Revised

FINAL GRANT REPORT

(November 20, 1995)

PROJECT: Demonstrate sound methods for applying and managing irrigation water using the latest cost effective drip irrigation techniques to reduce the total water demand placed on the Edwards Aquifer by the area's irrigated acres.

SUBMITTED TO: The Texas Water Development Board

SUBMITTED BY: Dr. Frank J. Dainello(Principal Investigator)
Extension Horticulturist-Commercial Vegetable Crops
Texas Agricultural Extension Service
Department of Horticultural Sciences
Texas A&M University
College Station, TX 77843

Co-Investigators:

Dr. Larry Stein, Extension Horticulturist
Texas Agricultural Extension Service
Department of Horticultural Sciences
Texas A&M University Agricultural
Research and Extension Center @ Uvalde

Dr. Guy Fipps, Extension Agricultural Engineer-Irrigation
Texas Agricultural Extension Service
Department of Agricultural Engineering
Texas A&M University

Dr. Charles Hall, Extension Agricultural Economist
Texas Agricultural Extension Service
Department of Agricultural Economics
Texas A&M University

Mr. Kenneth White
Texas Agricultural Extension Service
County Extension Agent-Agriculture
Uvalde County

STATEMENT OF NEED: Currently a controversy concerning the water use rights from the Edwards Aquifer is raging in Bexar, Medina, and Uvalde counties. Crop irrigation is credited with placing undue pressure on the Aquifer's water supply, especially during the peak pumping season of early-late summer. The integrity of the Comal and San Marcos Springs flow is also claimed to be threatened. Additionally, the high nitrogen fertilizer usage in crop-production could affect these ground water supplies. For irrigated agriculture to survive harmoniously in the environment with it's non agricultural neighbors, it's water use efficiency has to improve significantly.

Furrow irrigation is the predominant method of supplying crop supplemental water vegetable crops in the Texas Winter Garden area. This method, if not managed properly, is considered to have low distribution and application efficiencies. Drip irrigation on the other hand, if properly designed and operated, has an average efficiency of 90%. Consequently, the use of this technology could greatly reduce the total water volume used for crop production. However, producers are reluctant to convert to this method of irrigation due to the high cost associated with conversion of their existing systems, high risk associated with crop production in the area, and uncertainty of management techniques required by the more efficient systems. Successful demonstration and implementation of water saving irrigation techniques is needed to help reduce the total water demand placed on the Edwards Aquifer. The intent of this project was to demonstrate drip irrigation/plastic mulch systems and to compare their water use efficiency with conventional furrow irrigation methods.

APPROACH: Drip irrigation efficiency was demonstrated in two separate tests on two different farms in the Edwards Aguifer area; McFadin Farms, and, Cargil Produce. Both farms were located near the City of Uvalde. The McFadin Farm test **(Demonstration A)** was conducted during the Spring 1994 growing season, and , the Cargil Produce test **(Demonstration B)**, during the Spring 1995. Cantaloupe was used as the indicator crop in these demonstrations. A mobile drip trailer provided by the Texas Water Development Board was used to supply supplemental water needs. The self-contained unit consisted of a diesel pump, sand filters with auutomatic back flushing, and a chemical injector. The self-contained unit had the capacity to deliver 600 gallon of water per minute and could be used to irrigate one to 100 acreas. As a result, the test plots could be irrigated independently of the cooperators fields. Water contained in the farms' buried irrigation supply lines was used as the source. Several other water saving techniques were also evaluated in both demonstrations.

Demonstration A-McFadin Farms-1994

Two separate tests (1 & 2) were conducted on a Knippa clay soil site on the McFadin Farm. In test 1, the efficiency of drip irrigation/plastic mulch culture (DIPM) was compared to conventional furrow irrigation (CFI). In test 2, the use of an experimental technique, Rainfall Capture (RFC)- a moisture harvesting technique, was evaluated for merits in reducing total supplemental water needs.

Study 1- Demonstrating drip irrigation efficiency.

