Heinz Sourell and Asaad Derbala, Brunswick

Mobile Drip Irrigation on Centre Pivot Irrigators

In arid areas, evaporation rates are considerably higher than in humid ones. Therefore, the irrigation technique must be improved with regard to water conservation. Mobile drip irrigation allows water losses to be avoided and the operating pressure for water distribution to be lowered. Common drip tubes replace irrigators or nozzles on the machines. The low area-related capital requirements of the centre-pivot machine led to this technology being used as a carrier- and water feeding system for the drip tubes.

Dr. Heinz Sourell is a scientist working at the Institute for Production Engineering and Building Research (IBB) (director: Prof. Dr. F.-J. Bockisch) of the Federal Agricultural Research Centre (FAL), Brunswick; e-mail: *heinz.sourell@fal.de*.
Dr. Asaad Derbala is a scientist working in the Agricultural Engineering Department, Faculty of Agriculture at Tanta University, Egypt. From 1999 until 2003, Dr. Derbala was a host scientist at the IBB of the FAL on a scholarship of the Egyptian government. In 2003, he obtained his doctorate from the Institute of Agricultural Engineering in Gießen.

Keywords

Drip irrigation, center-pivot irrigation machines, mobile drip irrigation

Literature

[1] *Derbala, A.*: Development and evaluation of mobile drip irrigation with center pivot irrigation machines. Landbauforschung Völkenrode, Sonderheft 250, 2003

Over the course of the development of irrgation technology, numerous solutions were sought which pursued the goal of improving the irrigation process under technical, organizational, and economic aspects. In general, this was achieved by increasing the amount of capital employed for modern irrigation systems. Since the development of the mobile irrigation machine in the seventies, no new irrigation techniques have been put on the market. Even at a worldwide level, drip irrigation as a capital-intensive irrigation technique with possibilities for water- and energy conservation has not found the acceptance which was hoped for. In addition to the large amount of capital needed, the great worktime requirements for the assembly and disassembly of the drip irrigation system in one-year cultures must be mentioned. Based on this analysis, mobile drip irrigation was developed. *Figure 1* shows the installation of the machine.

Choice of Emitters

The emitters for use in mobile drip irrgation must meet the following prerequisites: great uniformity and a low coefficient of variation of discharge, small emitter distance on the drip tube, and easy handling during installation on the centre pivot irrigation machine. The distance of the emitters on the drip tube is intended to be smaller than on common drip tubes. If water quantity at the centre pivot irrigator and the discharge rates of the emitters are known, drip tube length can be calculated. Five common emitters were tested with regard to discharge as a function of pressure and water temperature (*Fig. 2*).

The technical criteria of selection and the corresponding performance characteristics for the evaluation of the suitable emitter are summarized in *Table 1*. The Hydrogol emitter with an emitter distance of 0.15 m on the drip tube and a discharge of ~ 10 l/h at an operating pressure of 100 kPa was chosen. The emitter is not pressure-compensated, and if pressure fluctuates, the discharge rate varies as well. This dependence is also shown in *Figure 2*. The performance data for the description of discharge uniformity, such as the variation coefficient and the uniformity factor, show good results.

Field Trials

In the field trial, the selected drip tubes were mounted to three cross beams of a centre pivot irrigator. In addition, a sub-distributor pipe was installed at the centre pivot irrigator where the drip tubes are mounted. Further planning is based on the assumption that the drip tubes are directly connected to the main pipe. At a distance of 0.75 to 1.00 m, the main pipe is intended to be equipped with outlets by the factory. In the area between the connection of the drip tube to the machine and the ground, no emitters are installed because the water would otherwise flow together and time for infiltration into the soil would be insufficient. This would result in surface runoff. On soils hav-

Fig. 1: Installation of mobile drip irrigation at a center pivot irrigation machine

ing low infiltration rates, the drip tubes must be extended, and the discharge per emitter must be reduced.

Irrigation height during the trial was 20 mm, and the rotational period of the centre pivot machine was 48 h. The drip tubes were installed at a distance of 0.75 m. In order to determine lateral distribution precisely, the soil water content was measured with the aid of the gravimetric method directly before and 24 h after irrigation (*Fig. 3*). The trials and experiences in practical use prove that a distance of 0.75 m is sufficient in order to keep the soil water content constant from one drip tube to the next. In the long run, installation at a distance of 1 m is being striven for.

Another criterion for evaluation in use is the length of the drip tubes. Length is determined by emitter distance on the tube, the discharge rate per emitter (which, in turn, is dependent upon the operating pressure and water temperature), the position on the centre pivot irrigator, and finally the infiltration rate of the soil. At the location of the FAL in Brunswick, which is characterized by loamy sand soil (soil points 30 to 40), drip tube lengths of up to 17 m were calculated (emitter distance 0.15 m, operating pressure 50 kPa, position: at a distance of 415 m from the pivot of the centre pivot machine). The goal of further studies is the selection of presure-compensating emitters having high discharge rates so that the installation of pressure- or discharge limiters can be dispensed with.

