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Management Practices for Drip Irrigation in Baca County, Colorado

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James Valliant, Irrigation Specialist

Colorado State University
June 2007

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MANAGEMENT PRACTICES FOR DRIP IRRIGATION IN BACA COUNTY, COLORADO

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SUMMARY

The Ag Professional + Producer project was designed to help establish management practices for drip irrigation on onions in Baca County, Colorado that would improve germination, emergence and stands with resulting increase in yield, quality and returns. Due to a declining water table with diminishing pumping volumes, agricultural producers are looking for ways to improve irrigation efficiency, lower labor and production costs while maintaining and/or increasing yields and returns.

Three major problems confront agricultural producers, (1) tillage methods to maintain beds over subsurface driplines in the same location, (2) a means of protecting the small emerging onion plants from blowing sands in an area with high average winds, and (3) ways to improve movement of water from subsurface driplines to the shallow planted onion seed for adequate germination and emergence.

A specially designed disk was purchased and used to maintain the beds as close as possible to the same location each year because of the subsurface driplines under the beds. Tillage also had to be shallow enough to prevent disking the subsurface driplines. This disk is an Arizona Drip Wide Bed Disk.

In the spring of 2005, oats were planted on the middle of the bed and in the furrow, and then in the spring of 2006, a mix of oats, triticale and wheat were planted on the middle of the bed combined with roughing of the furrows. Both of these practices substantially reduced damage from blowing sand resulted in excellent stands of onions from seed.

AgriBlend, a combination of HYDROGEL, a water-absorbing polyacrylamide, and Zeolite, a water-transporting volcanic material, was incorporated in the bed in an attempt to improve germination of the small, shallow planted onion seed. With well-timed rains in 2005 and 2006, germination in the treated and untreated areas produces similar stands. In 2005, the AgriBlend treated area and the untreated area produced similar yields of 986 and 944 50-lb bags of onions per acre, respectively. However, in 2006, the AgriBlend produced a significantly higher yield of 955 50-lb. bags per acre compared to 843 bags harvested from the untreated area. The AgriBlend area also produced a significantly higher number of jumbo-sized onions, 628 compared to 510 50-lb. bags per acre. Unfortunately, a bacterial soft rot infected the onions in 2006 and prevented commercial harvest.

INTRODUCTION

The Baca Conservation District teamed up with the Natural Resource Conservation Service (NRCS) to offer irrigators an opportunity to install subsurface drip irrigation (SDI) systems with a 75% cost-share incentive of $900 per acre because of their concern for the rapid dewatering of the groundwater aquifer in southeast Colorado. The dewatering of the aquifer is resulting in lower yields and financial returns from crops such as corn, grain sorghum, sunflowers and wheat.

The Ogallala Aquifer has been dewatered in many areas and the remaining areas are being rapidly dewatered. The underlying Dakota Aquifer is a sandstone formation where amounts of water are affected by the size of the crevices in the limestone and precipitation. The region averages 15 inches of precipitation annually and about 75% occurs between March and September. Rainfall during the growing season is very erratic and unpredictable, varying from as little as 8 inches to as high as 30 inches. Because of the unreliability of amounts and timing of rainfall, crops need to be supplemented with ground water for optimum crop production and financial returns.

Driven by the need to use the remaining groundwater more efficiently and by the high cost of pumping, producers are looking for a more efficient and profitable irrigation system for producing these crops as well as some high-value crops, such as cantaloupe, onions, squash and other vegetables.

SDI applies water to crops in small amounts with little waste when managed properly. And, water can be applied in amounts to match the crops' water-use rates and can be as efficient as 98%. This is because the water is emitted below the ground surface and not subject to surface runoff and has limited evaporation. Most of the water lost by SDI is due to over-irrigation.

Furrow irrigation is used on most of the land, but recently, more center pivot sprinkler systems have been installed in an effort to use the groundwater more efficiently. Furrow irrigation is about 50% efficient as excessive winds in the region results in high levels of evaporation. These same winds can severely affect patterns of the center pivot irrigation systems and reduce irrigation efficiency. Both of these methods of irrigation require larger amounts of pumped water because of the inefficiencies of the systems under these environmental conditions when compared to SDI.

