USING A SUBSURFACE DRIP IRRIGATION SYSTEM TO MEASURE CROP COEFFICIENTS AND WATER USE OF COWPEA (VIGNA UNGUICULATA)

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We have a 1.8-acre experimental plot on the south-40 (field 41A) of the UC Shafter Research and Extension Center, where a subsurface drip irrigation system is installed with dripperlines buried 10-11" below each plant row. Row spacing is 30" and we irrigate on a daily basis. The field is level in both directions and extra-large diameter tubing (7/8") was used so that pressures throughout the field are very uniform. A distribution uniformity (DU) test was made on the system earlier this season, and the DU was found to be 96%, which is very high. The system is still very efficient after 9 seasons of operation, mostly with cotton. The main goal this season (2005) was to find out how much water blackeyes use. For the results to be accurate we needed well-watered (no moisture stress), healthy plants (no pests, no diseases) that eventually reached full ground cover (100% canopy).

The water use is calculated by multiplying a crop coefficient by a reference evapotranspiration (ET). We like to use evaporation from a USDA Class A evaporation pan as a reference ET, but we also use the more standard CIMIS (California Irrigation Management Information System) value of ETo, which is available on-line.

We are using a Aslope@ procedure we developed and published for cotton (DeTar, 2004). A basic requirement of the procedure is a good overall average value of the moisture content of the soil in the root zone for the entire field. We measured the moisture content of the soil at 24 locations in the field with a neutron probe down to a depth of 5', and we did this twice a week. The procedure is based on the fact that if insufficient water is applied the field gets drier, and if too much is applied it gets wetter. This change in soil moisture is used to predict the application rate that would be needed to hold the soil moisture constant, a condition where we assume that the amount of water applied is the same as the amount of water being used by the plants.

The results are shown in the figure 1 below. These are preliminary results, subject to some adjustment when more data become available. Shown are the crop coefficients for the Pan and for CIMIS plotted against heat units. The averages for the 9 times periods of the mid-season plateau are 0.987 and 1.253 for the pan coefficient and the CIMIS coefficient, respectively. These are considerably higher (by 12-15%) than we found for cotton, which had corresponding values of 0.877 and 1.089. We are not yet sure where this mid-season plateau starts and ends. The literature, e.g., FAO-56 (Allen et al., 1998), shows that for most crops the mid-season plateau should start at about 80% canopy. For these blackeyes, 80% canopy occurred at about 610 heat units. At this point the Pan coefficient was about 0.825 and the CIMIS coefficient was about 1.015, neither of which is anywhere near the level of the mid-season plateau.

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There was a 20 to 23 % increase in the rate of water use as the canopy closed in from 80% ground cover to 100% ground cover. This unusual water use caught us by surprise, and caused the soil moisture to be depleted at a higher rate than intended during the last half of July. The soil moisture levels throughout the season are shown in figure 2, and indicate that the soil moisture was held fairly constant after July 29.

In other findings, the roots penetrated very rapidly to a depth of 5', and water use from the 4^{th} and 5^{th} feet seemed much higher than found in cotton for the same stage of growth. The table below shows the actual water application for each time period and the amount that was needed by the plants. This latter number is the amount that should have been applied to hold the soil moisture constant. The crop was planted on May 20, 2005 at a rate of 73,00 seeds/ac. A stand count on June 6 showed 47,000 plants/ac. Temik was applied at planting time. Dimethoate was applied twice (Aug.6 and Sep.3) and Provado once (July 21), all by helicopter. The crop harvested was on October 25, with a yield of 53 cwt/ac of clean, grade #2 blackeyes. By comparison the furrow-irrigated blackeyes on this station produced 19 cwt/ac., also grade #2. The yield in the region averaged about 28 cwt/ac this year, which is said to be somewhat below normal due to the very hot weather this summer. The total depth of water applied was 23.9 inches.

Acknowledgements:

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Literature Cited:

1. Allen, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998. FAO-56. Crop evapotranspiration guidelines for computing crop water requirements. (Irrigation and drainage paper 56) Food and Agriculture Organization of the United nations, Rome.