The production of cantaloupe utilizing DIPM and scheduling irrigation based on soil moisture tension was compared to CFI scheduling based on the cooperator's personal experience with crop water needs. Total water application verses fruit yield and quality were the parameters used as the basis of comparison. Fifteen beds, each 6 ' wide X 500 ' long (approx 1 A) were established per production method on 4 April, 1994. Drip irrigation tape with in-line emitters spaced 1 ' apart was buried approximately 3 " deep and approximately 3 " to one side of the bed center in the DIPM plot. Six ft. wide black polyethylene was applied as mulch. The furrow beds were established by the cooperator in his usual manner. A mechanical transplanter was used to punch holes and sow seeds of ' Caravelle ' cantaloupe on 12 April in the DIPM plot. The grower was delayed in sowing of the CFI plot until 29 April.

One inch of supplemental irrigation water was applied in the DIPM plot when soil moisture tension exceeded 40 centibar at a 12 " depth. As indicated above, the grower controlled when and how much water was applied to the CFI treatments. Weed control in the furrow plot and between the mulch strips was achieved with one post emergence application of a Curbit/Roundup mix according to labeled rates. Fruit harvest was initiated when the full slip stage of maturity occurred in the first maturing fruit (6 and 27 July respectively for the DIPM and furrow plots).

Study 2- Evaluating RFC as a means to reduce supplemental water needs.

Earlier small plot work by the principal investigator indicated that naturally occurring moisture could be retained and stored for future use. In this test, this experimental concept was evaluated under field conditions.

The RFC technique as evaluated consisted of polyethylene lined mini catchment basins constructed on raised beds (figure 1). The RFC system was established 26 October, 1993 in an attempt to harvest and store fall and winter moisture. Fruit yield and quality was then compared to that obtained from DIPM, RFC + 2, one " supplemental irrigations (@ vining and fruit swell), RFC + one " irrigation based on 40 centibar soil moisture tension, and, furrow irrigation methods. Drip tubing was installed in the appropriate treatment beds during the establishment of the RFC techique. Three beds, 6 ' wide X 500 ' long were established per treatment. Four 20 ' sub section per treatment were harvested and the fruit weighed and graded (6 and 27 July respectively for the drip and furrow plots respectively).

Results and Discussion(Demonstration A)-

Study 1- Demonstrating drip irrigation efficiency.

The data obtained for this study, shown in Table 1, illustrates the effectiveness of the DIPM as a cantaloupe production system. Total cantaloupe yield from the DIPM system exceeded that from CFI by 6,453 lbs/A. More importantly, marketable yield was increased 12,445 lbs/A.

Figure 1. Cross-section RFC bed

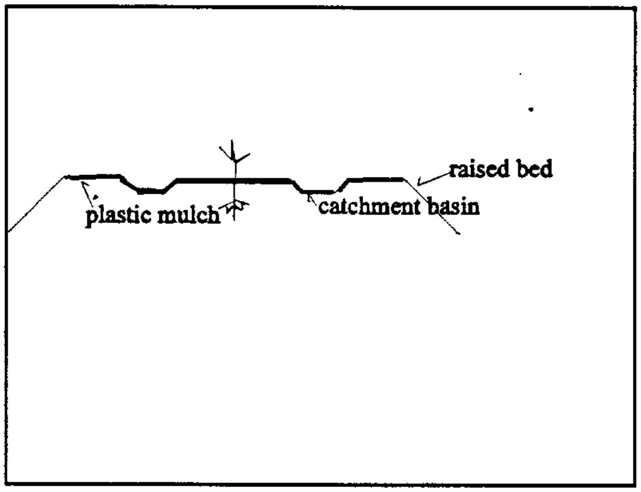

Table 1. Cantaloupe yield in response to irrigation method and quantity water applied.

Irrigation system a/	Mktbl yld (lbs/A)	% culls	No. irrig.	Water applied (in./A)	Water applied (gal/A)	Ratio gal water applied/ lb fruit produced
DIPM	25812	3	4	4.04	109702	4.3 : 1
CFI	13367	33	3	24.6	667988	50 : 1

a/ DIPM= Drip irrigation/plastic mulch system; CFI= Conventional furrow irrigation

Table 2 shows the effect of irrigation technique on fruit quality. The dramatic increase in cull fruit yield with CFI was primarily due to the high incidence of fruit rots caused by soil borne pathogens. The plastic mulch of the DIPM system served as a barrier to the these organisms by preventing the fruit from coming into contact with the soil. Consequently, the incidence of culled fruit was reduced 31% with DIPM. The fruit rot incidence within the CFI plot was enhanced by over watering by the grower. The data in Table 2 support this observation. A total of 4.04 " /A of water was applied in four irrigations using the DIPM system; whereas, 24.6 "/A were applied in three furrow irrigations (Table 1). The percent harvested fruit per grade appeared to be unaffected by irrigation method (Table 2). The greatest differences can be seen in the percent grades 15's and 18's. DIPM produced a higher percentage of 15's than the CFI. The furrow method resulted in a higher percentage of grade sizes 18's.