With an average elevation of approximately 4,000 feet, the area is subject to high winds. Because of these high winds, wind generators with three (113 foot) blades have been installed on several hundred acres. These winds cause blowing of the predominately loam soils and can quickly destroy young crops.

See Figure 1 for location of Baca County in Colorado.

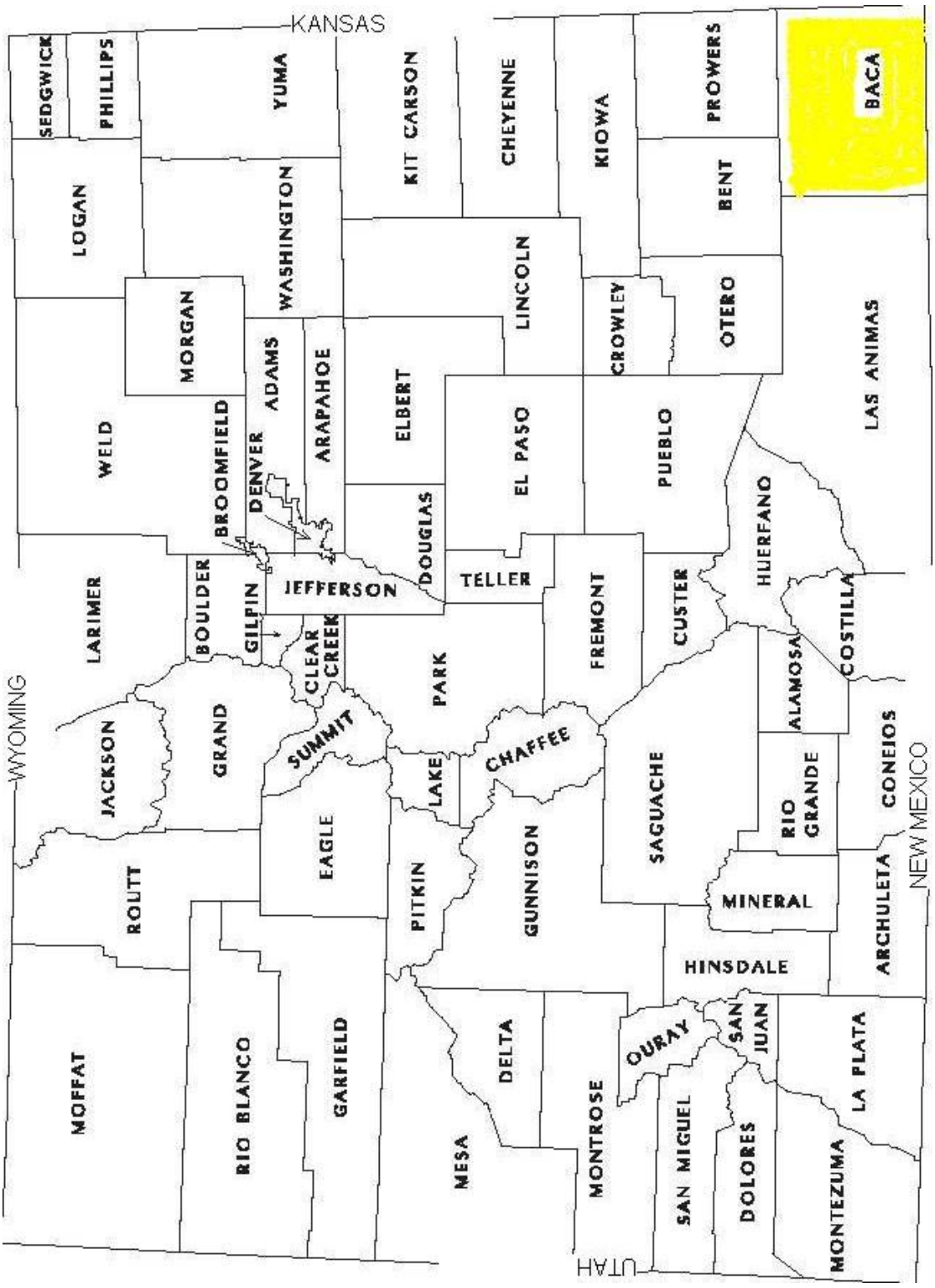

Figure 1. Location of Baca County in Colorado.