2. DeTar, W.R. 2004. Using a subsurface drip irrigation system to measure crop water use. Irrig. Sci. (2004) 23:111-122.

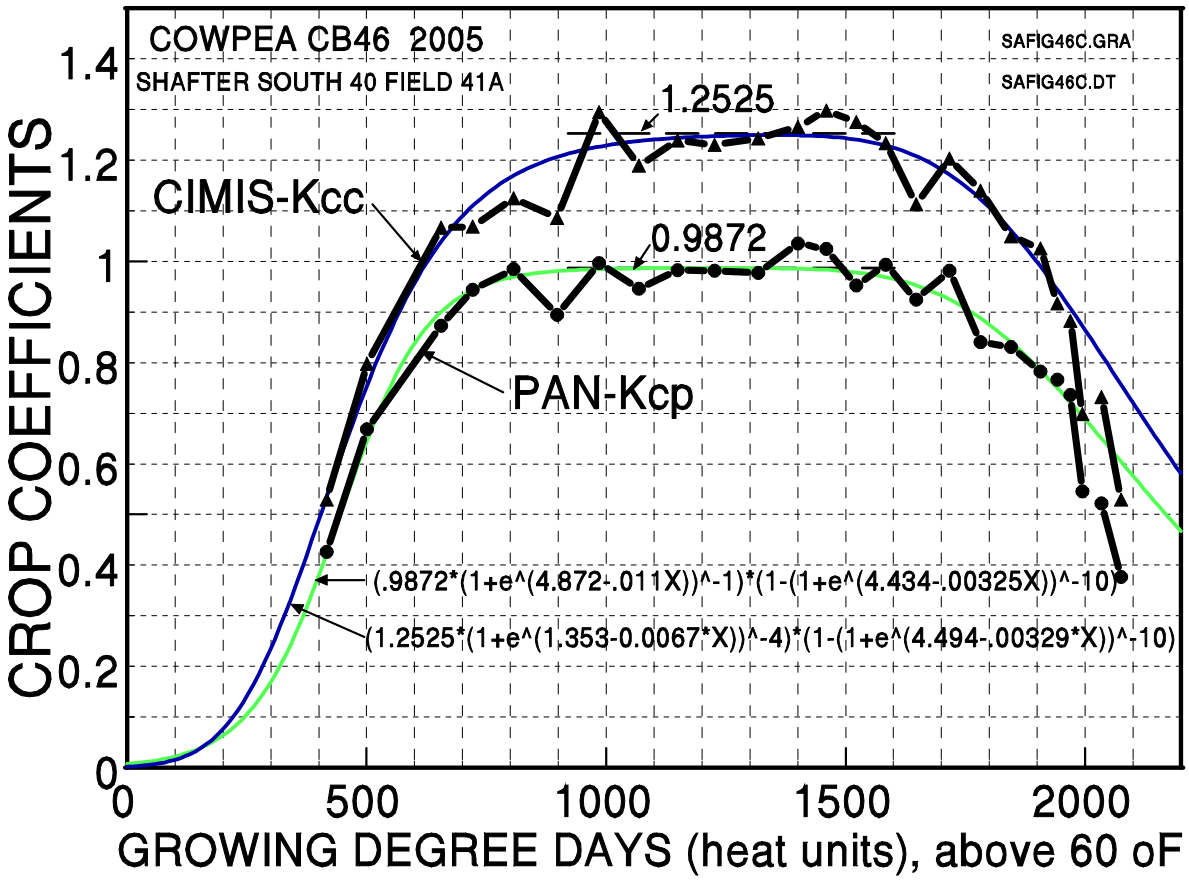

Figure 1. Crop coefficients for cowpea CB46 in 2005

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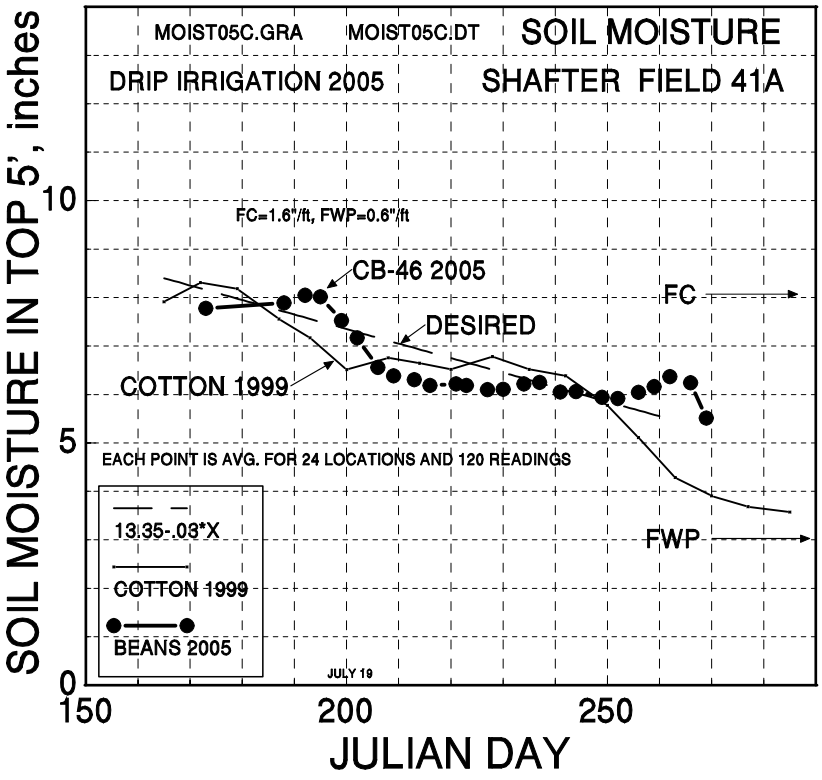

Figure 2. Total soil moisture, in inches, to depth of 5 ft.

Period No.	Dates	Water Applied in/day	Water Needed (ETc) in/day	Canopy %	Reference ET Pan evap in/day	Reference ET CIMIS-ETo in/day	Crop coefficients Pan Kcp	Crop coefficients CIMIS Kcc	Heat Units	Days
1	June 22-28	0.096	0.136	34	0.320	0.257	0.426	0.530	417	7
2	June 22-July 6	0.214	0.211	51	0.316	0.265	0.668	0.797	501	15
3	July 7-10	0.286	0.272	88	0.311	0.255	0.873	1.067	656	4
4	July 11-13	0.271	0.274	100	0.290	0.257	0.944	1.069	721	3
5	July 14-17	0.251	0.295	100	0.300	0.263	0.985	1.125	806	4
6	July 18-20	0.256	0.293	100	0.328	0.270	0.894	1.086	898	3
start of mid-season plateau.										
7	July 21-24	0.275	0.330	100	0.331	0.255	0.997	1.294	985	4
8	July 25-27	0.293	0.313	100	0.331	0.263	0.946	1.189	1069	3