Table 2. Influence of irrigation technique on fruit quality.

		%boxes harvested/size grade					
Irrigation systems	**% culls**	**9's a/**	**12'**	**15's**	**18's**	**23's**	**30's**
Drip irrigation/plastic mulch	2	6	27	33	8	5	8
Conventional Furrow Irrig.	33	6	37	19	23	9	5

a/ = number of fruit / 40 pound box

Differences in water use efficiency between the two techniques are apparent when examining the ratio of the gallons of water applied to pounds fruit produced (Table 1). The superiority of DIPM to CFI is clearly illustrated by the ratio comparisons, 4.3:1 and 50:1 respectively. These results indicate that the DIPM system can result in a major reduction of the supplemental water requirement for vegetable crop production. Under the conditions of this demonstration, nearly an 84% reduction in water use (20.56 "/A) was achieved with DIPM. Such a reduction across the Winter Garden's 1,500 cantaloupe acres would have a significant impact on the Edwards Aquifer.

Approximately 16 inches of water/A is required to produce a cantaloupe crop. As a result the estimated water used by the Winter Garden cantaloupe approximates 24,000 acre inches. An 84% reduction would result in a water savings of 20,160 acre inches (1,680 acre feet).

Annual total vegetable acreage in the entire Winter Garden area ranges from 25,000 - 50,000A. It is estimated that 15 - 25 inches of water is required to produce one average acre of vegetables. As a result, 31,250 - 104,167 acre feet of water are required to support vegetable production in the Winter Garden. If similar water saving can be acheived across the total acerage as found in this test, a net water savings range of 25,938 to 87,059 acre feet would be realized.

Historically the major limiting factor to widespread adaptation of drip irrigation and/or plastic culture to row crop agriculture has been economics. Under the conditions of this investigation, the DIPM system was found to be a profitable venture. Economic analysis of the production systems investigated in study 1 is presented in Table 3. The data in this table is presented in terms of total marketable boxes (40 lbs/box), the measure by which cantaloupe are sold. Production costs used are based on the Texas Agricultural Extension Service crop budgets and the grower cooperator input. The DIPM system was estimated to cost $ 3560.14 per acre whereas the furrow method, $ 1865.90. Considering the yields of both systems, 645 and 300 boxes, respectively with DIPM and CFI, a breakeven price of $5.52 and $6.22 is required. With an average price received of $6.50 per box, DIPM netted $632.36 per acre as compared to $84.05 from CFI.

The cost of the DIPM system was high, $3,560.14/A. Although this technique was found to be profitable, it's use does not assure success, and, may result in even greater loss of money under adverse weather and/or market conditions than CFI. As a consequence of current economic conditions, DIPM is best suited to high value crops such as the vegetables.

Table 3. Cost and returns of drip irrigation/plastic mulch system versus furrow irrigation.

Irrigation system	Production Cost/A	Mktbl yld. boxes/A	Breakeven price/box	Net profit / A
Drip Irrg/plastic mulch	$3560.14	645	$5.52	$632.36
Furrow	$1865.95	300	$6.22	$ 84.05

Box = 40 pounds Average price = $6.50/box

Study 2- Evaluating RFC as a means to reduce supplemental water needs.

In an attempt to further enhance water use efficiency, the potential to catch and store moisture for future use was investigated. The intended use of the stored moisture was to reduce supplemental water use during the seed germination phase of stand establishment. When evaluating water input versus crop response, the least efficient use of irrigation water is during seed germination . Sufficient seed to plant one acre of cantaloupe can be germinated in the lab with less than one gallon of water. However, it is not uncommon to require as much as 9 acre inches (nearly one quarter million gallons) of water to accomplish this under field conditions. Previous work by the investigators indicated that moisture harvesting prior to planting can store sufficient water to accomplish seed germination of cantaloupe under field conditions. Results obtained in this study are similar to those found in the earlier studies. RFC produced acceptable commercial fruit yield and quality without the application of supplemental water (Table 4). Fruit yield from RFC was within 6,700 lbs of the total yield produced with DIPM. Four plus inches of supplemental water was applied with DIPM technique. The CFI method yielded 5,755 lbs/A fruit while receiving 24.4 " of supplemental irrigation water. Although all of the RFC treatments produced 7 - 11 % more culled fruits than the DIPM system (Table 5), these percentages were significantly lower than that noted in the CFI plot.

