Monterey variety. This single year data supports the findings in our 3-year study that Twin N can provide a substantial yield increase in organic almond orchards.

Trial Conclusion: Our findings show that the use of Twin N microbes in commercial organic almond production systems can provide significant yield increases and financial benefits, especially in situations where orchards cannot access enough available nitrogen to meet the demand of the new kernels that set during the bloom period. Our data does not show that Twin N microbes increase soil ammonium or nitrate levels, but it just may be that nitrogen being fixed in the soil is put in a different form other than ammonium or nitrate. Nevertheless, leaf tissue analyses seem to indicate that Twin N is supporting higher overall nitrogen levels in the trees, confirming the claims that Twin N microbes enter plants as endophytes and serve as nitrogen-fixing agents within the plant as the plants exchange gases with the atmosphere.

More work needs to be done to determine whether Twin N microbes can provide yield benefits in non-organic commercial almond orchards, and if so, to determine on what parameters these microbes can successfully be used. It is known that the use of excess conventional nitrogen fertilizers can suppress beneficial soil bacteria, so growers will likely need to determine how best to merge these two fertilization technologies to get maximum benefit.

It is likely that Twin N microbes could serve a key role in helping California growers meet the requirements of the Irrigated Lands Regulatory Program (ILRP) by helping them reduce their nitrogen application rates while still supplying a means by which their crops can extract the nitrogen they need from the atmosphere. Without a doubt, this product would likely help all growers improve their Nitrogen Use Efficiency (NUE) on their farms.

Tracy D. Miller, CCA, PCA
Ph. 209-480-3320
Agronomic Services Dept.
Mid Valley Agricultural Services, Inc.