Subsurface drip irrigation (SDI) is a means of conserving the ground water supply that some of the more innovative producers began installing in 2003 with the help of the cost-share incentive. Even with the cost-share incentive, SDI is a costly and new method of irrigation to all of the producers in the area. As a result, many producers are reluctant to make the investment in SDI without knowing more about management of these systems.

Because of the high cost of installation, producers are looking at high-value, high-risk crops such as onions, cantaloupe and other vegetables as a means of increasing returns from the land. And, because most of these crops are hand-harvested, the labor coming in for the harvest can help to improve the local economy through increased economic activity.

Producer Information

Brent Morris is a young farm operator in Baca County. He and his wife, Penni, own and rent approximately 1600 acres of non-irrigated, dryland farm ground and rent 1780 acres of irrigated farmland. Dryland crops include wheat, grain sorghum and sunflowers. There are presently 1250 acres under center pivot irrigation and only 90 acres still being furrow irrigated because of the inefficiency of furrow irrigation and the high labor costs. Crops grown under irrigation are corn, grain sorghum, onions, sunflowers and wheat.

Reduced tillage, using stubble-mulching sweeps to maintain crop residue on the soil surface, and strip-till, planting on the previous year's beds, are some of the conservation practices being used to help prevent soil moisture loss and reduce soil erosion. This conservation of soil moisture helps reduce irrigation needs and will help prolong the groundwater supply providing for a more sustainable agriculture in the region.

In 2003, a 170.1-acre drip irrigation system was installed with NRCS cost share and technical support and the farm started growing cantaloupe, squash and onions. It was felt that these high-income crops were needed to justify this investment. The driplines were installed from 6 to 8 inches below the soil surface using 30-inch spacing of the driplines on 80-inch beds.

Mary Kay Higgins, the 75 year-old landowner, is a partner in the drip irrigation operation and is considered an innovator for agriculture in the area. With the drip irrigation system located next to the major highway in the area, interested producers are closely watching the success of this system.

Management Problems

Adverse weather and inexperience with the drip system led to several management mistakes in 2003. Strong winds, normal to the area, caused excessive damage to the young, emerging seedlings and young plants due to blowing sand and this severely reduced stands that resulted in reduced yields. Cover crops are needed to prevent wind damage to these emerging and young plants. The high winds in the area can severely

affect direct-seeded and transplanted onions as well other crops, especially in the seedling stage.

Over-irrigation was another management problem caused by planting the seed too far from the driplines and then trying to soak the water over to the seed for germination. This resulted in water moving six feet or more and below the effective root zone of onions and cantaloupe. This water was lost due to deep percolation.

Equipment for tilling the beds without damaging the driplines is an important part of drip irrigation system management. The driplines were installed at varying depths throughout the field causing the need for fairly shallow tillage of the beds.

Situation for Production

Brent Morris of Springfield, Colorado, as the producer, consented to work with Jim Valliant, Irrigation Specialist, and with Colorado State University on a Western Sustainable Agriculture Research and Education grant. The grant was designed to work with both onions and cantaloupes, but the market for growing cantaloupes was not available for 2005 or 2006.

Brent provided two drip zones to be planted to onions in 2005 and one zone and part of another in 2006. One of the zones would be treated with AgriBlend, a blend of 40% HYDROGEL and 60% Zeolite. HYDROGEL is a water-absorbing cross-linked molecular structure polyacrylamide and Zeolite is a water-transporting volcanic material. The Zeolite is used to help move the water toward the seed and the HYDROGEL will absorb the water and hold it in the area of the seed.

DEMONSTRATION GOALS

Minimizing production problems by developing management practices that are adapted to the area was the goal of the project.

