Effect of Hydraulic Head and Slope on Water Distribution Uniformity of a Low-Cost Drip Irrigation System

by

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Paper Presented at the 2008 Annual International ASABE Meeting

Providence, Rhode Island, USA

July 1, 2008

Background of Study

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- Potential use of low cost drip irrigation technology in upland watersheds for dry season cropping
- Use of drip is gaining popularity in developing countries (e.g. use of IDE Easy drip in SEA watersheds through SANREM)
- Maximization of crop yield depends on irrigation water distribution uniformity
- Choice of operating head compounded by topographic condition

Basic Issue

What operating head to employ to maximize water distribution uniformity under sloping conditions?

OBJECTIVE

To determine the effect of hydraulic head and slope on the water distribution uniformity of the IDE ‘Easy Drip Kit’ and consequently develop mathematical relationships to characterize the effect of slope and head on water distribution uniformity

METHODOLOGY

- 100 sq. m IDE Easy drip kit (10 m x 10 m)
- Submain Slopes: 0%, 10%, 20%, 30%, 40% and 50% (S_l = 0%)
- Operating Head: 1.0 m, 2.0 m and 3.0 m
- Sampled from 11 emitters per lateral for a total of 110 samples
- Direct volumetric measurement for emitter discharge
- 3 trials per setting
- At least 54 laboratory experiments

Experimental Set-up for Testing the IDE Drip Irrigation System

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Sampling and Data Collection

Evaluation of Water Distribution Uniformity

Christiansen's Coefficient of Uniformity

$$UC = (1-D/M)100$$

where:

- **UC = coefficient of uniformity (%)**
- **D = average of the absolute values of the deviation from the mean discharge**
- **M = average of discharge values**

Evaluation of Water Distribution Uniformity

Merriam and Keller's Emission Uniformity

$$EU = (q_{LQ}/q_{mean})100$$

where:

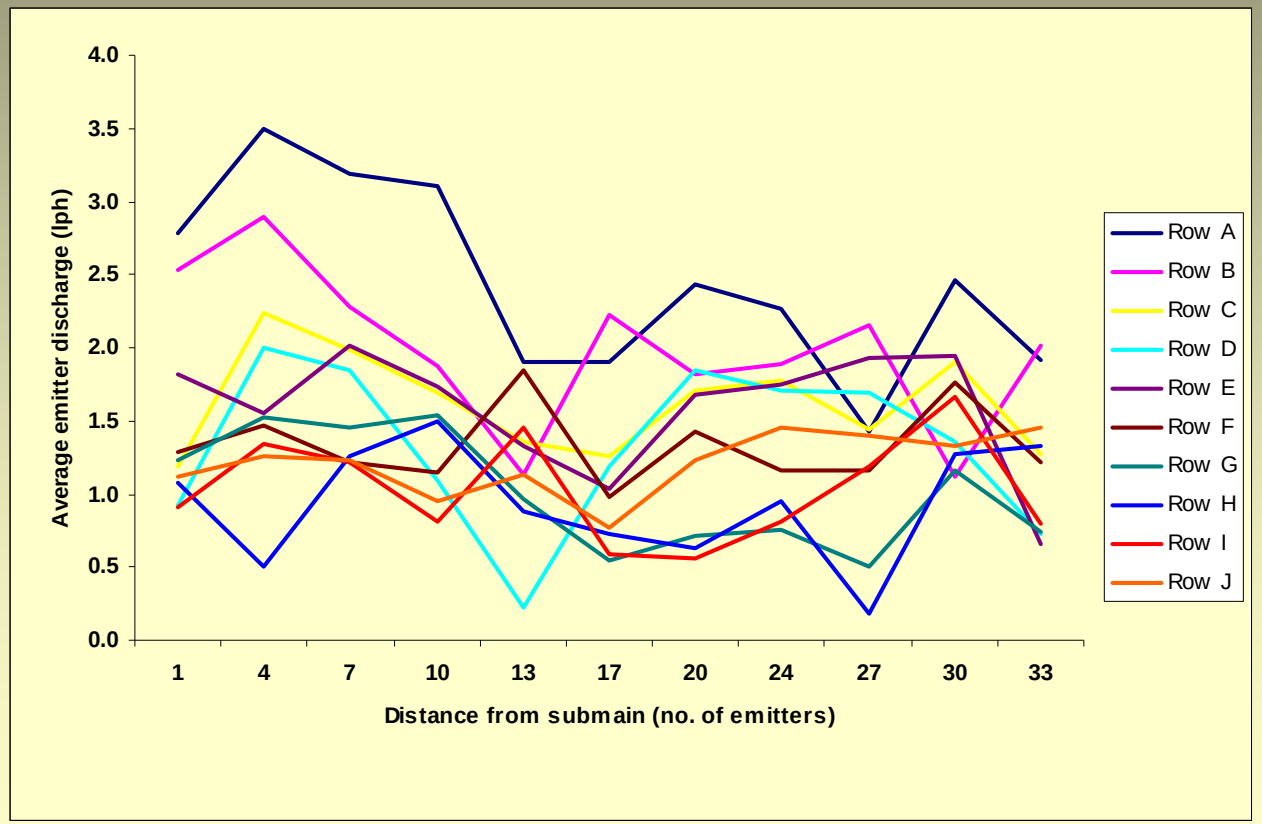
EU = emission uniformity (%)

