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INSTALLATION ISSUES FOR SDI SYSTEMS

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Summary:
Successful adoption of SDI technology will require durable, compatible, and user-friendly components; local support for design, installation, and service; and continuing educational programs on proper operational and management procedures. Success will depend on a heightened awareness and commitment to quality similar to those required in other advanced technologies.

Keywords:
Subsurface drip irrigation, Microirrigation, Irrigation system design, Irrigation systems,

INSTALLATION ISSUES FOR SDI SYSTEMS[1]

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INTRODUCTION

This paper discusses issues that should be considered by manufacturers, distributors, and end users for installation and subsequent operation of subsurface drip irrigation (SDI) systems. These issues include factors associated with quality control during the manufacturing and installation processes that can be much more crucial for SDI installations than for surface drip installations. Even small failures in SDI systems are troublesome because of the increased difficulty associated with repairs below the soil surface. Experiences and concerns that have developed from SDI research installations in Kansas, Texas, Arizona, Colorado, and California will be presented.

In the future, SDI probably will have an increased focus on lower value crops, which do not have the income potential to help "write off" system failures. Early consideration of the special design and installation requirements of SDI by manufacturers, distributors, consultants, and end users can minimize the negativism of avoidable system failures and advance early adoption of this useful technology.

SUITABILITY OF DESIGN

A successful SDI system begins with an appropriate hydraulic network design and selection of appropriate water treatment system (filtration and chemical amendment). These are not focuses of this paper, but because of their importance, they are discussed briefly. Disregarding the suitability of the design and filtration system will likely result in a system that is costly in both time and money to operate and will likely increase the chance of system failure.

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Design characteristics such as dripline spacing, crop/dripline orientation, emitter spacing, installation depth, and dripline flow rates are site specific and governed by soil type, climate, crop, and other factors. Consultants, distributors, and end users should remember that these issues are not generic and that appropriate technology in one region may not be appropriate in another region. Consultants, distributors, and end users instead should strive to understand these issues from a conceptual approach. These design characteristics are very important to the success of the system and should not be ignored. Consistent dripline spacing, crop/dripline orientation, and depth of placement are important in managing salinity and water redistribution and in minimizing tillage damage to the driplines (Ayars et al. 1995; Kruse and Israeli, 1987; Lamm et al. 1992). Major factors related to dripline spacing include the lateral extent of the crop root zone, lateral extent of soil water redistribution, and the within-season precipitation. Deeper installation depths reduce the potential for soil evaporation and also allow for a wider range of tillage practices. However, deeper installations can limit effectiveness of the SDI system for seed germination, restrict the availability of surface-applied nutrients, and result in high salinity levels in surface soils when used with saline water supplies. Dripline flow rates must be sufficient to provide for the water needs of the crop. Some designers prefer higher capacity driplines, because they are less subject to plugging and allow more flexibility in irrigation scheduling. However, higher capacity driplines typically require shorter lengths of run to maintain acceptable uniformity and can increase "surfacing" of water on some soil types. Resource books that discuss many of the important concepts for SDI are available for additional information (Jorgenson and Norum, 1992; Schwankl et al. 1993; Hanson et al. 1994; Burt and Kasapligil, 1992). It should also be noted that an improperly designed SDI system is less forgiving than an improperly designed surface irrigation or center pivot sprinkler irrigation system. Water distribution problems associated with an improperly designed SDI system may be difficult or impossible to correct.

The filtration system is one of the most important components of the SDI system. Its operation and maintenance must be well understood by the end user to help ensure its longevity. Many different types of filtration systems are used with SDI systems, and their design and specifications are based upon the characteristics of the water source and emitters. Improper filter selection can result in a SDI system which is difficult to maintain and a system that is prone to failure. In addition to the filtration system, a water treatment system generally will be required to inject chemicals, to prevent emitter plugging, and to possibly renovate partially plugged driplines.