Table 4. Influence of RFC on cantaloupe yield and response to applied moisture.

RFC techniques	Total yld (lbs/A)	Mktbl yld (lbs/A)	No. irrig.	water applied (gpa)	water applied (in./A)
DIPM a/	26,463	25,812	4	109,702	4
RFC	20,990	19,122	0	0	0
RFC + 2-1 inch irrigations b/	19,928	17,272	2	54,851	2

a/ = DIPM, Drip irrigation/plastic mulch system (irrigated @ 40 centibar moisture tension at the 12 " depth

b/ = Rainfall Capture + 2-one inch irrigations; one inch applied at the vining stage, and, one at the fruit swell stage of development through buried drip lines

Table 5. Influence of RFC techniques on fruit quality.

RFC techniques	% culls	% boxes harvested fruit / grade a/ 9's	12's	15's	18's	23's	30's
DIPM b/	2	6	27	33	82	5	8
RFC	9	8	32	19	21	2	8
RFC + 2-1 inch irrigations c/	13	2	57	17	16	18	8

a/ = percentage boxes of fruit harvested per grade size (40 lbs / box)
b/ = DIPM, Drip irrigation/plastic mulch system (irrigated @ 40 centibar moisture tension at the 12 " depth
c/ = Rainfall Capture + 2-one inch irrigations; one inch applied at the vining stage, and, one at the fruit swell stage of development through buried drip lines

Total rainfall received from RFC establishment time (26 October, 1993) until the end of harvest (27 July, 1994) is presented in Table 6. A total of 14.04 " of rainfall was received from RFC establishment until planting (7 April, 1994). It is generally accepted that approximately 16-20 acre inches of water is required to produce a cantaloupe crop in most area of Texas. In Demonstration A 14.04 " of rainfall was received prior to planting, and 13.12 " from planting through harvest. The bulk of the rain was received in April and May prior to the peak crop demand period of vining to fruit maturation. The application of additional water to the RFC system during the suspected critical cantaloupe growth stages, vining and fruit swell, did not have any benefits in this study. In fact, yield suppression was noted. These results suggest that adequate soil moisture was available during these growth stages. The additional water only served to water log the soil which in turn resulted in yield reductions. No data is presented for the RFC + 1" irrigation when soil moisture tension reached 40 centibar at the 12 inch depth. Unfortunately overlap from a center pivot system in an adjacent block resulted in excessive amounts of unwanted moisture to be applied to this block. Based on these findings it is believed that RFC can be used to improve water use efficiency, and, merits further study to determine how it can be incorporated into economical production systems.

Table 6. Rainfall received October 1993 through July, 1994.

October (RFC established 26 October)	0.05------|
November	0.70 |
December	5.38 | -----RFC period
January	2.96 |
February	0.29 |
March	4.35 |--------> 14.04 "
April (Planting)|	6.53 ---------|
May |	5.10 |
June |	1.76 |
July |/ End of harvest(27 July)	1.90 |------> 13.12 "
Total	**29.14**

Demonstration B-Cargil Produce-1995

Materials and methods-

The purpose of this study was to demonstrate how selected cultural practices can impact supplemental water needs under large scale crop production situations. Furrow and drip irrigation, plastic mulch, and, RFC were combined to produce five water management techniques: Conventional furrow irrigation (check)-CFI; Furrow irrigation of plastic mulched beds-FIPM; Standard drip irrigation-SDI; Drip irrigated plastic mulched beds-DIPM; and, Rainfall capture-RFC. Each irrigation water management technique, except RFC, was implemented in a single block consisting of 20 plant beds, 6.7' wide by approx 1,800 ' long(approx 10A). The RFC technique was implemented on three plant beds 1,800 feet long. A smaller plot size was used for the RFC technique because previous work indicated that its' effectiveness in harvesting moisture was dependent upon establishment well ahead of anticipated planting. Poor weather conditions during the intended establishment period of Fall 1994 prohibited implementation. Consequently, it was decided not to invest a large area in this experimental concept.