q_{LQ} = average of the lowest quarter of the observed discharge values

q_{mean} = average of observed discharge values

RESULTS

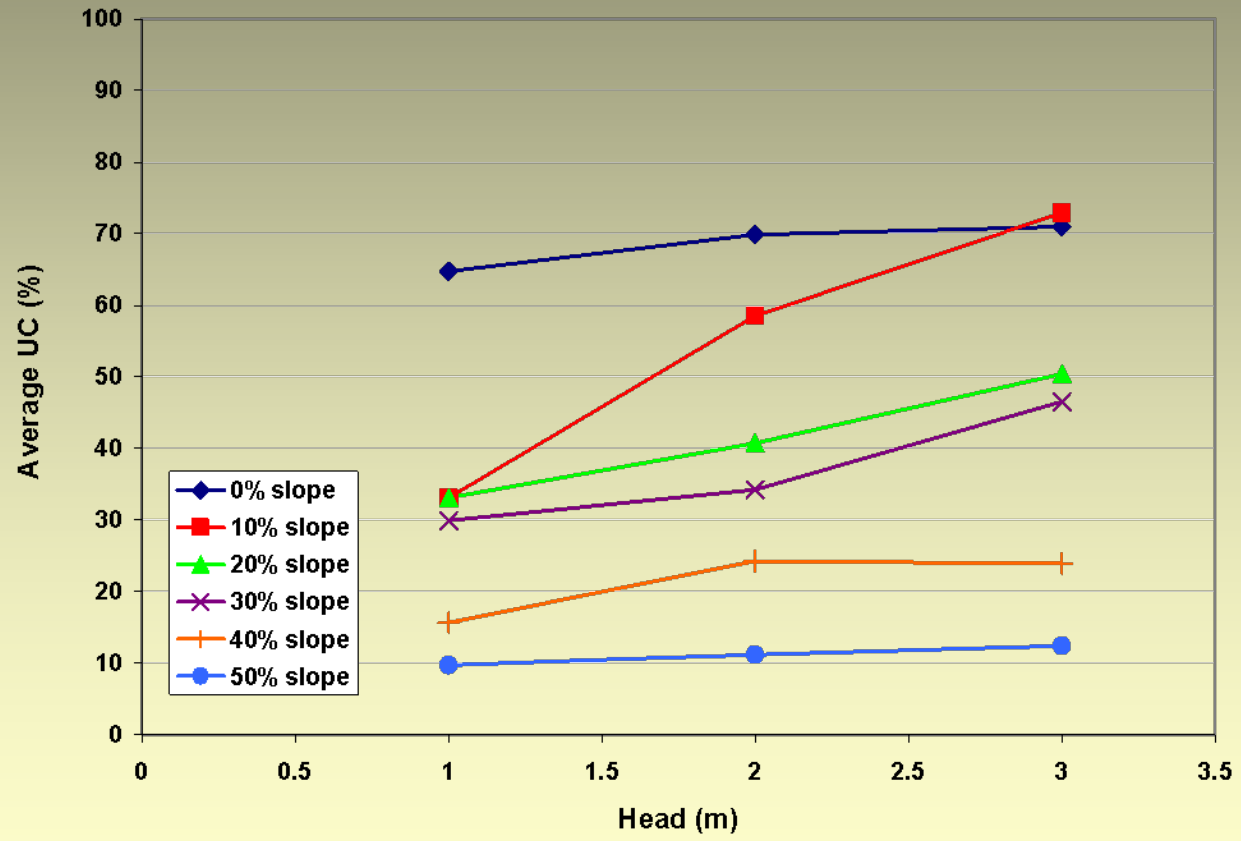
Typical emitter discharge variation along the lateral of the IDE drip kit at 0% slope



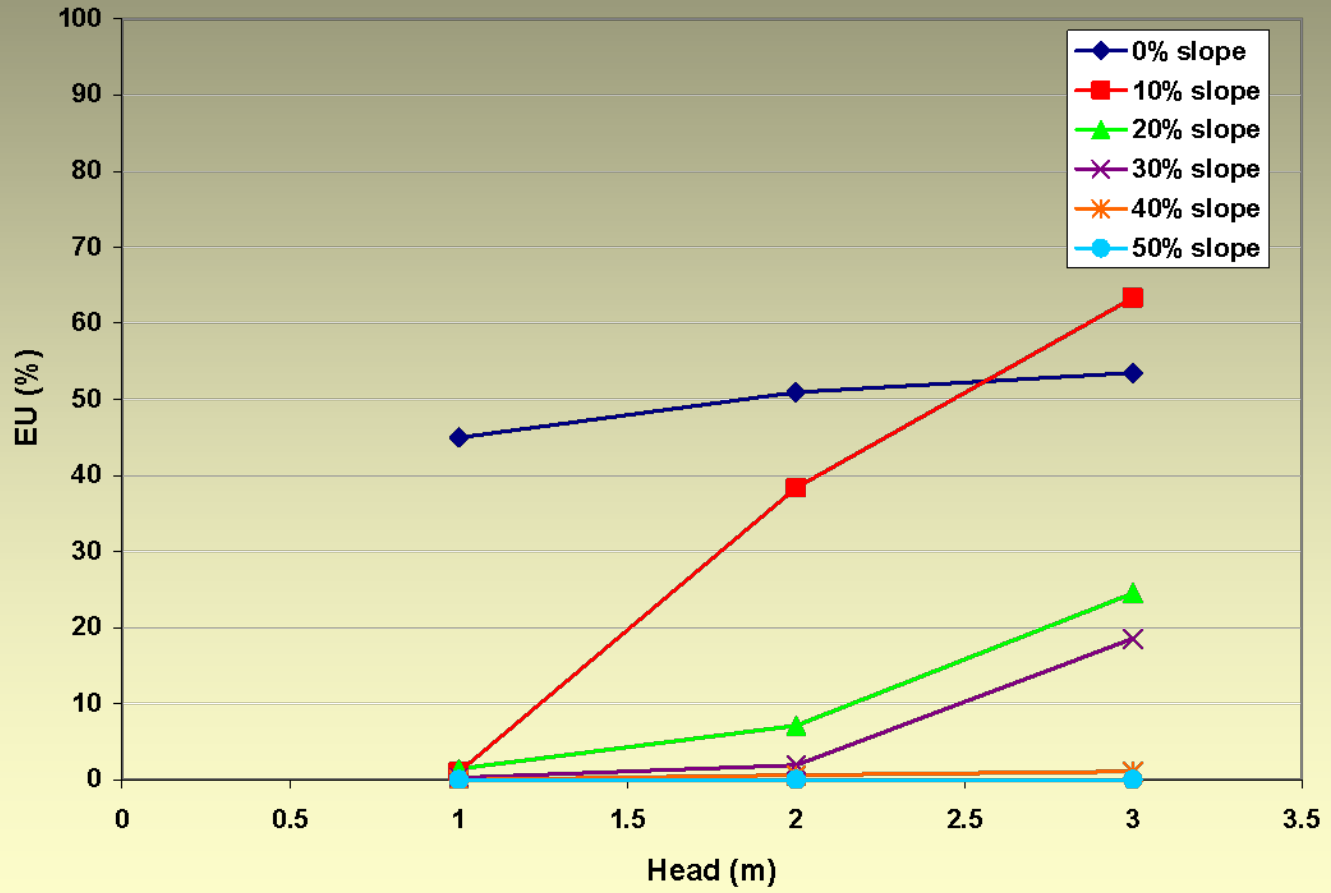
UC and EU at various Heads at 0% slope

Head (m)	Coefficient of Uniformity, UC (%)				Emission Uniformity, EU (%)			
	1	2	3	Mean	1	2	3	Mean
1.0	66.99	62.51	64.82	64.77	52.10	38.89	43.98	44.99
1.5	70.66	68.68	70.10	69.81	50.79	50.33	50.01	50.38
2.0	72.62	66.81	70.15	69.86	56.13	46.89	49.81	50.95
2.5	65.24	62.87	65.67	64.60	46.81	38.06	46.47	43.78
3.0	72.48	70.47	70.06	71.00	55.11	53.61	51.80	53.51
3.5	72.20	67.56	71.37	70.38	53.24	45.52	51.35	50.04