9	July 28-30	0.321	0.328	100	0.334	0.265	0.983	1.238	1149	4
10	Aug 1-3	0.310	0.324	100	0.330	0.263	0.981	1.230	1226	3
11	Aug 4-8	0.318	0.316	100	0.323	0.254	0.978	1.243	1318	5
12	Aug 9-10	0.317	0.323	100	0.312	0.255	1.035	1.266	1400	2
13	Aug 11-14	0.317	0.324	100	0.317	0.250	1.025	1.298	1459	4
14	Aug 15-17	0.256	0.255	100	0.268	0.200	0.9528	1.275	1523	3
15	Aug 19-21	0.300	0.290	100	0.292	0.235	0.9931	1.233	1584	4
weighted average for mid-season plateau.							0.9872	1.2525		
16	Aug 22-24	0.278	0.275	100	0.297	0.247	0.924	1.113	1647	3
17	Aug 25-28	0.263	0.280	100	0.285	0.233	0.982	1.203	1717	4
18	Aug 29-31	0.262	0.262	100	0.312	0.230	0.841	1.140	1781	3
19	Sept 1-5	0.233	0.241	99	0.290	0.230	0.831	1.049	1846	5
20	Sept 6-8	0.209	0.212	98	0.271	0.207	0.782	1.025	1906	3
21	Sept 9-12	0.179	0.167	96	0.219	0.183	0.766	0.917	1942	4
22	Sept 13-15	0.170	0.156	95	0.212	0.177	0.736	0.883	1969	3
23	Sept 16-18	0.145	0.121	95	0.222	0.173	0.546	0.698	1995	3
24	Sept 19-22	0.115	0.126	95	0.242	0.173	0.522	0.732	2033	4
25	Sept 23-25	0.000	0.087	90	0.2293	0.163	0.377	0.53	2075	3