Subsurface drip irrigation (SDI) is new to the Baca County area and most of the management practices being used came from other areas.

Because of this need to develop better management for SDI in this region, the following three practices were demonstrated at this site.

a. Tillage methods for preparing the beds are a problem. These beds need to remain in the same location because of the buried driplines, even though the lines were installed with the use of a GPS system. Disking was done with a specially designed disk to remake beds in the same location.

b. With driplines installed approximately eight (8) inches below the soil surface and 30 inches apart on the 80-inch beds, ways are needed to get moisture to the seed for germination. AgriBlend, a combination of

HYDROGEL, a water-absorbing cross-linked molecular structure polyacrylamide, and Zeolite, a water-transporting volcanic material, was used to help get water to the seeds and hold the moisture around the seed and seedling. The HYDROGEL used in this project is similar to that used with seedling trees.

c. Cover crops are needed to prevent wind damage to the emerging and young plants. The high winds in the area can severely affect crops in the seedling stage. Small grains, planted in late winter or early spring, were selected because of cost and availability of chemicals to kill the crop without injuring the seedling onion crop.

There are 27 zones in the drip irrigation system, each connected to a mainline water delivery pipe, and each of these zones is 6.3 acres (170.1 acres). The 6.3 acres in a zone are irrigated with equal amounts of water that are applied to the zone from the main line. Depending on the crop acreage, two or more zones can be irrigated at the same time.

The control center for the SDI system is shown in Pictures 1 and 2.

2005 Cultural Practices

In the fall of 2004, the 80-inch beds were disked twice with the specially-made Arizona Drip Wide Bed Disk to prepare the beds for the 2005 cropping season. The beds were then worked four to five times with a culti-packer.

AgriBlend was applied at the rate of 30 pounds per acre in 2004 on beds to be planted to cantaloupe, which was not planted because weather delayed planting beyond an acceptable planting date. Then on February 15, two rows of oats were planted in the middle of the bed and two rows of oats were planted in the bottom of the furrow. The oats were planted in an effort to reduce sand blowing and damage to the seedling onions.

On March 15, Commeta white onions were planted at the rate of 135,000 seed per acre or about 3- to 4-inch spacing. Three rows, spaced 7 inches apart, were planted over the top of the driplines on each side of the 80-inch bed, about 12 to 14 inches from the center of the bed.

The onions were fertilized with 120 pounds of nitrogen per acre as 32% liquid nitrogen and 70 pounds of P2O5 as 52% phosphoric acid. SELECT herbicide was sprayed at the rate of 10 ounces per acre to kill the oats when the plant height was 6 to 8 inches and for weed and grass control.

The crop was irrigated to maintain good soil moisture throughout the season and a total of 13.6 inches was applied. The onions plants received a severe hail on June 12 while still in the vegetative stage of growth and left just tips showing. Since the plants were still in the vegetative stage, the onions were able to recover with some thinning of stands.

Blowing winds caused many of the furrows to be filled with sand and also caused some thinning of stands. The dead oat stubble did offer some protection from the blowing sand while the plants were still small.

Cultural practices in 2005 were as follows:

1. 05-24-05 Sprayed 10 oz. Select, 1.5 pts. MSO, 3 lbs. Ammonia-Sulfate (AMS) and 20 gals. Water for weed control.
2. 05-24-05 Sprayed 12 oz. Goal and 4 oz. Buctril for weed control.
3. 06-25-05 Sprayed 3.84 oz. Warrior, 1.5 pts. Lannate for thrip control.
4. 06-27-05 Sprayed 16 oz. of Goal for weed control.
5. 06-28-05 Sprayed 16 oz. Chlorine
6. 07-01-05 Sprayed 16 oz. Chlorine
7. 07-01-05 Sprayed 1.32 oz.. Warrior and 1.5 pts. Lannate for thrip control.
8. 07-05-05 Sprayed 16 oz. Chlorine
9. 07-08-05 Sprayed 3.84 oz. Warrior, 1.5 pts. Lannate for thrip control.
10. 07-08-05 Sprayed 10 oz. Select, 1.5 pts. MSO, 3 lbs. Ammonia-Sulfate (AMS) and 20 gals. Water for weed control.
11. 07-21-05 Manual hoeing of weeds.
12. 08-22-05 Manual hoeing of weeds.