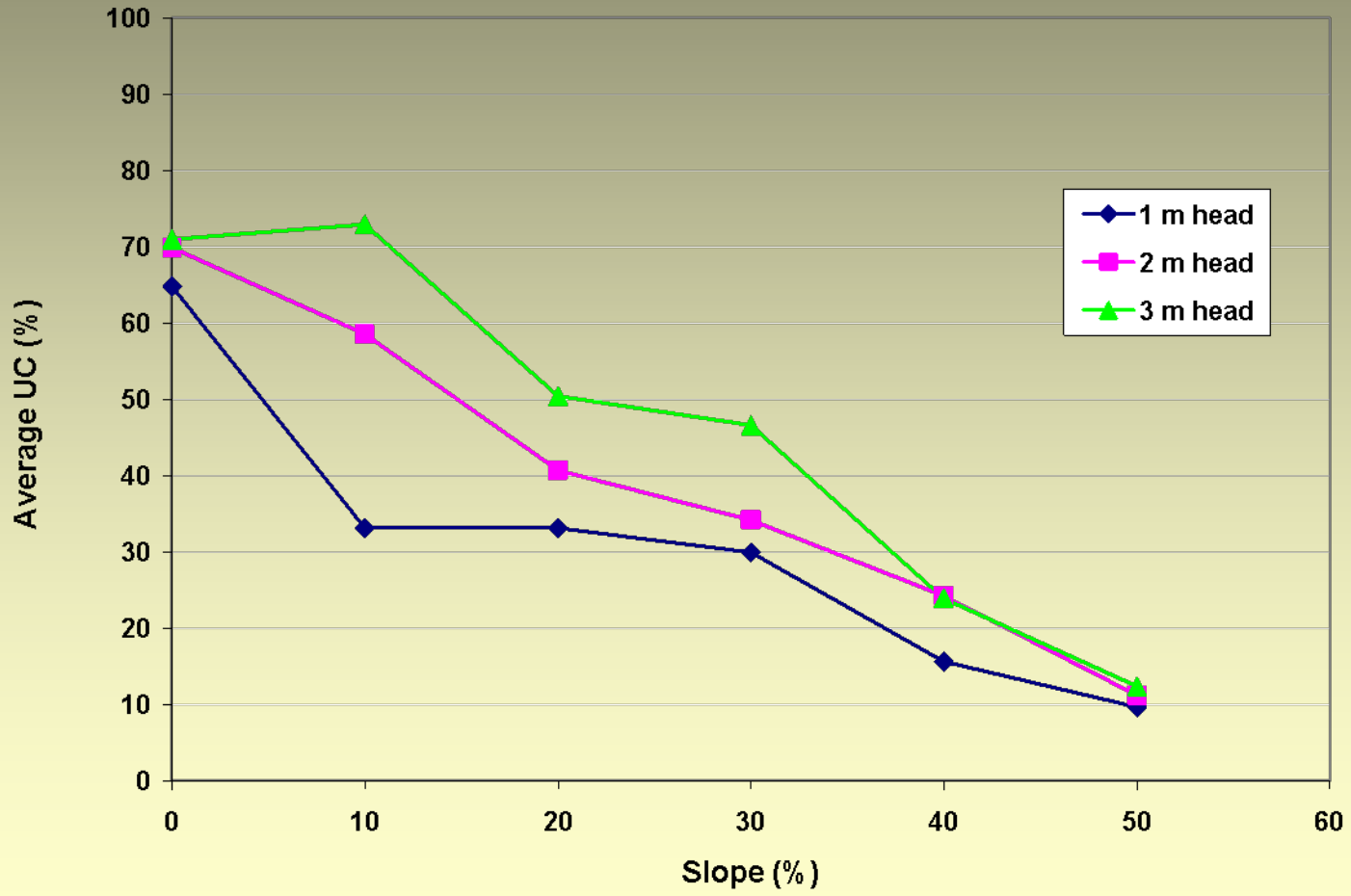
Effect of Head on UC at Various Slopes



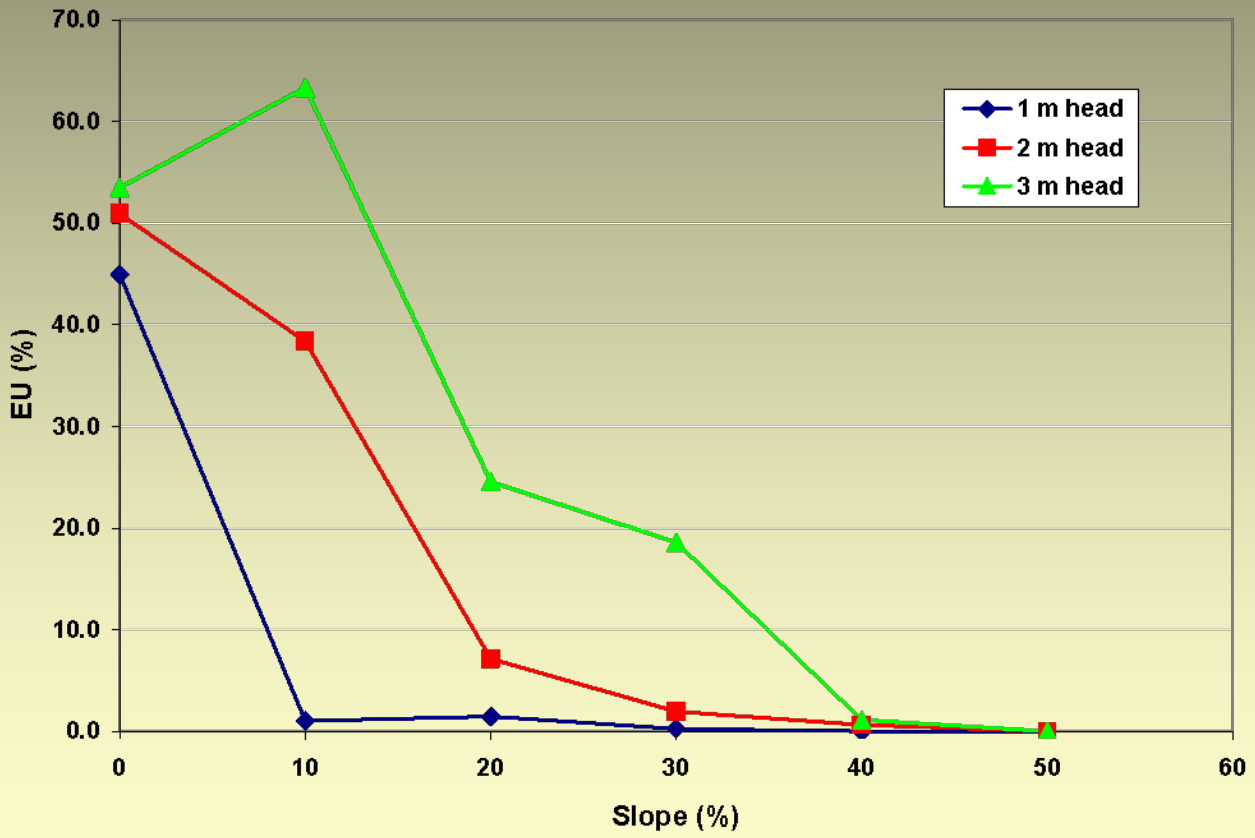
Effect of Head on EU at Various Slopes



Effect of Slope on UC at Various Heads



Effect of Slope on EU at Various Heads



Linear Regression Models for UC as a Function of Head at Various Slopes

Slope (%)	Linear Regression Model*	R^2
0	Y=1.50X + 65.02	0.233
10	Y=19.90X + 15.06	0.975
20	Y= 8.67X + 24.09	0.995
30	Y = 8.32X + 20.25	0.927
40	Y=4.14X + 12.98	0.722
50	Y = 1.35X + 8.37	0.997

