DRIP IRRIGATION FOR COTTON

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BY

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B.Sc. (Agric. Mech.), Menoufiya University, 1988

THESIS

Submitted in Partial Fulfilment of the Requirements for the Degree of

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IN

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Department of Agricultural Engineering

Faculty of Agriculture

Menoufiya University

1997

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1- INTRODUCTION

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The Egyptian cotton is one of the most important crops for fiber and oil production.

Most of the growing summer crops including cotton usually follow the winter crops at the end of May. Cotton production in silty-clay-loam is often limited by environmental conditions. In recent years, cotton high yield has not resulted into high profits due to the increase in the production costs as a result of lack of mechanization and the intensive cultivation practices.

The most irrigation technique which is applied for cotton is the surface irrigation every two weeks. Water losses under surface irrigation is high compared with those of the new irrigation systems such as drip irrigation, due to deep percolation and evaporation.

In view of the importance that irrigation management has in controlling the growth and the earlines of cotton, techniques such as drip irrigation with its controlled use of water according to specific application rates might be useful in irrigation cotton.

The current investigation was carried out at the farm of Faculty of Agriculture, Menoufiya University to compare between drip and surface irrigation techniques for irrigating cotton in silty-clay-loam soil.

2- REVIEW OF LITERATURE

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2.1 - Definition of drip irrigation : -

There are many definitions for drip irrigation. However, there are no much difference between them.

Gustafson (1969) defined drip irrigation as the daily maintenance of an adequate section of the root zone of plant with moisture, somewhere at any range from available water, as plant needs during the growing season.

Grossi (1971) stated that drip irrigation system is generally a line carries out the watering of the soil with drippers of various characteristics able to supply singly little surface and to distribute discharge, feeble but more or less continuous of the order of 0.5 - 25 Lit/h.

Havely et al. (1973) defined drip irrigation as mainly a technique where water and fertilizers can be placed at the direct disposal of the root zone, with the help of especially designed emitters, calculated for significant rates of flow.

Leon and Franceois (1974) defined drip irrigation as the method which provides small controlled amounts of irrigation water at frequent intervals to the root system of the plants.

Bucks et al. (1974) stated that drip irrigation consists of the slow delivery or water to the soil surface from a plastic pipeline fitted out with a series of emitters.

Tacheschke et al. (1974) stated that in the drip irrigation water is slowly applied to the soil surface from a point source and hydraulic potential gradients at a rate which is affected by the flow properties of the soil.

Goldberg et al. (1976) reported that water is delivered to plant by means of drippers or emitters, hence, the term drip irrigation is postulated. The water is applied at a very slow rate ranging from 2 to 8 Lit/h per dripper.

Davis (1967), Goldberg and Shmueli (1970), Mcnamara (1970), and Packard (1970) stated that advocates of trickle irrigation claim that it could produce higher yield, improve quality of production, decrease water usage, increase fertilizer efficiency and reduce labor cost.

2.1.1 - Manufacturer Variation

Keller and Karmeli (1974) introduced the coefficient of variation as a statistical measure for emitter manufacturing variation as follow :

$$C_v = \frac{1}{q`} \sqrt{\frac{\sum (q_i - q`)^2}{n}}$$

where :-

C_v = coefficient of variation.
$q`$ = the average of the discharge in (L/h).
q_i = the discharge of a given emitter, in (L/h).
n = number of emmitters.

This coefficient of manufacturer's variation was then included in design equations for emission uniformity as follow :

$$Eu = 100\left(1 - \frac{1.27 C_v}{\sqrt{e}}\right) \frac{q_m}{q_a}$$

where :-

C_v = the manufacture coefficient of variations.
e = number of emitters per plant.
q_m = the minium emitters discharge, (L/h).
q_a = the average emitter discharge, (L/h).

Solomon (1977, 1979) determined the manufacturing variation for various single and multiple orifice type emitters.

Nakayama et al. (1978) proposed a method based upon the coefficient of variation, for relating the number of emitters per plant to the application uniformity.

Bralts et al. (1981) reported that the purpose of drip irrigation is to apply water to the base of plants in frequents low volumes in an attempt to meet the consumptive use of plants. With this purpose in mind, it is essential that emitter flow variation and /or the uniformity of water distribution be known, particularly since irrigation time and rate are ultimately based upon these variables. The design of single chamber drip irrigation lateral lines considering hydraulic variation has been presented by various researchers.