Four replications were taken throughout the field in both the AgriBlend treated zone and the untreated zone, selecting locations with uniform stands on September 1. Total field harvest was done on September 12 –14.

Table 1. 2005 Production Cost on Seeded Onions
Brent Morris Farm, Baca County, Colorado

Production Category	Cost - $ /Acre
30 lbs AgriBlend	112.82
Seed, Onion and Oats	243.02
Fertilizer	57.05
Chemicals	324.26
Irrigation-Electricity Cost	131.72
Machine Hire	58.82
Crop Consultant	6.19
Harvest Costs	964.05
Loading and Hauling Costs	402.48
TOTAL	**2,300.41**

2005 Results

Yields calculated from the test plots taken from the AgriBlend treated zone averaged 986 bags per acre (50 pounds per bag), while the untreated zone averaged 944 bags per acre. There was no significant difference at the 10% level based on these results. These yields include only Jumbo, Medium and Pre-pack grades as culls and doubles were very minimal.

Percentage of onion grade also had little or no variation due to the addition of AgriBlend as both zones averaged approximately 62% Jumbos, 36% Mediums and 2% Pre-packs. Visually there appeared to be better stands in the AgriBlend treated zone than in the untreated zone.

Yields from field harvesting averaged 812 bags per acre (50 pounds per bag) with 94% rated acceptable and 6% discarded as culls. Unfortunately, production yields from the two demonstration zones were not kept separately.

The reduction in yield of field harvest as compared to yields from the plots indicate that yields were severely affected by stand and that total zone yields need to be taken to compare the AgriBlend treated zone to the untreated zone. Separate zone yields plan to be taken in 2006 as well as plot yields and plot grading.

Table 2. The Effect of AgriBlend on Seeded Onion Yield and Grade with Sub-surface Drip Irrigation Brent Morris Farm, Baca County, Colorado, 2005.

Treatment	Yield 50# bags/acre	Jumbos 50# bags/acre	Medium 50# bags/acre	Pre-packs 50# bags/acre
Untreated	944	585	340	19
AgriBlend	986	611	355	20

These results indicate that the addition of AgriBlend, HYDROGEL/Zeolite combination, did not affect onion yield or grade in 2005.

Table 3. Returns* based on Yield and Quality of Seeded Onions With Sub-surface Drip Irrigation Brent Morris Farm, Baca County, Colorado, 2005					
Treatment	Jumbos 50# Bags/acre	Returns on Jumbos @ $9/bag	Mediums 50# Bags/acre	Returns on Mediums @ $8/bag	TOTAL Return $/acre
Untreated	944	8,496	340	2,720	**11,216**
AgriBlend	986	8,874	355	2,840	**11,714**
*Based on price after grading. No value placed on pre-packs.					

2006 Cultural Practices

The beds were prepared by disking twice with the specially-made Arizona Drip Wide Bed Disk, from Coolidge, AZ, Pictures 3 and 4. The beds were then worked four to five times with the culti-packer shown in Picture 7.

AgriBlend was applied at the rate of 30 pounds per acre on beds with Gandy Boxes and incorporated with a culti-packer, Pictures 5, 6 and 7. Then, on March 10, a combination of oats, triticale and wheat was planted in the middle of the bed, Picture 10. This combination of small grains was planted in an effort to reduce sand blowing and damage to the seedling onions.

On March 8, Granero white onions were planted at the rate of 135,000 seed per acre or about 3- to 4-inch spacing. Three rows, spaced 7 inches apart, were planted over the top of the driplines on each side of the 80-inch bed, about 12 to 14 inches from the center of the bed, Picture 8 and Figure 2 below.