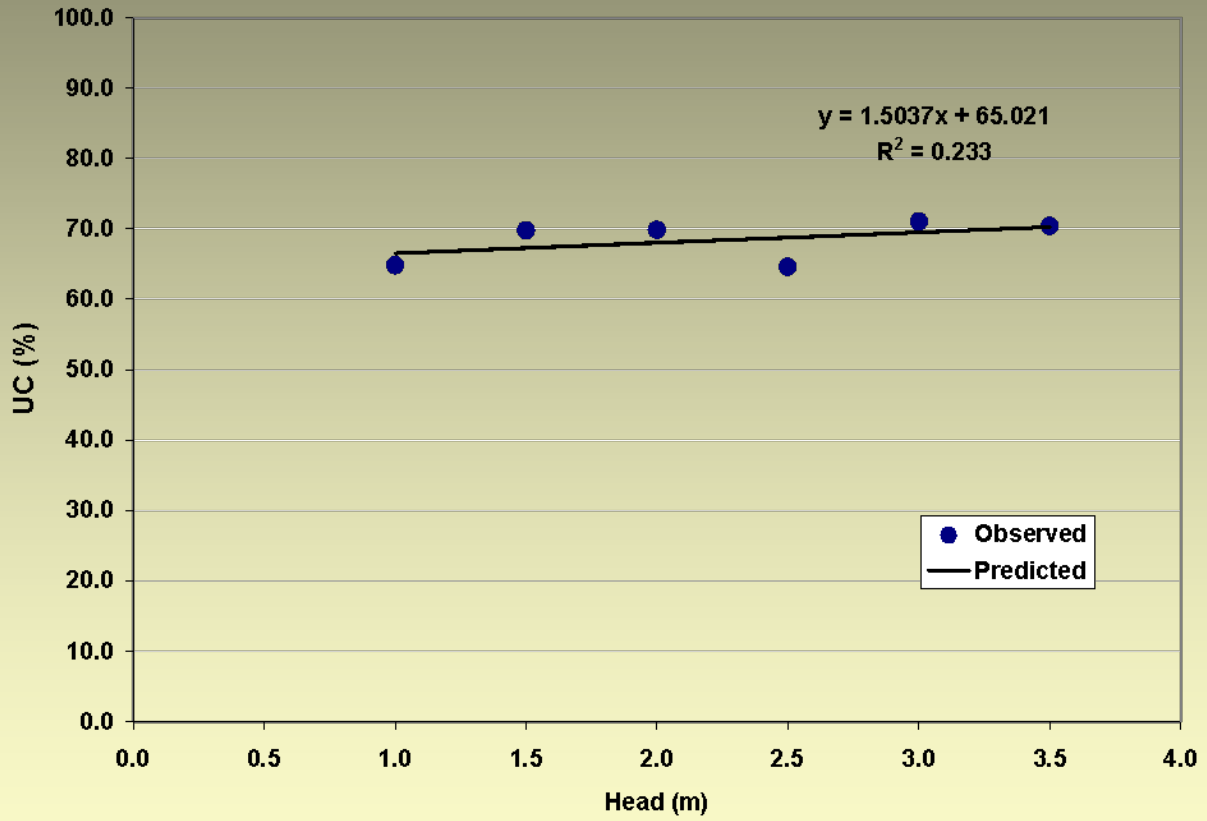
* Y = coefficient of uniformity, UC (%)
  X = head (m)

Linear Regression Models for UC as a Function of Slope at Various Heads

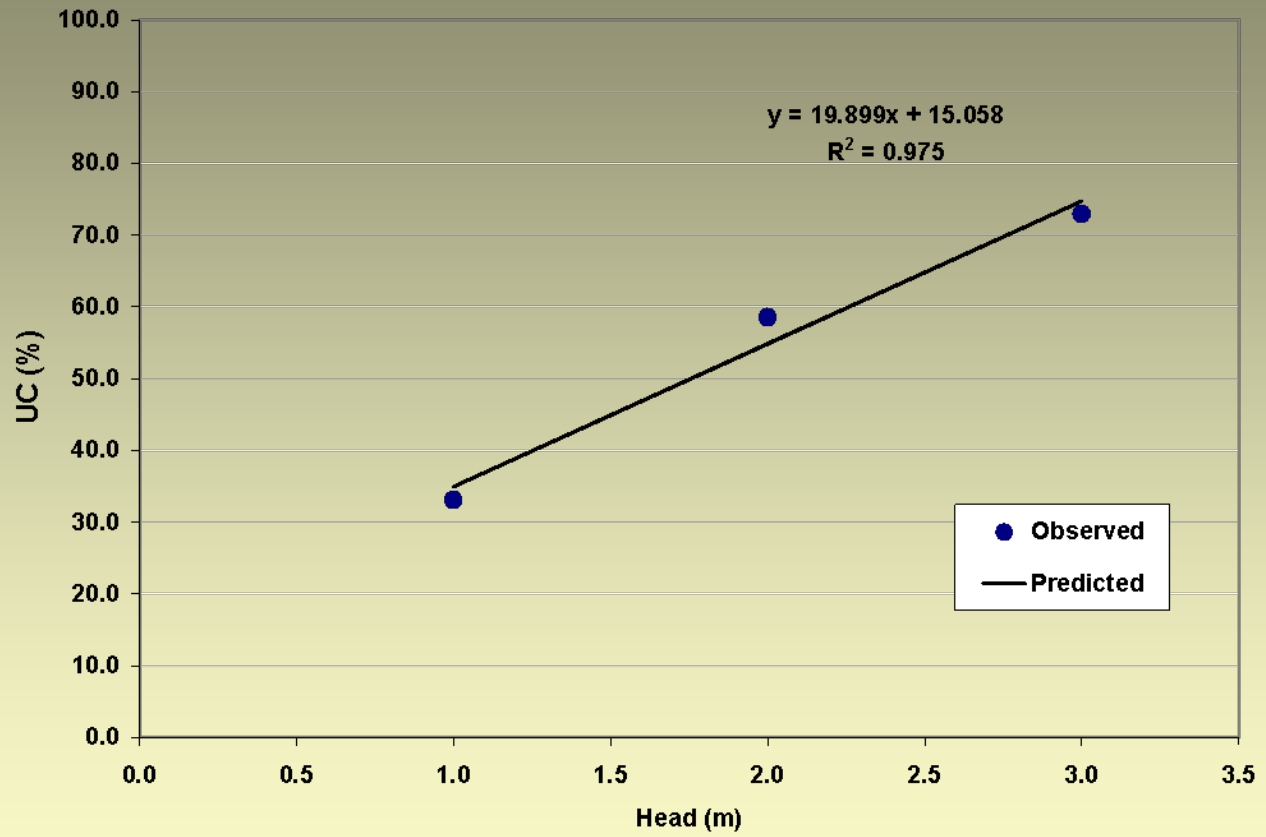
Head (m)	Linear Regression Model*	R^2
1.0	Y= -0.95X + 54.69	0.850
2.0	Y= -1.15X + 68.57	0.987
3.0	Y= -1.27X + 77.91	0.943