A flushing system is recommended at the distal end of the dripline laterals to assist in removing sediment and other materials that can accumulate in the driplines during the irrigation season. This is used in addition to a proper filtration system. All of the distal ends of the driplines in a zone can be connected to a common submain or header, which is called the flushline. This technique allows flushing from one central point. Two other distinct advantages exist for this closed-loop method. If a dripline becomes plugged or partially plugged, pressurized water will be provided below the plugged area by the interconnected flushline. Additionally, if a break in the dripline occurs, positive water pressure on both sides of the break will limit sediment intrusion into the line.

Seven other design components critical to successful use of SDI are worth noting. Pressure regulation is necessary to ensure uniform water distribution to the various points in the SDI system. Primary pressure relief must be provided to prevent excessive pressure, which could cause component failure or bursting of the driplines. Pressure gages should be installed on riser pipes at each of the four corners of the closed-loop zone. Recorded pressures from these gages and flow rates from the system flowmeter can be compared from one event to the next to help reveal system performance problems. Checkvalves, air vents, and vacuum breakers may be required at various points in the system to prevent back-siphoning of chemically treated water into the water supply and also to prevent ingestion of soil into the driplines at system shutdown.

End users should take the responsibility to ask questions of knowledgeable consultants, distributors and other current users of SDI systems to avoid installation problems. Substantial knowledge is available from experts, but it is not readily available in written form as a complete source book of information on SDI installation. This is particularly true for deeper dripline placements used in permanent systems. Burt and Kasapligil (1992) discuss California perspectives associated with the shallow installation issues for 7- to 20-cm dripline depths. In the absence of adequate knowledge and regional experiences, the end user should use a go-slow approach to SDI development. Most manufacturers, distributors, and consultants recommend that users start their SDI experience with a small area to limit their financial risk and to allow for a slower-paced learning curve.

COMPONENT SELECTION AND COMPATIBILITY

There are numerous manufacturers of SDI components and obtaining compatible components for a SDI system is not always a straightforward process. Competition among manufacturers for market niches can be a double edged sword. Although a myriad of new and innovative products are available, their use can lead to confusion and misapplication by the end user.

Connecting the dripline to the submain or header appears to be the most troublesome point in SDI installations, complicated by the fact that it is usually a double connection with a supply tube providing the transition. Copeland and Yitayew (1990) reported incompatibility between dripline and dripline connectors as one of the main problems encountered on a research SDI system at the University of Arizona. Much of this problem seemed to stem from the fact that the SDI system installation was split into bids from two companies that did not always match components. This problem would have been fairly inconsequential if the system had not been subsurface. Manufacturers might help to eliminate problems such as these by explicitly stating the brand names and specifications of known compatible products in their product literature. Color coding of connectors to a particular tubing size, tubing manufacturer, or tubing style might be another way to enhance compatibility. Some product literature uses terms like "universal" or "generic" to describe compatibility, when new products are being introduced continuously. Dealers and distributors can provide help by suggesting brand name products and specific part numbers. They should also educate end users about possible component incompatibilities caused by various dripline wall thicknesses and inside diameters.

Couplers that use rotation of a threaded collar to create an interference fit between the connector and thin-wall drip tape can cause problems. Although these couplers create a watertight seal when properly connected, variability in the squareness of the dripline cut; dripline temperature and dryness; and the installer's experience, fatigue, and hand strength can have a large influence on the success of the final connection. Making the connection for surface systems is very different than making the connection in a trench or hole that may 45 to 60 cm below the soil surface. Manufacturers might consider developing new, reliable, watertight, foolproof, easy-to-install connectors for SDI systems. The higher costs of such connectors might be buffered by labor savings in ease-of-use and in fewer repairs of leaking connections. End users also must use quality control because of the variability among installers. Checking all connections for water tightness before backfilling is very important.