A Uvalde silty caly loam soil test site was bedded on 8 March, 1995, and, the drip irrigation tape installed in the appropriate blocks on 21 - 29 March. The RFC block was established 30 March. Plastic mulch application was delayed until 6 - 15 April. The CFI and SDI blocks were direct seeded using a precession planter on 6 April. The RFC block was seeded on 6 - 7 April with a mechanical transplanter used as the seed delivery unit. All other blocks were hand seeded 15 - 16 April. The hybrid cantaloupe variety `Mission' was sown in double plant rows per bed spaced 12 " apart with 12 " in-row spacing.

Tensiometers were placed at 1, 2, and 3 ft depth in each block to monitor soil moisture. Irrigations were scheduled in the drip irrigated blocks when a 45 centibar tension was reached at the 1 ' depth. Supplemental water applications in the furrow irrigated blocks were managed by the cooperator, in his usual manner, independently of soil moisture tension . All other cultural practices were also managed by the cooperator.

Results and Discussion-

The test was an observational trial design consisting of one block per water management technique. A clay loam soil site near Uvalde was provided for the demonstration. One month was required to establish the various water management techniques due to the size of the demonstration in combination with improper field equipment and limited labor availability. This posed serious challenges to our ability to obtain valid data for scientific comparisons. Additionally, the demonstration was negatively impacted by a late season vine decline disease complex which infected cantaloupe fields across the entire Winter Garden area. Consequently, a near crop failure was experienced due to premature vine death. No apparent differences were observed across the treatment blocks in severity of the vine decline disease complex.

The extent of vine death coupled with poor fruit quality and a weak market situation removed the cooperator's incentive to harvest all of the demonstration planting. As a result, the intended yield and quality comparison based on a real world commercial harvest and grading criteria was not possible. Instead the water management blocks were sub sample harvested and graded, disregarding the fruit quality factor. The cooperator's primary interest in this demonstration was to determine if drip irrigation was more suited to his operation than furrow irrigation. As a result only a limited harvest was taken from these blocks. Unfortunately the CFI block was harvested before the investigating team could travel to the test site. Consequently, no sub sample harvest data was obtained from this block.

The yield data obtained by the Cargil Produce harvest and grading crews is presented in Table 7. As anticipated, the yield was exceptionally low, 50 and 14 marketable boxes/A respectively from the SDI and CFI blocks. A similar yield situation was experienced by Cargil produce in their other late season cantaloupe blocks.

The Uvalde county area historically has yielded approximately 350 boxes of cantaloupe/A. Using the production cost data from Demonstration A ($1,865/A and $3,560/A for the CFI and SDI techniques), and a $6.50 market price for the 14 and 50 boxes/A yields, only $91 and $350/A was generated respectively. This created a net loss/A of $91 with the CFI technique and $2675 for the SDI technique! **(This occurrance is the major reason for the reluctance to convert to drip irrigation).**

More positive results can be found in the data presented in Table 8 for volume of supplemental water used per technique. A total of 8.1 inches of water was applied in two applications using the SDI technique (based on attainment of 45 centibar soil moisture tension at a 12 " depth). The cooperator, using his normal means of scheduling applications, applied a total of

Your Organization____

Street Address

City____________________ State/Province______________ Zip/Postal Code________________

Telephone Number (with area code)____________________________________

Your Name____

Your Title____

If you already have a gardening-related site on the Internet, what is the address?

What are the subjects of the gardening information you produce?

How often do you create or update gardening information?

Weekly___ Monthly___ Other______________________________

In what region (geographic, climate) is your gardening information applicable?

Do you have plans to produce other gardening information?

If you create text, in what form are the words? (For example: in typed or printed form, in a word-processing program such as Word or WordPerfect, in a desktop publishing program such as PageMaker, or in SGML)

If you create artwork, in what form is it? (For example: transparencies, black-and-white line drawings)

Do you create audio?

Do you create video?

How would you describe the audience for your information? (For example: novice gardener, rose enthusiast)

Table 7. Yield from drip versus furrow irrigation Cargil Produce harvest crew.

Irrigation technique	boxes/A	% Mktbl yield / grade					
		9's	12's	15's	18's	23's	30's
Drip irrigation	50	0	27	20	53	0	0
Furrow irrigation	14	0	57	43	0	0	0

29.4 inches in four applications by the CFI technique. A net water savings of 21.3 inches resulted with the use of SDI as compared to the CFI technique. This represented a 72.4% reduction of required supplemental water under the conditions of this demonstration. A 72.4% reduction in water use across all vegetable acerage of the entire Winter Garden area would result in a water savings ranging from 22,625 to 75,417 acre feet.