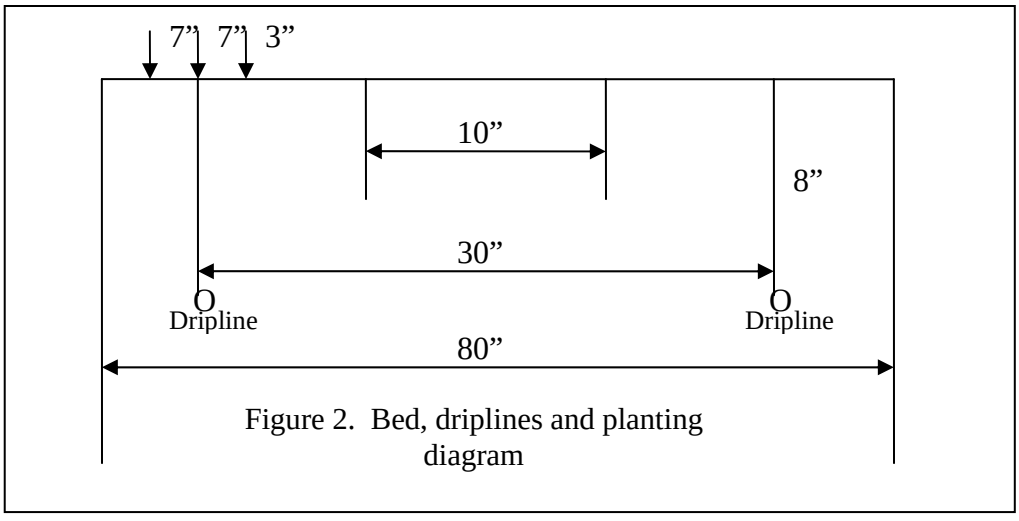

Figure 2. Bed, driplines and planting diagram

The onions were fertilized with 150 pounds per acre of nitrogen as 32% liquid nitrogen and 50 pounds of P2O5 as 52% phosphoric acid through the SDI system. SELECT herbicide was sprayed at the rate of 10 ounces per acre to kill the small grains when the plant height was 6 to 8 inches and for weed control, Picture 11 and 12.

Cultural practices in 2006 were as follows:

1. 04-12-06 Sprayed 2.5 pts. Prowl H20 for pre-emergence weed control.
2. 05-08-06 Sprayed 8 oz. Goal and 10 oz. Buctril for weed control.
3. 05-16-06 Sprayed 10 oz. Select for control of unwanted grass and to kill the small grains planted to reduce sand blowing.
4. 05-17-06 Sprayed 12 oz. of Goal and 10 oz. of Buctril for weed control.
5. 05-29-06 Sprayed 2 gal. Warrior and 7.5 gal. Lannate for thrip control.
6. 06-01-06 Manual hoeing of weeds.
7. 06-10-06 Sprayed 2 gal. Warrior and 7.5 gal. Lannate for thrip control.
8. 06-24-06 Sprayed 2 gal. Warrior and 7.5 gal. Lannate for thrip control.
9. 06-28-06 Manual hoeing of weeds.
10. 06-29-06 Sprayed 10 oz. Select for weed control.
11. 07-18-06 Sprayed Pencozeb and Kocide for disease management.
12. 07-27-06 Applied 3 lb. Mankocide for disease management.
13. 07-28-06 Manual hoeing of weeds.
14. 08-03-06 Applied 3 lb. Mankocide for disease management.
15. 08-10-06 Applied 3 lb. Mankocide for disease management.
16. 08-17-06 Sprayed 24 gal. Dithane and 6.7 gal. Kocide for disease management.
17. 08-23-06 Applied 2 lb. Ridomil Bravo Gold and 3 lb. Mankocide for disease management.

The crop was irrigated to maintain good soil moisture throughout the season and a total of 24 inches was applied.