* Y = coefficient of uniformity, UC (%)
  X = submain slope (%)

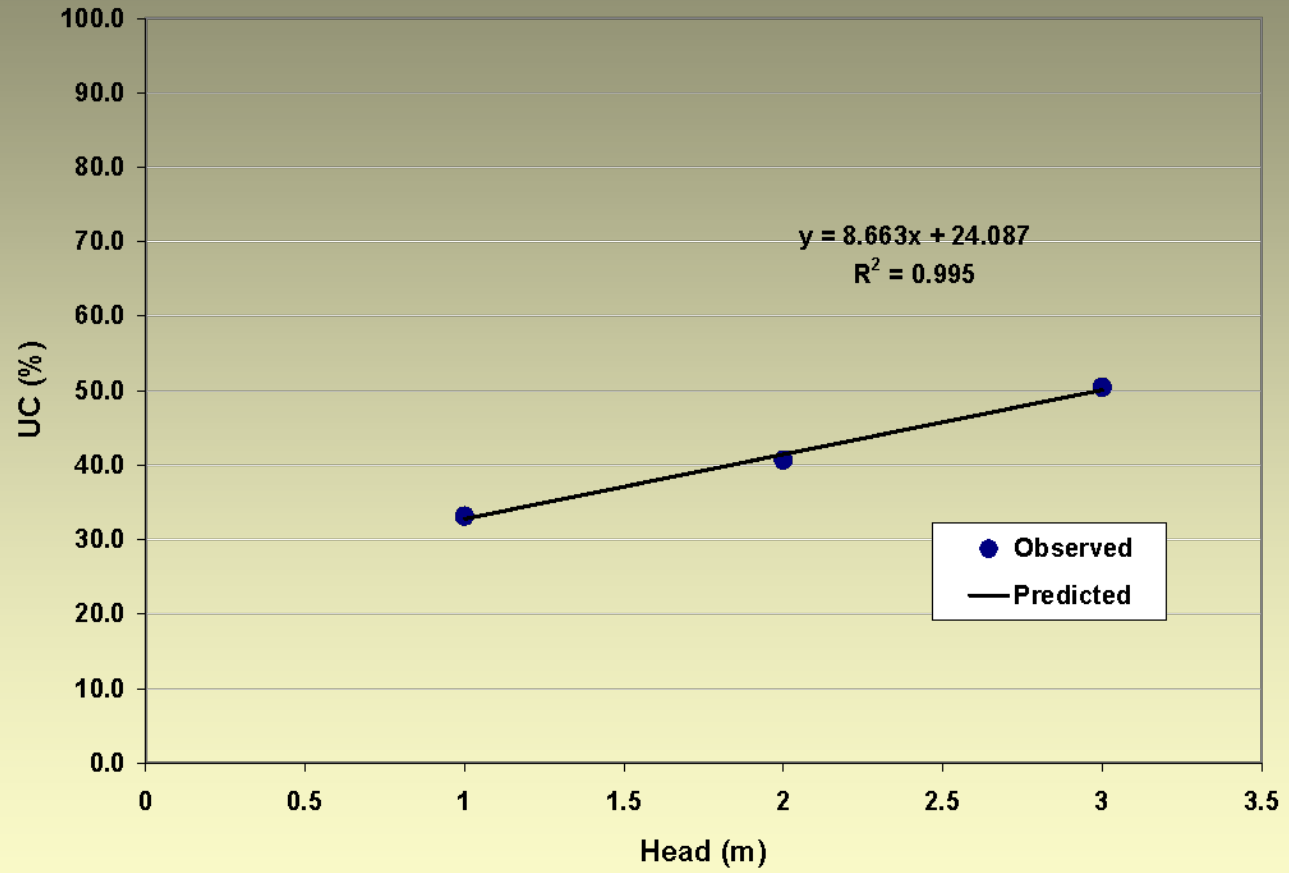
Observed and Predicted UC vs. Head at 0 % Submain Slope



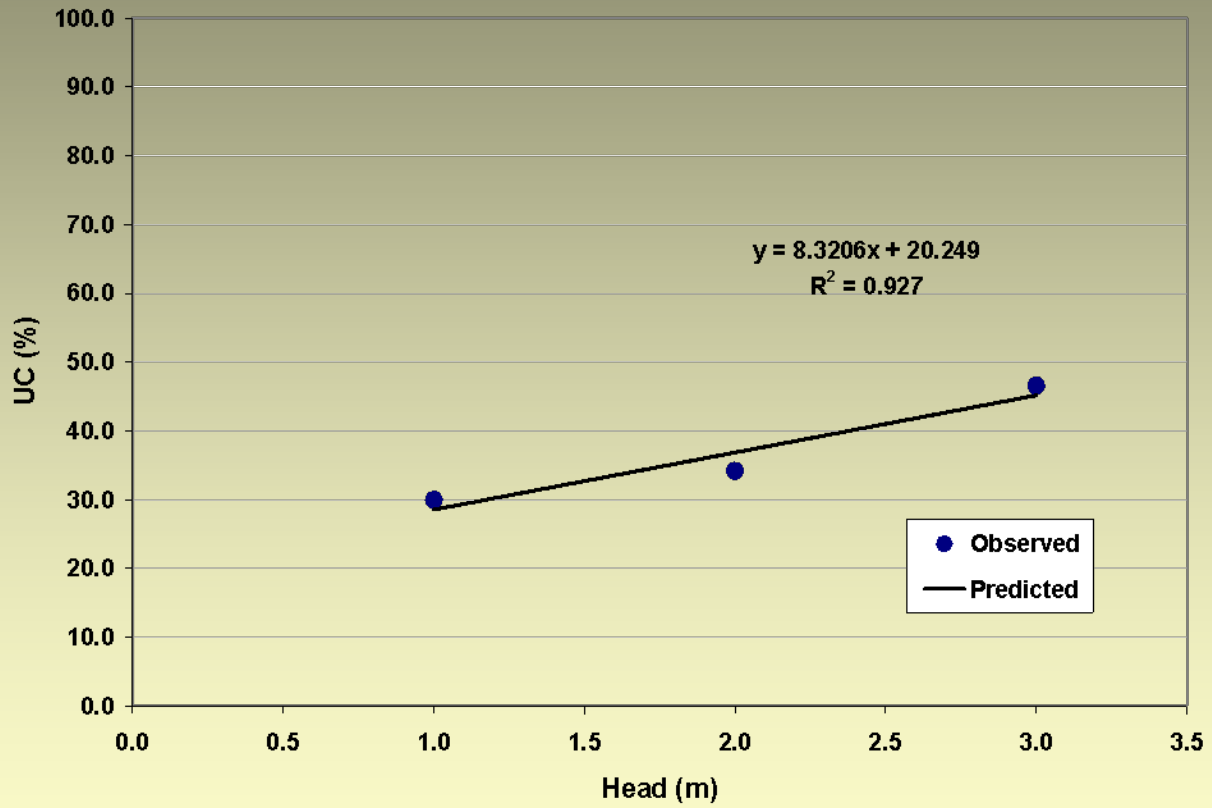
Observed and Predicted UC vs. Head at 10% Submain Slope