Myers and Bucks (1972) and Wu and Gitlin (1974 and 1975) derived the hydraulic energy gradient line for determining the emitter flow variation and uniformity along a lateral line.

Howell and Hieler (1974 a and b) used the hydraulic energy gradient principle and developed lateral line design equations based upon specific uniformity criteria.

2.2 - Characteristic of trickle irrigation :

Cole (1971) found that about 50 percent of the water was saved using trickle irrigation.

Hitler and Howell (1973) Bernstein and Francais (1973), and Cho et al.(1974) stated that trickle irrigation results in considerable increase in water use efficiency (yield per unit volume of water applied) over furrow irrigation.

Keller and Karmeli (1974) stated that the objective of trickle irrigation is to provide each plant with a continuous readily available supply of soil moisture which is sufficient to meet transpiration demands.

Trickle irrigation offers unique agronomical, agretechnicall and economical advantages for the efficient use of water.

Belchevi and Floroy (1983) stated that drip irrigation is characterized with a good uniformity distribution of water. They also mentioned that drip irrigation gives a yield higher than that which is irrigated with another methods.

Howell and Hiler (1974 a) reported that trickle irrigation is a method of watering plants frequently and with volumes approaching the consumption use of the plant, thereby minimizing such "conventional" losses as deep percolation, run off, and water evaporation.

Goldberg (1971) reported that the rate of the horizontal water movement in the soil and the metric potential at different distance from the trickle source are functions of both soil type and trickle discharge rate. The final width of the wetted zone along a trickle irrigation line is therefore, a function of amount and rate of water application and soil type.

Philip (1971) stated that the soil moisture distribution is one of the most important factors involved in successful design and management of trickle irrigation system.

Levin et al. (1974) concluded that the soil water distribution volume was directly dependent on both the discharge rate of trickles and the duration of the irrigation

EL-Awady et al. (1975) designed a trickle system successfully operated on a new trickling of very low pressure (about 40 cm head), with the main advantages of using large trickles resulting in less plugging troubles in addition to other simplifications in the system.

Rawlines and Raats (1975) cleared that the need for increasing crop production with a limited water supply has made trickle irrigation the subject of many recent scientific investigations. Uniform, frequent irrigation offers great potential for optimizing the root environment while reducing irrigation water requirements.

El-Berry (1990) found out that (1) the emission uniformity values for the three lateral lengths (40, 60 and 80 m) where within the minimum recommended value (90%), and to a maintain a desired pressure variation the lateral's length must be shortened with precise leveling, (2) the exponent of the discharge - inlet pressure equation (x) was higher for the 40 m lateral length (0.53) and lower value for the 80 length (0.37), the lower the value of x, the less the flow rate affected by pressure variation and (3) the operating pressure head (5-8 m) is suitable for fodder and vegetable production, since, the available discharge under this pressure was 4-5 L/h/m length of bi-wali tube.

Badr (1991) showed that there was a different distribution for soil moisture using different discharges of dripper and different spacings between drippers on the lateral. Also the added that the irrigation internal affecting on the time which the soil takes to reach the field capacity.

2.3 - Field water use efficiency :

El-Away et al. (1990) stated that the water use efficiency "WUE" according to Viets (1962) equals :-

$$WUE = Y / ETC$$

Where :-

Y	= the total fresh crop weight, Kg/fed.
ETC	= the seasonal water use, m^3/fed.
WUE	= the water use efficiency, Kg/m^3.

Michael (1978) mentioned that water use efficiency can be increased either by increasing the numerator (crop yield) or by decreasing the denominator (the seasonal water use).The numerator, being plant production, depends on such plant factors as gains due to photosynthesis verses losses due to diseases and pests. Hence, water use efficiency can be influenced by such means as pest and diseases control, the choice of crop and the genetic improvement (by selection and breeding for its productivity and adaptation to the particular environment) as well as by improvement of the water, air and nutrient supply to the roots and the improvement of light and carbon supply to foliage.

Zeinab et al. (1990) had also used the same equation of Viets (1962) to calculate the water use efficiency.

2.4 - Cotton yield :

Mukerji et al. (1990) stated that cotton yield was the highest with alternate furrow irrigation, a method which used 50% of the water used in the commonly practiced flood irrigation system.