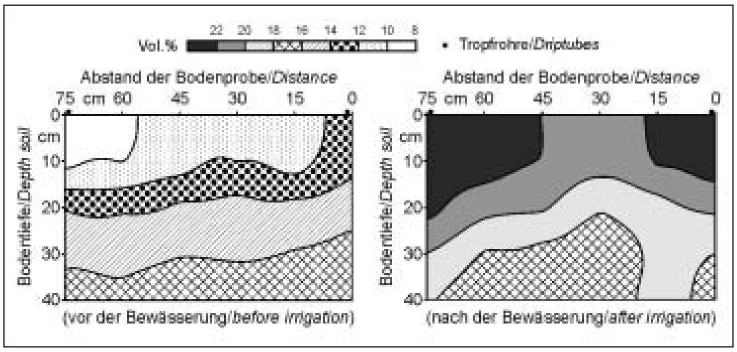

Fig. 3: Soil water content between two drip tubes before and after irrigation at a pressure of 50 kPa

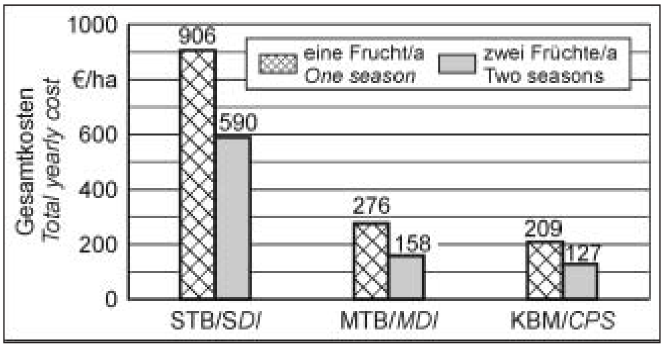

Fig. 4: Comparing total yearly costs of stationary drip irrigation (SDI), mobile drip irrigation (MDT) and a center pivot machine (CPS)

For the stability of the centre pivot irrigator, additional tensile force is important. The machine is not designed for tensile force. For the longest drip tubes installed (19 m), a frictional force of 183 N was measured. Per cross beam (in the segment ranging from 380 to 430 m), the sum of the frictional force for all drip tubes installed there is 2470 N. During the trial, the function of the centre pivot machine was not impaired. The travelling speed was kept, and the construction did not show any distortion. Statements by the manufacturer confirmed the problem-free absorption of the tensile forces.

Trials in potatoes show that the leaves were not damaged even if the drip tubes were drawn at right angles to the plant rows. In cereal cultures, there was no laid grain.

Evaluation

In conclusion, a comparison of the process costs between the different irrigation techniques was carried out. Given one vegetative period per year, stationary drip irrigation was the most expensive technique at total expenses of € 906/ha•a. At € 209/ha•a, centre pivot irrigation causes the lowest total costs. At € 276/ha•a, mobile drip irrigation lies between these two values (*Fig. 4*). The process costs can be reduced significantly if two vegetation periods per year are possible like in Egypt. In particular in arid and semi-arid areas, the advantages of water- and energy conservation will make a contribution towards the possibility of the new irrigation technique being able to protect resources in the future.

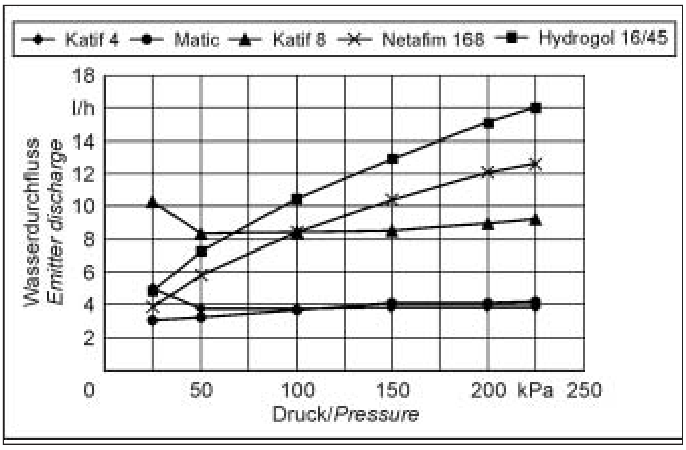

Fig. 2: Selection of emitters with high discharge for mobile drip irrigation

Table 1: Performance parameters of emitters tested under laboratory conditions at an operating pressure of 100 kPa

Performance parameters	Netafim	Hydrogol	Emitter Katif 8	Katif 4	Matic
Typ	In-Line	In-Line	On-Line	On-Line	On-Line
Water discharge in l/h	8,39	10,49	8,41	3,78	3,71
Variation-coefficient VK %	3,14	4,44	1,96	2,80	12,30
Factor of uniformity %	96,63	94,61	97,14	96,16	85,16
Distance between two emitters in cm	25	15	20	20	20
Installation	difficult	easy	rel. difficult	rel. difficult	rel. difficult