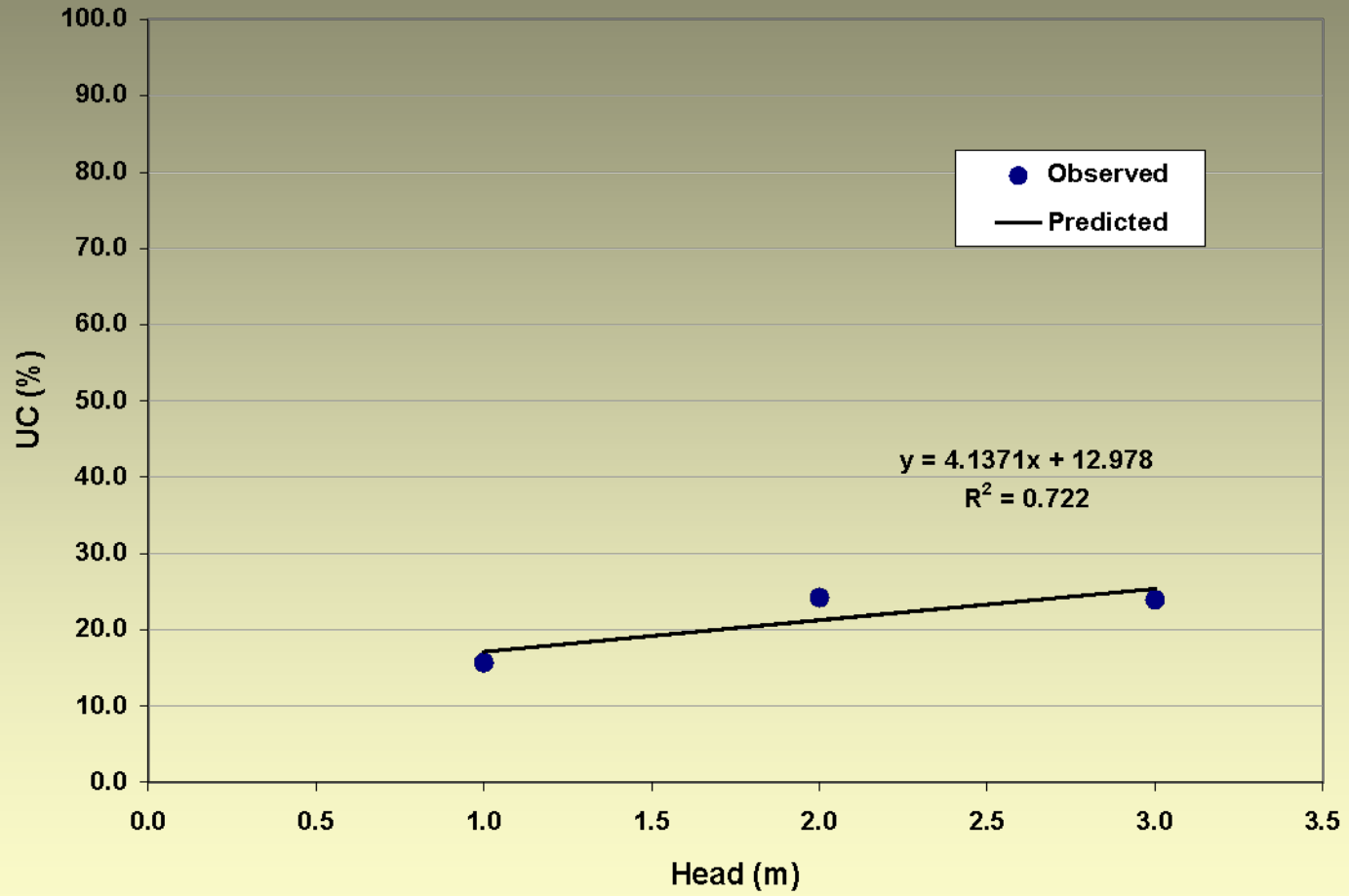
Observed and Predicted UC vs. Head at 20% Submain Slope



