

# ABSTRACT

Surface irrigation is the oldest and widely used method of irrigation in Egypt. A major cost in surface irrigation is the labor required for irrigation as well as high percent of the irrigation water applied loss and improper management, however, these caused to drop surface irrigation efficiency. Controlled surface irrigation systems by using enclosed pipelines have been successfully demonstrated in recent years. The common pipes type is that perforated system, which is a simplified type of gated pipes system. The main purpose of this study was to improve surface irrigation management by developing of perforated pipes system to give high efficiency under furrow irrigation systems. To achieve the competence of the preceding developed system, the following work is carried out hydraulic studies of developed (telescopic) perforated pipes to determine the energy gradient curve and outflow orifices variation along the telescopic perforated pipes, and estimate orifice discharge coefficient ( $C_d$ ). The developed perforated pipe was tested under five different inlet (pumping) discharge rates which are 15.43, 21.25, 21.73, 22.38 and 23.80 m<sup>3</sup>/h. Field evaluation of developed system by estimating water application, water distribution and field water use efficiencies on soybean "Giza 111 variety" were carried out during the summer growing season of 2004 under five different irrigation treatments.

Results indicated that the trend of measured resultant pressure head at the orifices along the telescopic perforated pipe increased as the discharge rate of inlet the pipe increased. The resultant pressure head reached about 103.28 % to 103.96 % at the last orifice of the inlet pressure head at the pipe inlet. The average orifice discharge rate increased as the pressure head at the pipe inlet increased. The average orifice discharge coefficient equals 0.503 based on the circular orifices that were 25 mm in diameter where, rubber seals were fixed in the edge of orifices. The flow variation through orifices along the telescopic perforated pipe decreased as the inlet flow (pumping) discharge increased. The theoretical performance of pressure component and outflow discharge flow rates of orifices correlated experimental results. Surge flow "15 min on - 45 min off" with telescopic perforated pipes (T.P.P.) had faster advance time and saved the amount of applied irrigation water by about 46.64 % compared with continuous irrigation by using conventional perforated pipes (C.P.P.). Also, highest water application efficiency ( $E_a$ ) (87.47 %) and water application efficiency of low quarter ( $E_{alq}$ ) (83.84 %), water distribution efficiency ( $E_d$ ) (84.26 %) and water distribution uniformity ( $D_u$ ) (86.46 %), yield ( $Y$ ) for soybean crop (1.81 Mg/fed.) and water use efficiency (WUE) (0.95 kg/m<sup>3</sup>) were observed for surge flow "15 min on - 45 min off" with T.P.P. Generally, it can be concluded that surge flow with T.P.P. technique can not only save the water amount, but also enhance the soybean yield and therefore, the net income of the farmers.

***Keywords:*** Hydraulic analysis, Discharge coefficient, Energy gradient, surge flow, Water use efficiency, Soybean.

## المستخلص العربي

الري السطحي من أقدم وأكثر طرق الري استعمالاً في مصر ، وتشكل متطلبات العمالة في الري السطحي التكلفة الباهظة بالإضافة إلى الإدارة غيرالصحيحة ونسبة فقد عالية في المياه مما يؤدي إلى انخفاض كفاءة الري السطحي. وقد ظهرت في الأعوام الأخيرة بعض التقنيات لتحسين كفاءة الري السطحي حيث يمثل تقنية الأنابيب المثقبة نوعاً مبسطاً من نظام الري بالأنابيب المبوبية. الهدف الرئيسي من هذه الدراسة هو تحسين إدارة الري السطحي بتطوير نظام الري بالأنابيب المثقبة لري المحاصيل بكفاءة عالية. وللتحقق من كفاءة النظام المطور ، تم إجراء دراسات هيدروليكية لإيجاد منحنى انحدار الطاقة واختلاف التصرف للفتحات على طول الأنبوب المثقب التلسكوبي وتقدير معامل التصرف للفتحات. وتم اختبار الأنبوب المثقب التلسكوبي عند خمس معدلات سريان داخلية هي ١٥،٤٣ ، ٢١،٢٥ ، ٢١،٧٣ ، ٢٢،٣٨ و ٢٣،٨٠ م<sup>٣</sup>/ساعة. وأجريت التجارب الحقلية لتقييم النظام المطور على محصول فول الصويا "صنف جيزة ١١١" خلال موسم النمو الصيفي ٢٠٠٤ من خلال تقدير كفاءات الإضافة والتوزيع واستخدام المياه تحت خمس معاملات ري.