Compatibility of solvent cements and the associated components has created problems in research installations in Texas and California. Bondable saddles installed on the submain seem to be one of the major points of concern. Although some product literature indicates that heavy body cements should be used, manufacturers and distributors might enhance this point by noting it on or in each box of saddles distributed. Maintaining the saddles in the proper position with sufficient pressure until adequate bonding has occurred is a problem in subsurface situations. This problem appears to be resolved best by securing the saddle with hose clamps, wire, tape, or heavy string. However, this can be costly or time consuming. Proper care also must be used when drilling the pilot hole for the saddle (Schoneman et al. 1992). Manufacturers need to clearly state the type and size of drill bit to be used for their saddles and inserts. Again, pressurized checking of the system before backfilling is important.

Installation guides published by some of the dripline manufacturers show numerous ways of making a connection or dripline closure. It would be useful if the literature could be expanded to discuss the pros and cons of the different connection methods and perhaps even suggest preferred or appropriate methods for SDI systems. For example, the method for drilling an undersized hole in the PVC submain for an interference fit with the supply tube is inexpensive but does require more care by the installer. Installer errors related to these interference connections were listed as a major source of problems in a research SDI system in Colorado (Kruse and Israeli, 1987). Leaks at the dripline connection also were listed as the greatest problem in a 100-ha strawberry operation in California (Feistel, 1992). Having a water-efficient and uniform irrigation system is difficult when it is full of leaks.

Manufacturers should offer optional availability of custom-length dripline rolls to accommodate a multiple of the end user's field length, thus minimizing the number of in-field splices. Splicing one reel of dripline to the next is critical, because the splices are buried before they can be tested. These splices are further away from field margins where they are difficult to repair and harder to detect under a growing crop. Dripline manufacturers need to develop a foolproof connection for this purpose. The connection needs to pass undamaged through the chisel injection tube as the dripline is installed into the ground.

Manufacturing defects in driplines were listed as a major problem in 2 of 20 systems in California surveyed by Feistel (1992). A small amount of defective dripline without emitters also was encountered in a research SDI installation in California. These occurrences are probably quite rare, but problems associated with defects in a SDI system are time consuming to diagnose and repair. Dripline defects in a SDI system might be noticed first when it is too late (i.e., when crop yields are reduced). As was previously mentioned, the repair or replacement of a surface installed dripline is much easier.

INSTALLATION OF SYSTEM

A few dripline injector systems are commercially available for plowing in the dripline. However, the suitability of these implements for a particular soil type and installation depth appears to be an unanswered question. Typical draft requirements and installation speeds should be specified for various soil types and operating depths, as well as the maximum allowable safe draft to prevent injector equipment failure (shear bolt strength ratings). Equipment options and their functions should be listed clearly in the product literature.

Dripline reels and rolls need to have standardized hubs to accommodate equipment from different manufacturers and should allow for easy changing of spools in the field. The cardboard roll retainers sometimes will allow the dripline to slide down to the hub and stretch or tear. Manufacturers have suggested sandwiching the cardboard retainers between plywood, which would help with clean spooled dripline, but does not solve the problem of pinched tape that occasionally occurs on rolls directly from the manufacturer. Recyclable, rigid, plastic, roll retainers could be offered as an option.

The dripline connection to the submain already has been noted as a major problem area. End users should pay particular attention to this area by selecting a methodology that they can use successfully and also by selecting appropriate skilled workers for this task. An additional installation problem is kinked supply tubes which can occur because of improper measurements, placements, or during backfilling. Use of the 13 to 19 mm flexible PVC tubing instead of the more conventional polyethylene tubing as the supply tube may help to avoid kinked tubes. Care should be during the dripline injection operation to ensure that the installation depth at the location of the submains is at the same uniform depth as the general field. Consistent installation depth allows for uniformity in length and placement of the supply tube, and allows for uniform tillage depths within the general field and the field margins.

Currently, installation generally is performed by the end user. However, this convention is slowly changing and, with time, dealers who can provide a turn-key system will evolve. Manufacturers should seek to nurture and encourage this process, while at the same time providing improved educational materials for those who want to install these systems on their own.