Table 8. Influence of irrigation technique on total water applied, Cargil Farms-1995.

Irrigation technique	Total water applied (inches/A)	No. applications	Avg water applied/ application (inches/A)
Drip Irrigation	8.1	2	4.05
Conventional Furrow Irrigation	29.4	4	14.7
Difference in volume applied	21.3(72.4%)	-----	------

Water use efficiency expressed as the ratio of gallons of water applied per box of fruit produced is listed in Table 9. A ratio of 57,023 :1 was derived from the furrow applied water as opposed to a ratio of 4,399 : 1 with the drip technique (Table 9). These results, as in Demonstration A, suggest that the cooperator over watered cantaloupe with CFI. They also indicate a need for more precise information on scheduling irrigations and quantities of water required per irrigation.

Table 9. Water use efficiency of drip and furrow irrigation based on yield obtained by Cargil Produce harvest crew

Irrigation technique	Mktbl boxes/A	No. irrig.	Gallons applied/A	Ratio gal water applied/box frt
Drip irrigation	50	2	219947	4399 : 1
Furrow irrigation	14	4	798328	57023 : 1

The yield data obtained from the sub sample harvests of each block were more closely aligned with normal Uvalde county cantaloupe yields. All fruit from the vines within three randomly selected section from each irrigation water management technique were stripped and graded according to size. The yield harvested in this manner is shown in Table 10. The highest yield was obtained from the SDI block (667 boxes/A). This represented an increase of 273 boxes over the check, FIPM. The next highest yield was obtained from the RFC block (497). This was not anticipated because this technique was established just prior to planting. Previously it was believed that establishment must occur several months prior to planting in order for the technique to have sufficient time to capture and store water. Based on these findings, more research is needed to determine how to best utilize this technique. Only 15 boxes of fruit separated the DIPM and the FIPM techniques. It is speculated that the lateness of the planting dates of the mulched blocks may have resulted in excessive soil warming. One of the major benefits of plastic mulch in early plantings is its ability to warm the soil and enhance earliness. However, when used in late spring or early summer, excessive soil and mulch surface heating can result and cause plant injury. This may have been the case in this demonstration.

Table 10. Influence of irrigation technique on sub plot harvest yield and grade.

			% Mktbl yield / grade a/					
Irrigation technique b/	**Total no. boxes/A**	**Avg wt. (lbs/frt)**	**9's**	**12's**	**15's**	**18's**	**23's**	**30's**
SDI	677	2.27	0	11	36	24	16	13
RFC	497	1.51	0	0	8	19	32	41
DIPM	419	2.8	0	37	22	19	16	6
FIPM	404	2.11	0	9	27	24	25	15

a/ grade based on fruit size (number fruit / box)
b/ Irrigation technique: CDI = Conventional furrow irrigation; RFC = Rainfall Capture
DIPM = Drip irrigated plastic mulched beds; FIPM = Furrow irrigated plastic mulched beds

Major differences among the various water management techniques were noted in supplemental water applied and use efficiency (Table 11). SDI required the least amount of supplemental water (8.1 in), whereas, CFI required the greatest volume (29.4 acre inches). The resulting fruit yields were 667 and 404 boxes/A respectively . Only slightly better yield was produced with DIPM as compared with FIPM. Although no comparative data is available, the CFI technique applied nearly 3.5 times the water as did SDI and FIPM, and, nearly 4 times that of DIPM. In order to determine actual water use efficiency of a water management technique rainfall received must be taken into consideration. Figure 2 illustrates the cumulative volume of rainfall received and supplemental water applied in each block. Rainfall received during the same period is represented by the data for RFC. The over watering within the CFI is very apparent with this data. Applied water use efficiency (gallons water applied per pound fruit produced) with SDI, was 7.4 : 1 and 33.4 :1 with FIPM. When rainfall received is considered, SDI produced a water use efficiency of 16.3 : 1 as compared to 49.2 : 1 with FIPM. As in Demonstration A, the highest use efficiency was found to occur within the RFC block where 497 boxes of melons were produced without the addition of supplemental water. As a result, the RFC plot was found to have a water use efficiency of 13.1 : 1. Although total yield from the RFC plot was better than that from the DIPM or the FIPM plots, the percent grade out(fruit size) was not economically acceptable. Nearly fifty percent of the yield fell in the 30 grade box count . Currently there is very little market for such fruit.