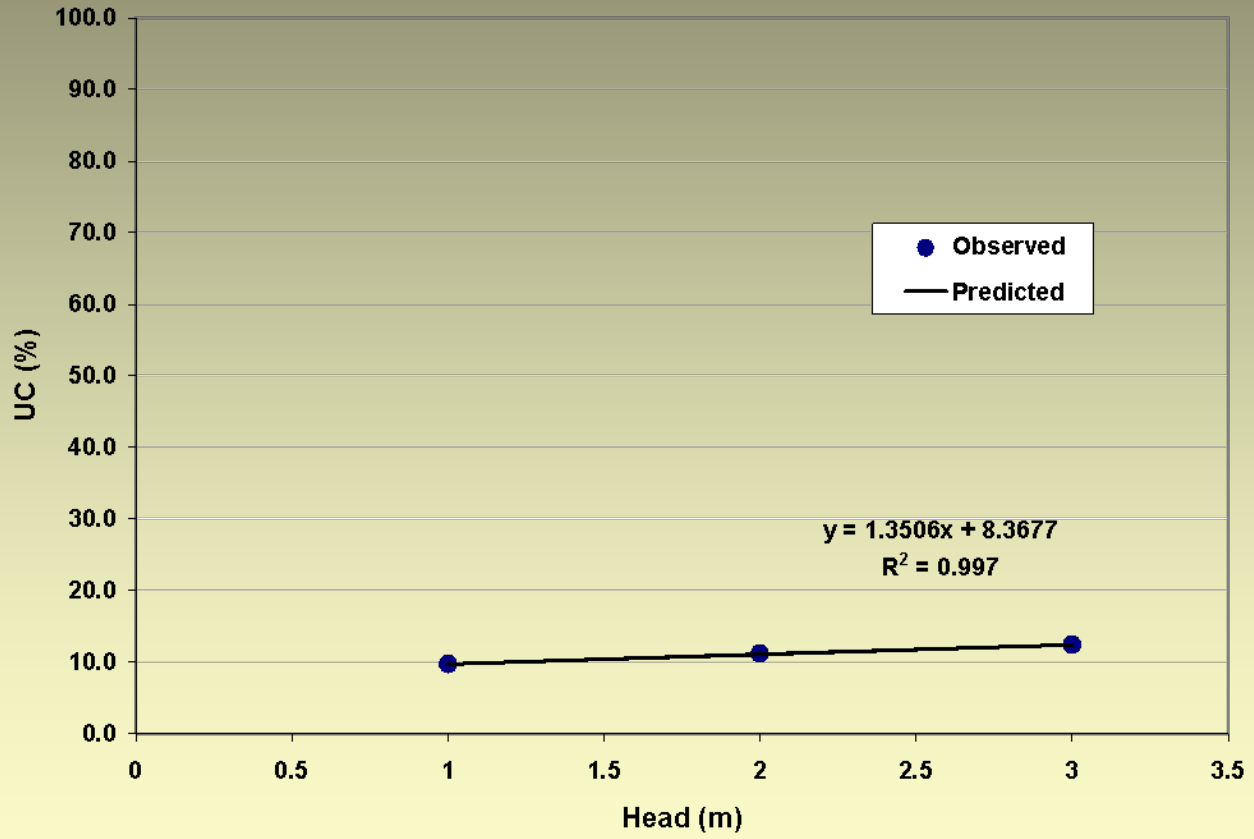
Observed and Predicted UC vs. Head at 30 % Submain Slope



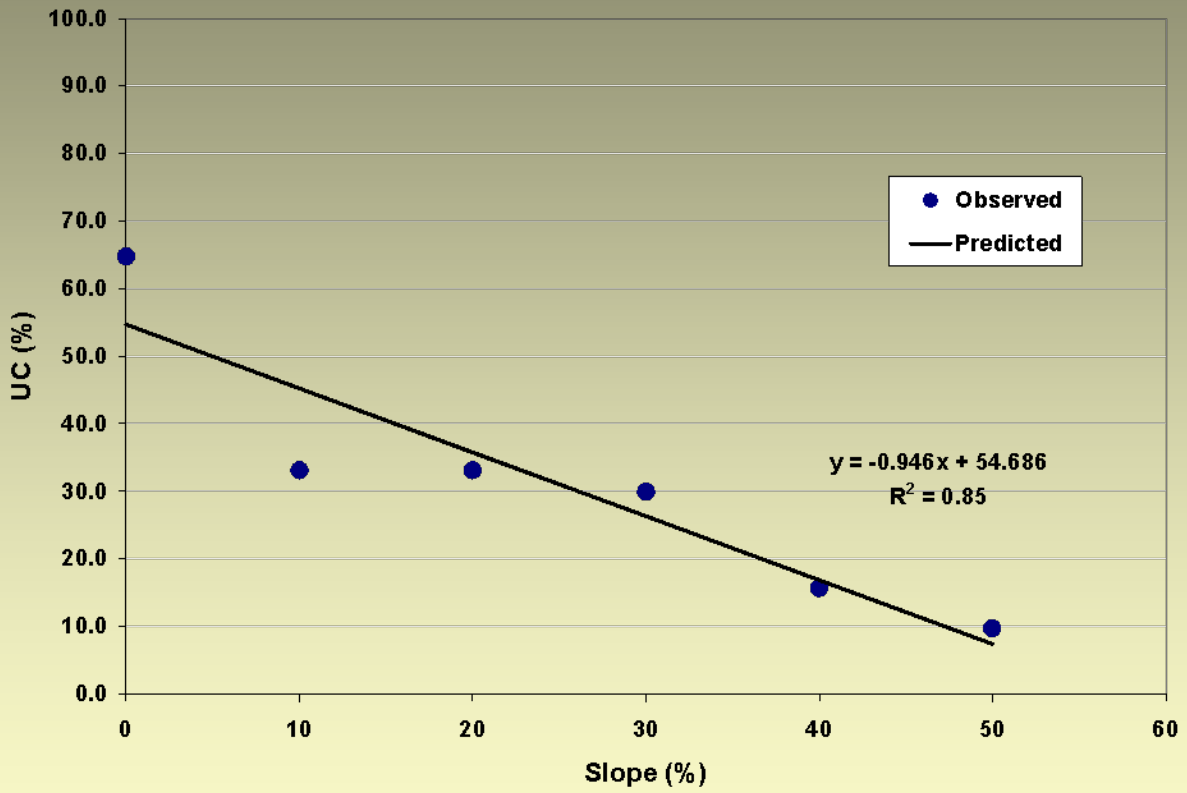
Observed and Predicted UC vs. Head at 40 % Submain Slope