Hake et al. (1992) stated that, the drip - irrigated cotton was grown on medium deep clay soil using spacings of 75 x 10, 75 x 20, 75 x 30 and 75 x 40 cm. Plant height at 150 days after sowing was lower at 75 x 10 cm than at all other spacing. Yield, leaf area, branch and boll number, and seed cotton yield per plant increased with increasing spacing, while seed cotton, lint and cotton seed yield per hectare were the highest at the 75 x 10 cm spacing.

Mateos et al. (1991a) studied the drip irrigation system for cotton and the effect of distance between emitters (0.4, 0.75, 1 and 1. 25 m) along driplines spaced 2m apart on yield They found out that the grain yield with drip irrigation was about 5t/ha and significantly higher than those from an adjacent furrow irrigated plot (< 3t/ha).

Bezborodov (1991) stated that when cotton irrigated in furrows by a self-propelled pipeline 800 m long with an output capacity of up to 95 Lit/s, the amount of raw cotton harvested increased by 15% and irrigation water needed decreased, on average by 28.7% than traditional irrigation method. However, he concluded that such a pipeline would reduce variation in soil moisture content, optimize irrigation method and increase cotton yield.

In field trials cotton was thinned to 8 or 12 plants /m of a row and drip - or sprinkler - irrigated at 1- to 14 - day intervals supplying 230 - 780 mm of saline or non-saline water was applied (Meiri et al, 1992). They found out that the response function for drip irrigation had no break point, but had the same slope and intercept as the sprinkler treatments.

Water salinity, irrigation method and frequency, and interrow spacing did not affect the linear response of seed cotton or yields to water when factor other than water availability were not limiting.

The effects of four irrigation methods flood irrigation, irrigation to each furrow, irrigation to alternate furrows, and irrigation to furrows between paired crop rows, on water economy, growth and yield of cotton was studied by Aujla et al. (1991). They found out that Irrigation water saving by the modified water delivery treatments in comparison with flood irrigation was in the order alternate furrows > single furrow between paired rows > every furrow. Alternate furrow irrigation required about 50% of the water needed for flooding with little or no loss in productivity.

Cotton was flood- irrigated about every 10 days and every 14 days (control treatment), and drip - irrigated daily throughout most of the season (Radin et al. 1992). A supplemental flood irrigation was applied during 1 or 2 long irrigation cycles coinciding with peak fruiting. The total amount of water applied was minimally changed from the control because other irrigations were reduced to compensate for the supplementation. They reported that one supplement increased seed cotton yield by 15% compared with the control, and 2 supplements increased it by 25%, while drip irrigation increased it by 40%. These 3 treatments increased crop water-use efficiency (yield per unit applied water + rainfall) by 12,22 and 50% , respectively.

A two- year experiment was carried out on a sandy loam soil at Cordoba, Spain, to compare drip with furrow irrigation in cotton. (Mateos et al, 1991b). They stated that, the results indicated an advantage for drip irrigation treatments, were water application efficiency was 30% higher for the drip irrigation treatments.

Qiu (1991) stated that, drip irrigation technology was successfully applied to grain, cotton and oil crops and reduced project costs.

Alvarez and Reyna (1991) stated that significant differences in plant growth were found between drip irrigation treatment comparing with water stress treatment. Lint yield was unaffected by irrigation treatments, but significant differences between cultivars were observed. Significant differences in fibber properties were observed between irrigation treatments and cultivars moreover, they added that water use efficiency decreased with increasing water supply.

Hodgson et al. (1990) stated that there were more roots and more deep roots with furrow irrigation than drip irrigation. They also found by calculation that the ratio between line yield and total water received by the crop was 16% higher with drip irrigation (2.23 kg/ha. mm) than with furrow irrigation (1.89 kg / ha . mm).

Constable and Hodgson (1990) stated that lint yields for cotton were 1.63, 1.73 and 1.68t/ha for surface and buried methods of drip irrigation and furrow irrigation of cotton. They concluded that even though the drip irrigation system had a higher yield potential, the performance of the system did not justify the high economic outlay to grow cotton at this site, especially in cool or wet seasons.

Furrow irrigated cotton on clay soil was studied by Pitts et al. (1990). They stated that furrow irrigation resulted in a