Average fruit weights produced by each technique are also given in Table 10. The largest fruit was found to be produced by the DIPM technique (2.8 lbs/frt), and, the smallest fruit by the RFC technique (1.5 lbs/frt). These results suggest that the RFC plot was stressed excessively at some point during plant growth and/or fruit development. It is speculated that one 2 " irrigation during the fruit swell stage would have been sufficient to produce adequate fruit size with RFC in this test. Additional work is needed to determine the critical growth stages of cantaloupe which irrigation.

Table 11. Use efficiency of supplemental water applications+rainfall within irrigation management technique(subplot harvest).

Irrigation technique a/	Yield (lbs/A)	water applied gpa (in)	Ttl. water rec. gpa (in)	Ratio gal water /lb frt produced applied	total
SDI	29,621	219947 (8.10)	481984 (17.75)	7.4 : 1	16.3 : 1
RFC	20,038	0	262036 (9.65)	0 : 1	13.1 : 1
DIPM	18,295	150162 (5.53)	412741 (15.20)	8.2 : 1	22.6 : 1
FIPM	16,988	567519 (20.90)	834986 (30.75)	33.4 : 1	49.2 : 1
CFI	--------	798328 (29.40)	1061721 (39.10)	--------	--------

The data obtained from demonstrations A & B indicate that supplemental water needs can be reduced by capturing and utilizing naturally occurring moisture. The rainfall received during the growing season (April - July) in Demonstration B is listed in Table 12. Although nearly 3" less rainfall was received in the 1995 growing season as compared to 1994, fruit yield was found to be slightly higher. Soil type differences between the two test sites and better rainfall distribution probably accounted for this occurance. The major difference in the use of RFC for the two seasons was time of field establishment. In Demonstration A the plots were established in the fall prior to anticipated spring planting. This was selected based on the assumption that the greatest probability for rainfall occurs in the fall within the Winter Garden area as opposed to winter and early spring. In Demonstration B, RFC was not established until planting. The effectiveness of this technique in view of its establishment date brings up the question as to the optimum time that RFC should be established. Additional research is needed to determine this as well as how to best utilize RFC in a crop production system.

Figure 2. Irrigation plus rainfall recieved.

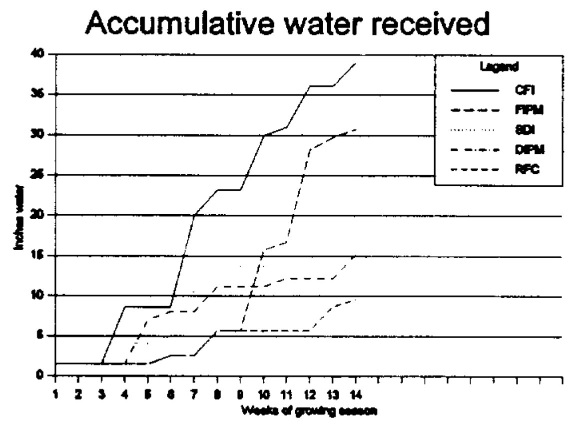

Table 12. Rainfall received during the growing season; Cargil Produce-1995.

Month	Inches
April	1.50
May	4.15
June	3.00
July	1.00
Total	9.65

Table 13. Influence of plastic mulch on efficiency of irrigation technique, Cargil Produce-1995.

	Total irrigation water applied (inches/A)	
Treatment	**Furrow irrigation**	**Drip irrigation**
Non mulched beds	29.4	8.1
Plastic mulched beds	21.0	5.2
Reduction due to mulch(in./A)	8.4	2.9
% water savings due to mulch	28.5	35.8

Although no apparent yield benefits or reduction in disease loss were realized from the plastic mulch in this demonstration, its value in reducing water requirements, regardless of irrigation method, is evident, Table 13. A net savings in supplemental water application of 28.3% and 35.8% respectively occurred with furrow and drip irrigation.