Installation practices for SDI systems need to be viewed with regard to their effect on the long-term operation of the system (Camp et al. 1997). For example, a 40-cm wide trench with the excavated dirt moved away from the trench is more expensive than a narrower trench with loose soil mounded along the sides. However, installers can make better quality connections inside a cleaner, wider trench and the total cost of the installation will likely be less since fewer repairs will be required. Another cost-saving technique is the use of stainless steel wire ties in dripline splices. They are initially more expensive but will not rust out nearly as soon as the less expensive black steel wire ties. Effective testing and quality control procedures for checking all connections before backfilling are other examples where the added effort will be cost effective in the long run.

CONCLUDING STATEMENT

The potential for SDI technology to move into the agronomic field crop market is increasing. However, cost/profit margins are much lower within these production systems as compared to horticultural crop systems. It is reasonable and justified to minimize SDI system investment costs whenever possible and practical. However, a quality installation that can be operated and maintained easily must be accepted as less expensive than a minimal substandard design that requires frequent and possibly frustrating repairs. Successful adoption of SDI technology will require durable, compatible, and user-friendly components; local support for design, installation, and service; and continuing educational programs on proper operational and management procedures. Success will depend on a heightened awareness and commitment to quality similar to those required in other advanced technologies.

REFERENCES

Ayars, J. E., C. J. Phene, R. A. Schoneman, B. Meso, F. Dale, and J. Penland. 1995. Impact of bed location on the operation of subsurface drip irrigation systems. Pages 141-146 in proceedings of the Fifth International Microirrigation Congress, Orlando, FL., Apr. 2-6, 1995. Available from ASAE, St Joseph, MI. 978 pp.

Burt, C. M. and D. Kasapligil. 1992. Permanent row crop drip -- management and design (with a California emphasis). Published by Irrigation Training and Research Center, California Polytechnic State University, San Luis Obispo, CA. 50 pp.

Camp, C. R., E. J. Sadler, and W. J. Busscher. 1997. A comparison of uniformity measures for drip irrigation systems. Trans ASAE 40(4) (in press).

Copeland, R. D. and M. Yitayew. 1990. Evaluation of a subsurface trickle irrigation system. Presented at the international winter meeting of the American Society of Agricultural Engineers, Chicago, IL, Dec. 18-21, 1990. ASAE Paper No. 902531, ASAE, St. Joseph, MI. 9 pp.

Feistel, S. 1992. Senior project survey. Pages 20-24 in Permanent row crop drip -- management and design (with a California emphasis). Published by C. M. Burt and D. Kasapligil, Irrigation Training and Research Center, California Polytechnic State University, San Luis Obispo, CA. 50 pp.

Hanson B., L. Schwankl, S. R. Graham and T. Pritchard. 1994. Drip irrigation for row crops. Water management series publication number 93-05, Univ. of California-Davis Cooperative Extension, Davis CA. 175 pp.

Jorgenson, G. S. and K. N. Norum. 1992. Subsurface drip irrigation -- theory, practices and application. Conference proceedings sponsored by California State University-Fresno and USDA ARS-Water Management Research Laboratory. CATI Publication No. 92-1001, CSUF, Fresno CA. 212 pp.

Kruse, E. G. and I. Israeli. 1987. Evaluation of a subsurface drip irrigation system. Presented at the international summer meeting of the American Society of Agricultural Engineers, 1987. ASAE Paper No. 87-2034, ASAE, St. Joseph, MI. 21 pp.

Lamm, F. R., L. R Stone, H. L. Manges and D. M. O'Brien . 1997. Optimum lateral spacing for subsurface drip-irrigated corn. Trans ASAE 40(4) (in press).

Schoneman, R. A., H. I. Nightingale and B. Yarnell. 1992. Subsurface drip installation. Presented at the international winter meeting of the American Society of Agricultural Engineers, Nashville, TN, Dec. 15-18, 1992. ASAE Paper No. 922552, ASAE, St. Joseph, MI. 6 pp.

Schwankl, L., B. Hanson, and T. Pritchard. 1993. Low volume irrigation. Water management series publication number 93-03, Univ. of California-Davis Cooperative Extension, Davis CA. 116 pp.