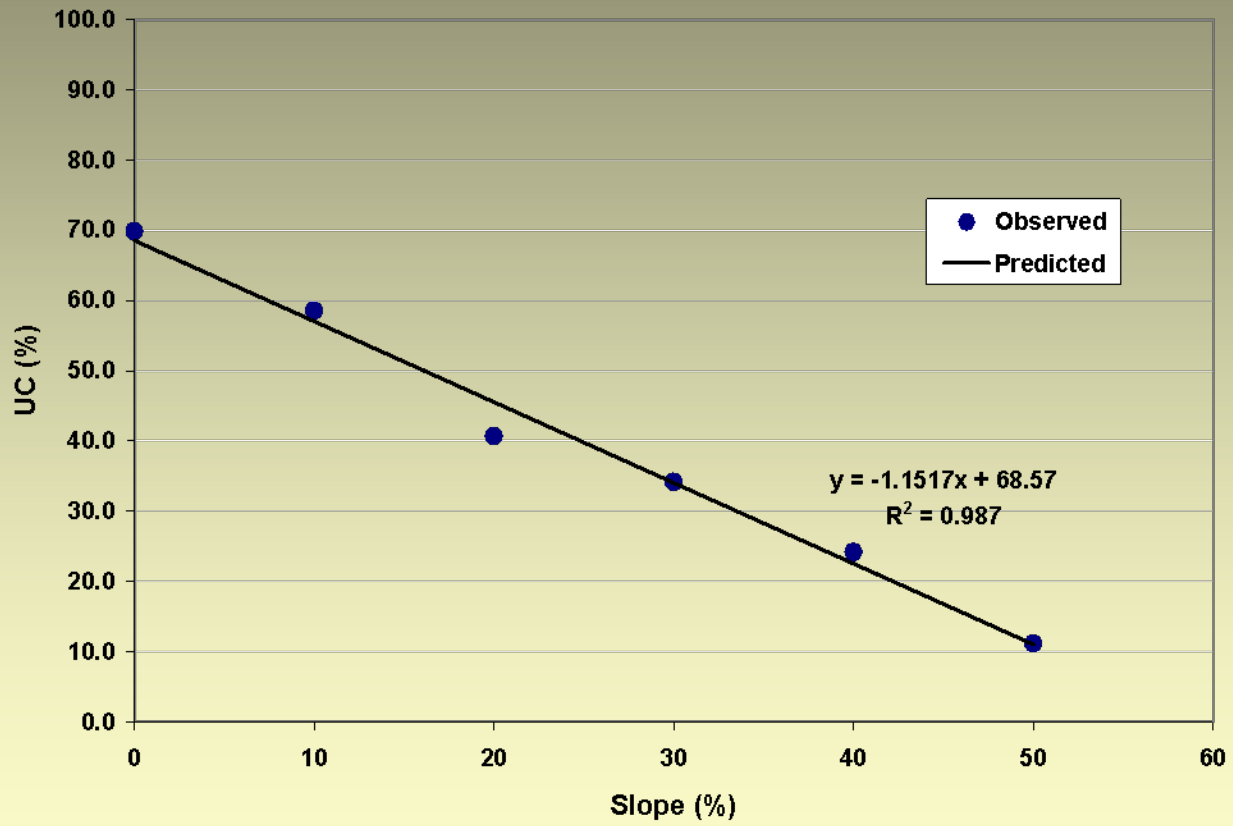
Observed and Predicted UC vs. Head at 50 % Submain Slope



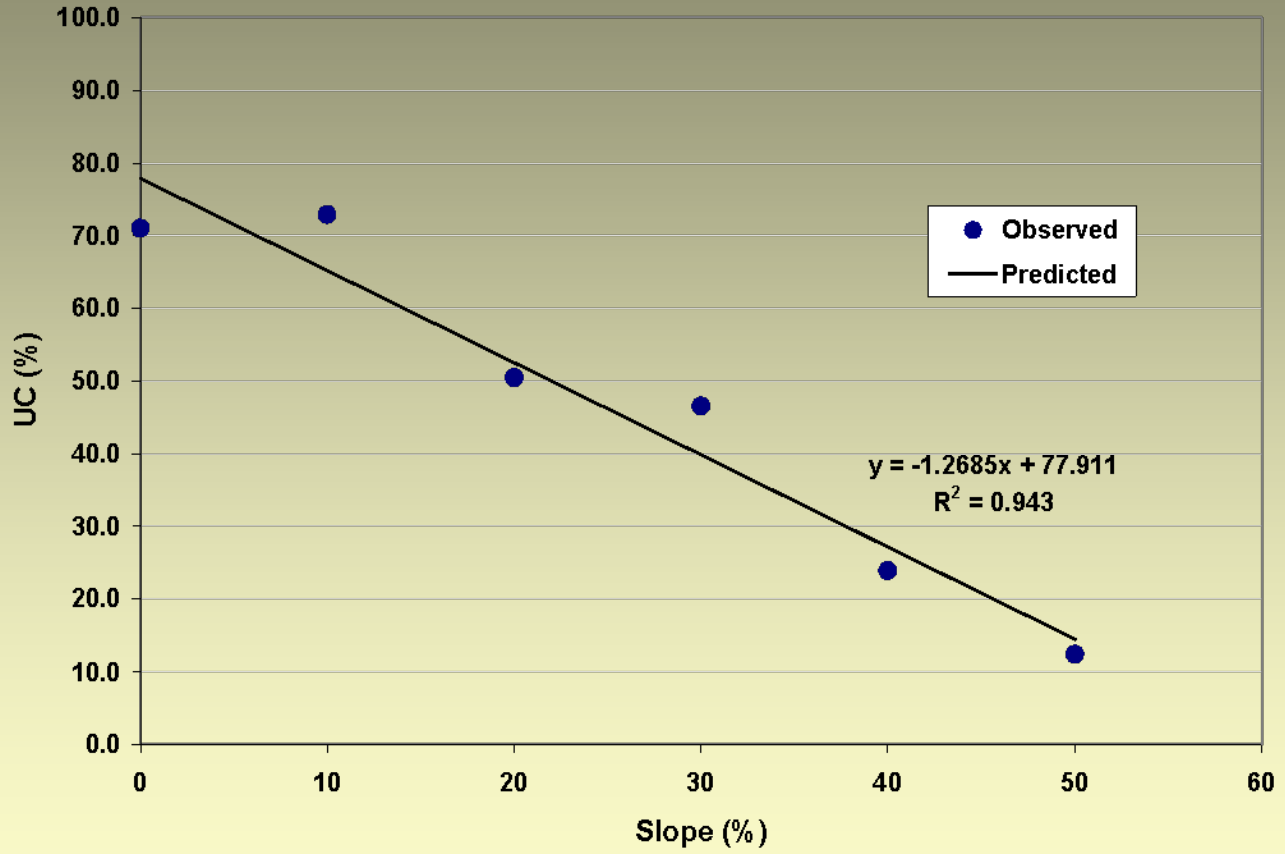
Observed and Predicted UC vs. Slope at 1.0 m Head



Observed and Predicted UC vs. Slope at 2.0 m Head



Observed and Predicted UC vs. Slope at 3.0 m Head



CONCLUSION

- Water distribution uniformity of the 100 sq m IDE Easy drip kit proved to be influenced by operating head and submain slope
- UC and EU increase with increasing head for all slopes
- A head of 3.0 m may be considered as optimum from both hydraulic and practical considerations for all slopes
- UC and EU decrease with increasing slope for all heads
- UC and EU decrease tremendously for slopes > 30%

CONCLUSION

- For 0% slope, a head differential of 0.5 m does not cause significant change in UC or EU
- UC is linearly related to either head or slope
- Linear regression models proved to be adequate to characterize the relationship between UC and head and between UC and slope

RECOMMENDATION

- To minimize non-uniformity of water distribution, control valves or pressure regulators may be installed along the submain
- IDE may consider including affordable pressure regulators for use of the drip kit in steep slopes
- Emitter clogging should be addressed to prevent occurrence of minimal or zero emitter discharge
- Further studies are recommended to address water distribution uniformity issues

Acknowledgements

- *This project was funded by **USAID** for SANREM-CRSP awarded to Virginia Tech, North Carolina A&T State University and University of the Philippines Los Baños Foundation, Inc.*
- *Paper presentation was made possible through the support from **DA-BAR** and **SEARCA***
- *Engrs. Arthur Fajardo and Noel Gordolan and everyone who helped in data gathering*

Thank You!

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