SUMMARY AND CONCLUSIONS

The major objectives of this project were: to demonstrate the use of efficient water management techniques; to determine the potential impact of such techniques on the Edwards Aquifer water supply; and to develop techniques which reduce supplemental water needs in crop production. Conventional furrow irrigation was compared to drip irrigation techniques on two farms in the Winter Garden near Uvalde. Furrow irrigation is the predominant method of supplying supplemental water in the area. This method is also one of the least efficient methods of delivery to meet vegetable crop water needs. Conversely, drip irrigation is one of the most efficient methods of supplying crop water needs. This method is beginning to become accepted in other vegetable production areas such as the Lower Rio Grande Valley.

Under the conditions of this study, drip irrigation was shown to be highly effective in reducing total supplemental water needs for cantaloupe production in the Winter Garden. At the McFadin Farms location, a reduction of 83% (20.2 inches/A) was found when comparing drip irrigation and plastic mulch with conventional furrow irrigation techniques. A similar reduction was noted at the Cargil Produce site (72.4% or 21.3 inches/A).

Results such as these reported in this study could have a major impact on the removal of water from the Edwards and other area aquifers. It is estimated that vegetable production annually ranges from 25,000 A to 50,000A. Under normal conditions approximately 15 - 25 acre inches of water is needed to produce a vegetable crop. Based on the results obtained in this study it is projected that a range in water savings of 22,625 - 87,059 acre feet of water savings is achievable with the adaptation of the demonstrated drip irrigation techniques to these crops.

Water use efficiency of cantaloupe produced with drip irrigation techniques is emphasized by the ratio of gallons of applied water to pound of fruit produced. At the McFadin Farm, drip irrigation under plastic mulch produced a ratio of 4.3 : 1, and, at the Cargil Produce location, 7.4 : 1. Comparative ratios of furrow irrigation were 50 : 1 and 33.4 : 1, respectively.

A key component of the water management techniques evaluated in this study was found to be the use of plastic mulch. In Demonstration B, a comparison of the two basic irrigation techniques, with and without plastic mulch, indicated that the mulch accounted for a 28.5% reduction with furrow irrigation and a 35.8% reduction with drip irrigation. Based on these results, use of plastic mulch is an effective method to reduce supplemental water needs and conserve the aquifer's water supply. Additional research is needed in order to determine optimum double cropping sequences for maximizing mulch use efficiency and reducing cost associated with its application and removal.

A third means shown to be effective in reducing supplemental water needs under the conditions of this study was harvesting and storing moisture to meet future crop needs. The intended use of RFC was to capture and store sufficient moisture to eliminate the need for a preplant irrigation(the least efficient use of supplemental water). The RFC techniqueproduced fruit yields which exceeded those of furrow irrigation. However, under the conditions of Demonstration B, fruit size from the RFC plot was significantly smaller than that from the furrow plot. Although RFC was able to capture sufficient moisture to set a heavy fruit load, it was insufficient to offset a moisture stress period occuring during the fruit swell stage. Consequently, fruit size was affected. Of the water saving techniques evaluated in this study, RFC is the least expensive and the easiest to adapt. Additional research is needed to determine how to best utilize this technique in large scale crop production systems.

One of the objectives stated in the grant proposal was to determine the effect of the various irrigation techniques on downward nitrate movement in the soil. Unfortunately, insufficient time and funds prevented this this study. Hopefully additional funds will be found to accomplish this in the near future.

Although the use of drip irrigation and plastic mulch was found to be highly effective in reducing supplemental water application, these techniques are extremely expensive and do not necessarily insure economic success. This fact was reaffirmed in this study. In Demonstration A drip irrigation under plastic mulch increased yield significantly as well as economically over that from the furrow method. However, in Demonstration B, a crop failure due to a vine decline complex which caused premature plant death resulted in a significantly greater economic loss than experienced with the furrow method. The increase loss of money with the drip techniques is directly associated with the high cost of establishment and use. Vegetable production is a very risky business under normal conditions due to fluctuations in market price. Increased production costs associated with drip irrigation techniques increases the potential for loss under adverse conditions. Because a high incidence of crop loss is experienced in the Winter Garden, growers are reluctant to invest more money in a crop than is absolutely necessary. If and when water availability becomes limiting to production, assistance program of some type may be needed to help growers convert to these more expensive and efficient irrigations systems.

The investigators would like to acknowledge the financial assistance provided to conduct this project by the Texas Water Development Board and the Texas Agricultural Extension Service. They would also like to acknowledge the cooperation provided by McFadin Farms and Cargil Produce. Without such cooperation, this project could not have been conducted.