بينت النتائج زيادة الضاغط الهيدروليكي للمياه الناتج عند الفتحات على طول الأنبوب المثقب كلما زاد معدل سريان المياه الداخلة للأنبوب ، حيث يتراوح عند آخر فتحة بين ١٠٣،٢٨ ٪ إلى ١٠٣،٩٦ ٪ من الضاغط الهيدروليكي الأصلي عند مدخل الأنبوب تحت مختلف معدلات السريان الداخل. كلما زاد الضاغط الهيدروليكي عند مدخل الأنبوب ازداد متوسط معدل التصرف الخارج من الفتحات. ومتوسط قيمة معامل التصرف للفتحة مساوية ٠،٥٠٣ حيث أن الفتحات دائرية بقطر ٢٥ مم بعد تثبيت موانع مطاطية على حوافها. ويقل الاختلاف في السريان الخارج من الفتحات على طول الأنبوب المثقب كلما زاد معدل السريان الداخل للأنبوب. ويوجد توافق بين الأداء النظري لمكونات الضغط ومعدلات التصرف الخارجة والنتائج التجريبية (الفعلية). في التجارب الحقلية ، أعطى الري النبضي "١٥ دقيقة فتح - ٤٥ دقيقة غلق" باستخدام نظام الري بالأنابيب المثقبة التلسكوبية أسرع زمن تقدم للمياه ووفر كمية المياه بحوالي ٤٦،٦٤ ٪ مقارنة بالكمية المضافة للري المستمر باستخدام نظام الري بالأنابيب المثقبة التقليدية . وأيضاً ، سجلت هذه المعاملة أعلى نسب في كفاءة إضافة للمياه (٨٧،٤٧ ٪) وإضافة لأقل ريع (٨٣،٨٤ ٪) وكفاءة توزيع للمياه (٨٤،٢٦ ٪) وانظمة توزيعها (٨٦،٤٦ ٪) وأكبر إنتاجية لمحصول فول الصويا (١،٨١ مياجرام/الفدان) وكفاءة استخدام للمياه عالية (٠،٩٥ كج/م<sup>٣</sup>). وفي النهاية ، يمكن استعمال نظام الري بالأنابيب المثقبة التلسكوبية مع السريان النبضي لتوفير وحفظ المياه ، وزيادة قيمة إنتاجية محصول فول الصويا وصافي الدخل الموسمي للمزارعين.

# CONTENTS

	Page
<b>1. INTRODUCTION.</b> .....	<b>1</b>
<b>2. REVIEW OF LITERATURES.</b> .....	<b>3</b>
2.1. Advantages and disadvantages of surface irrigation. ....	3
2.2. Theory of surface irrigation. ....	4
2.3. Hydraulic of surface irrigation. ....	8
2.3.1. Field geometry. ....	8
2.3.2. Flow characteristics. ....	9
2.3.3. Surface roughness. ....	10
2.3.4. Infiltration. ....	11
2.4. Irrigation efficiencies . ....	13
2.4.1. Water conveyance efficiency. ....	14
2.4.2. Water application efficiency. ....	14
2.4.3. Water storage efficiency. ....	15
2.4.4. Water Application uniformity. ....	15
2.4.5. Water use efficiency. ....	16
2.5. Design and management of surge irrigation. ....	16
2.6. Perforated pipe system. ....	21
2.6.1. The advantages of perforated pipe. ....	23
2.6.2. Design and hydraulic analysis of perforated pipe. ....	23
2.6.2.1. Total head and loss of head in pipeline. ....	24
2.6.2.2. Flow characteristic through pipeline. ....	30
2.6.2.3. The orifice description and their types. ....	31
2.6.2.4. The orifice outflow characteristic. ....	31
2.7. Cost analysis. ....	34