Table 4. 2006 Production Costs* on Seeded Onions
Brent Morris Farm, Baca County, Colorado

Production Category	Cost* - $ /Acre
30 lbs AgriBlend	112.50
Seed-Onion and Small Grains	250.58
Fertilizer	90.41
Chemicals	493.65
Irrigation-Electricity Cost	92.29
Machine Hire	69.08
Crop Consultant	4.81
TOTAL	**1,113.32**
* Does not include any costs associated with harvest	

Winds caused some blowing sand, but the stands of small grains and roughing up of the furrows prevented significant damage, Pictures 9 and 10. Using both of these practices resulted in excellent stands of seeded onions, Picture 13.
Rains and cold weather were received starting September 1 before the onions could be harvested. As a result, a bacterial soft rot infected many of the onion plants, Pictures 14 and 15. As a result, the crop could not be harvested for commercial sale.

Six replications were taken throughout the field in both the AgriBlend treated zone and the untreated zone on September 25. These yield samples were taken at the same locations in the field in the two zones**. None of the onions were harvested for production due to disease and the crop was a total loss!**

Table 5. The Effect of AgriBlend on Seeded Onion Yield and Grade with Sub-surface Drip Irrigation Brent Morris Farm, Baca County, Colorado, 2006.

Treatment	Yield 50# bags/acre	Jumbos 50# bags/acre	Medium 50# bags/acre	Prepacks 50# bags/acre
Untreated	843	510	333	*
AgriBlend	955	628	327	*

*Prepacks were not weighed in 2006 due to the very small number and market price.

These results indicate that the addition of AgriBlend, HYDROGEL/Zeolite combination, significantly increased seeded onion yield and jumbo grade in 2006.

Table 6. Returns* Based on the Yield and Quality of Seeded Onions With Sub-surface Drip Irrigation Brent Morris Farm, Baca County, Colorado, 2006

Treatment	Jumbos 50# bags/acre	Return on Jumbos @ $10/bag	Mediums 50# Bags/acre	Returns on Mediums @ $10/bag	TOTAL $/acre
Untreated	843	8,430	333	3,330	**11,760**
AgriBlend	955	9,550	327	3,270	**12,820**

*Returns based on yield and grade after grading if the onions **had been** acceptable on the market. Shown only as potential for return.

Jim Valliant, Colorado State University irrigation specialist in Rocky Ford, Colorado as the Ag Professional, took soil and water samples as well as plot yields and conducted the onion grading.

Brent and Penni Morris recorded the cultural practices and financial costs as well as taking timely pictures of these practices throughout the year.

INFORMATION DISTRIBUTION

Two subsurface drip irrigation workshops were held in Springfield, Colorado as part of the demonstration project. The 1st workshop was held on August 11, 2004 and followed with a field trip to the SDI installation at the Brent Morris farm. The 2nd workshop was held in Springfield, Colorado on January 8, 2007 presenting results from the 2005 and 2006 crop years.

A poster program was also presented and discussed at the 2006 Bi-annual Field Day at the Colorado State University Arkansas Valley Research Center in Rocky Ford which was attended by some 120 growers, drip irrigation representatives and other interested persons.

This Final Report with information and pictures of the Demonstration Project will be posted on the Web Page of Colorado State University at: http://www.colostate.edu/depts/prc/pubs/tr07-13.pdf or by e-mail upon request at: James.Valliant@ColoState.EDU.

CONCLUSION

Tilling of the beds with the specially designed wide bed disk appears to be the best way to maintain the beds in the same location above the driplines and to prevent damage to the subsurface drip lines.

Planting of oats in the middle of the beds between the onions and in the furrows or planting of oats, triticale and wheat in the middle of the beds between the onions and roughing of the furrows did reduce wind damage on the young emerging and seedling onion plants. Planting the small grains in February or March allowed for sufficient growth to provide a wind barrier, but did not produce too much foliage to prevent killing of the small grains with chemicals.

The results of the addition of AgriBlend, a HYDROGEL/Zeolite combination, to the soil were not conclusive over the 2-year study period as significant increases in yield and quality was produced only in 2006. Additional demonstration work, under these conditions, are needed to confirm the results of applying AgriBlend on seeded onions using subsurface drip irrigation (SDI).