<b>3. MATERIALS AND METHODS. ....</b>	<b>36</b>
3.1. Telescopic perforated pipes. ....	36
3.1.1. Geometrical description. ....	36
3.1.2. Operational plan. ....	42
3.2. The experimental pumping unit. ....	45
3.3. Hydraulic analysis. ....	45
3.4. Field experimental. ....	46
3.4.1. Experimental site. ....	46
3.4.2. Experimental layout. ....	46
3.4.3. Some soil physical properties of experimental site. ....	47
3.4.3. Soil infiltration rate. ....	49
3.4.3.1. Infiltration equation for continuous flow. ....	51
3.4.3.2. Infiltration equation for surge flow. ....	54
3.4.5. Experimental procedure. ....	57
3.5. Measurements. ....	58
3.5.1. Outflow rate and pressure head measured at each orifice. ....	58
3.5.2. Flow advance and recession (distance and time). ....	58
3.5.3. Time of irrigation. ....	59
3.5.4. Soybean yield. ....	59
3.6. Methods of calculations of the parameters. ....	59
3.6.1. Outlet discharge coefficient “ $C_d$ ”. ....	59
3.6.2. Outflow distribution uniformity and pressure head variation at orifices. ....	59
3.6.3. Theoretical performance of outflow and pressure head along telescopic perforated pipes. ....	60
3.6.4. Applied irrigation water. ....	62
3.6.5. Water application efficiency ( $E_a$ ), %. ....	62
3.6.6. Water application efficiency of low quarter ( $E_{alq}$ ), %. ....	63

3.6.7. Deep percolation percentage ( $D_{pp}$ ), %.	63
3.6.8. Water storage efficiency ( $E_s$ ), %.	63
3.6.9. Water distribution uniformity ( $D_u$ ), %.	64
3.6.10. Water distribution efficiency ( $E_d$ ), %.	64
3.6.11. Water use efficiency (WUE), $kg/m^3$ .	64
3.6.12. Cost and economic returns analysis.	65
<b>4. RESULTS AND DISCUSSION.</b>	<b>68</b>
4.1. Hydraulic analyses of telescopic perforated pipes for different the inlet flow rates.	68
4.1.1. Internal flow characteristics along the telescopic perforated pipes.	68
4.1.2. Actual discharge rates through orifices characteristics along the telescopic perforated pipes.	74
4.1.3. Pressure head variation, discharge flow variation and outflow distribution uniformity through orifices along the telescopic perforated pipes system.	78
4.1.4. Calculated vs. measured data of the hydraulic analysis parameters of the telescopic perforated pipes.	81
4.2. Field evaluation of telescopic perforated pipes technique.	91
4.2.1. Effect of telescopic perforated pipes technique with continuous and surge flow irrigation on advance rate, total amount of applied water and infiltrated water distribution.	91
4.2.1.1. Advance rate.	93
4.2.1.2. Total amount of applied water.	97
4.2.1.3. Infiltrated water distribution.	99
4.2.2. Performance parameters of furrow irrigation for telescopic perforated pipes with continuous and surge	

flow irrigation. ....	106
4.2.2.1. Water application efficiency ( $E_a$ ) and water application efficiency of low quarter ( $E_{alq}$ ). ...	106
4.2.2.2. Water distribution efficiency ( $E_d$ ) and water distribution uniformity ( $D_u$ ). ....	111
4.2.2.3. Crop yield (Y). ....	113
4.2.2.4. Water use efficiency (WUE). ....	116
4.3. Economic analysis. ....	118
<b>5. SUMMARY AND CONCLUSIONS. ....</b>	<b>122</b>
<b>6. REFERENCES. ....</b>	<b>127</b>
<b>7. APPENDIX A. ....</b>	<b>137</b>
<b>8. APPENDIX B. ....</b>	<b>146</b>
<b>9. ARABIC SUMMARY.</b>	