Many of the groundwater aquifers in Colorado, Kansas, Texas and throughout the southwest are being rapidly dewatered. With fuel costs increasing, water tables dropping and pumping rates diminishing, pumping less water and being able to produce a comparable or better crop with SDI is an economically sound method of irrigation, especially in these windy, arid regions.

Many of these areas are faced with similar situations as in Baca County, Colorado. Use of this project information could help to prolong the life of their groundwater aquifers and sustain their economies.

Picture 1. Housing for control center.

Picture 2. Computer control and filters for drip system.

Picture 3. Arizona Drip Wide Bed Disk.

Picture 4. Arizona Drip Wide Bed Disk.

Picture 5. Gandy Box feeding AgriBlend above driplines.

Picture 6. AgriBlend being fed through fan applicators.

Picture 7. Culti-packer used to work beds and incorporated AgriBlend.

Picture 8. Six rows of onions planted on bed.

Picture 9. Roughing furrows to reduce wind blowing.

Picture 10. Oats, triticale and wheat in middle of 80 inch bed to reduce wind blowing.

Picture 11. Spraying for weed control and killing small grains.

Picture 12. Weeds and small grains dying, but still protecting young onions.

Picture 13. Excellent stand of seeded onions with little damage due to blowing sand.

Picture 14. Onions after cold, damp weather in early September.

Picture 15. Bacterial soft rot caused by cold, damp weather.

Results For : BRENT MORRIS
Location : SD1 ONIONS

	1:1 Soil pH	WDRF Buffer pH	Soluble Salts 1:1 mmho/cm	Excess Lime Rating	Organic Matter LOI-%	Nitrate-N (FIA) ppm N	Nitrate-N Lbs/A	Phosphorus Method ppm P	-Ammonium Acetate- K ppm	Ca ppm	Mg ppm	Na ppm	Ca-P Sulfate ppm S	----------DTPA---------- Zn ppm	Fe ppm	Mn ppm	Cu ppm	Hot Water B ppm	$CaNO_3$ Cl ppm	Sum of Cations me/100g	% Base -----Saturation----- H	K	Ca	Mg	Na
Sample ID : AB6							0-6 in	Mehlich P2																	
84830	7.6		0.85	HIGH	1.5	11.0	20	29	320	4028	308	116	81	0.50	23.4	8.5	2.60	0.85		24	0	3	84	11	2
Sample ID : AB18							12-18 in	Mehlich P2																	
84831	8.0		0.94	HIGH	1.3	15.2	27	15	374	4951	415	123	72	0.29	9.3	5.3	2.48	0.65		29.7	0	3	83	12	2
Sample ID : C6							0-6 in	Mehlich P2																	
84832	8.1		0.78	HIGH	1.1	22.5	41	32	337	4010	326	109	80	0.45	5.8	6.8	3.24	0.91		24.1	0	4	83	11	2
Sample ID : C18							12-18 in	Mehlich P2																	
84833	8.1		0.88	HIGH	1.3	30.5	55	9	366	4971	403	122	66	0.22	8.7	4.8	2.09	0.65		29.7	0	3	84	11	2

Brent Morris

Results For:	
Lab Number	13027
Field Identification	
Sample Identification	BMS D1 WELL
pH	8.0
Sodium Adsorption Ratio (SAR)	0.9
Adjusted SAR	1.2
Total Dissolved Solids (TDS) Est.	522.0
Electrical Conductivity, mmho/cm	0.87
Cations/Anions, me/L	8.7 / 8.8

	ppm	lbs/Ac9"
Sodium, Na	39	78
Potassium, K	4	8
Calcium, Ca	104	208
Magnesium, Mg	20	40
Total Hardness, CaCO3	343	686
Nitrate, NO3-N	3.7	7.4
Sulfate, SO4-S	66	132
Chloride, Cl	31	62
Carbonate, CO3	6	12
Bicarbonate, HCO3	199	398
Total Alkalinity, CaCO3	173	346
Boron, B	0.12	0.24

SELENIUM ANALYSIS
Brent Morris Sub-surface Drip Irrigation Well

Lab No.	Sample ID #	Se mg/L
W560	BMSDI Well	0.045