Alfalfa-based Penman Crop Coefficients for Western Kansas

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There are a number of crop coefficient curves that have been developed over the years to use with evapotranspiration equations to estimate actual crop water use. Most of these curves are specific to a particular equation. The terminology differs from curve to curve also, which sometimes makes it difficult to compare one to another. **These crop coefficients are appropriate for alfalfa-based Penman Equations. They are not appropriate for shortgrass-based Penman Equations.**

The procedure used here for corn, grain sorghum, and soybeans uses equations developed by Kincaid and Heerman (1974) to generate crop coefficient curves developed by Jensen et al. (1969, 1970, 1971). The sunflower values were developed in North Dakota.

This work of Kincaid and Heerman did not develop an equation for grain sorghum. However, comparison of curves developed by Jensen and Haise (1963) for corn and grain sorghum show very similar characteristics. It appears a single curve for corn and grain sorghum might be adequate if the length of growing season is adjusted for the grain sorghum.

The equation developed by Kincaid and Heerman is

$$Kco = Ar^3 + Br^2 + Cr + D$$

where Kco is the crop coefficient; A, B, C, and D are constants for each particular crop; and r is the fraction of time from emergence to effective cover. After effective cover, r is equal to the number of days from effective cover. The constants in the equation are given in Table 1 for corn, grain sorghum, and soybeans.

The crop coefficients generated in Table 2 are based on the following assumptions for each crop:

Corn	- vegetative period – 70 days
	- emergence to physiological maturity – 130 days
	Note: This assumption appears fine even though full-season maturity corn is generally considered 120 days.
Grain Sorghum	- vegetative period – 70 days
	- emergence to physiological maturity – 105 days
Soybeans	- vegetative period – 65 days
	- emergence to physiological maturity – 130 days

How well the crop coefficients will work will depend in part on how valid these assumptions are. My experience with utilizing these crop coefficients for corn is good. I do not have as much confidence in the Kc values for the other crops, but they hopefully are reasonable approximations.

In the computer program used to generate these values, some data smoothing was necessary for the corn and grain sorghum immediately following effective cover. This is necessary because of the discontinuity of the polynomial equations.

The crop coefficient curves can be tested and refined as necessary. Crop coefficient curves in terms of heat units or stage of growth may be more accurate; further research may point this out. The curves may need adjustment if different assumptions on growth periods are made.

References

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        USDA Publication ARS-NC-12. February 1974. 55 pp.

Table 1. Polynomial constants for crop curves

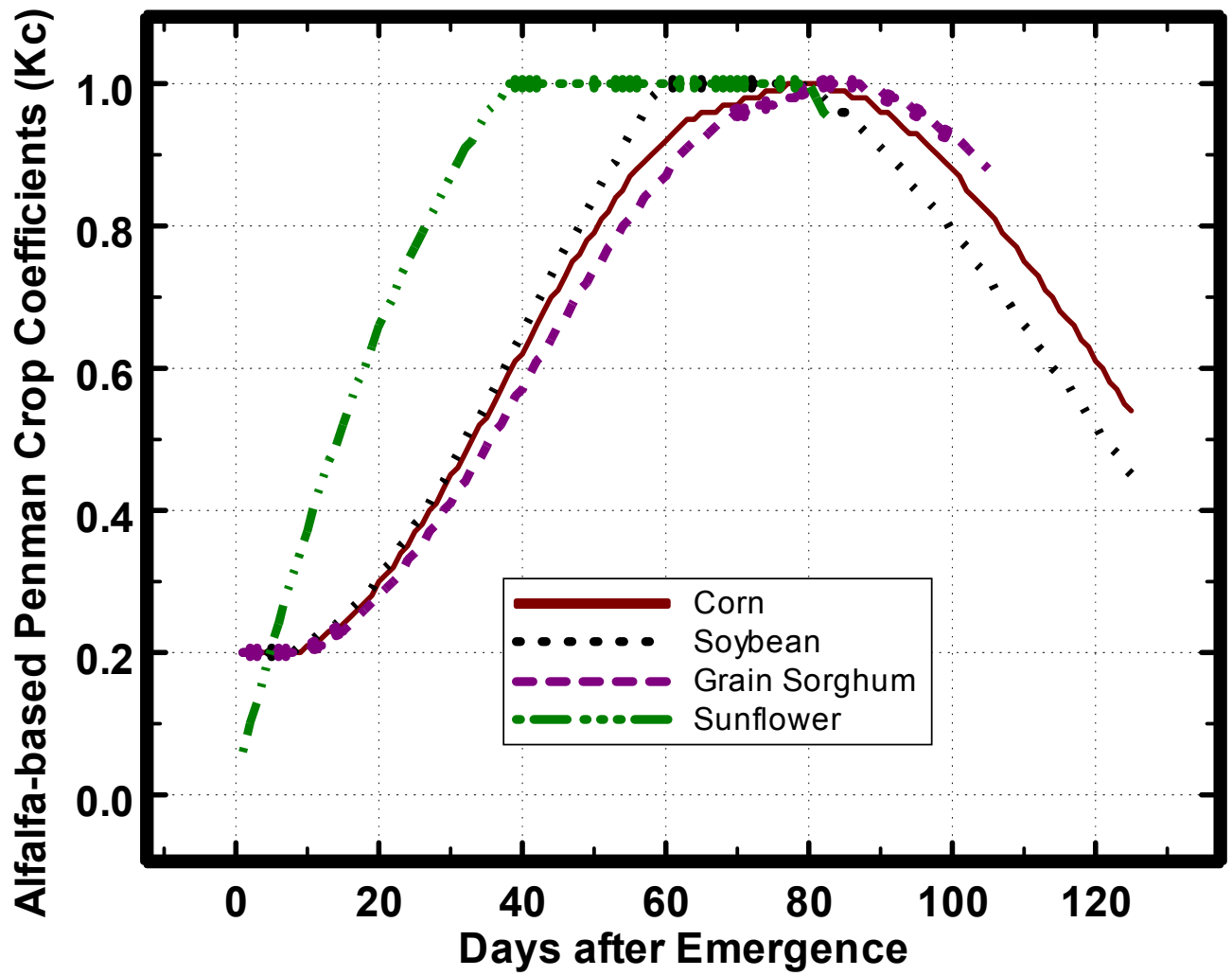| Crop	Constant			
	A	B	C	D
Before effective cover				
Corn and grain sorghum	-1.583	2.756	-0.4276	0.213
Soybeans	-1.353	2.562	-0.3532	0.212
After effective cover				
Corn and grain sorghum	275 E-08	-4688 E-07	0.01195	0.915
Soybeans	165 E-08	-2644 E-07	-112 E-06	1.050

Table 2. Alfalfa-based Penman Equation Crop Coefficients (Kc)

Days Post Emergence	Corn	Soybeans	Grain Sorghum	Sunflower
1	0.20	0.20	0.20	0.06
2	0.20	0.20	0.20	0.10
3	0.20	0.20	0.20	0.13
4	0.20	0.20	0.20	0.17
5	0.20	0.20	0.20	0.21
6	0.20	0.20	0.20	0.24
7	0.20	0.20	0.20	0.28
8	0.20	0.20	0.20	0.31
9	0.20	0.21	0.20	0.34
10	0.21	0.21	0.20	0.37
11	0.21	0.22	0.21	0.41
12	0.22	0.23	0.21	0.44
13	0.23	0.23	0.22	0.47
14	0.23	0.24	0.23	0.49
15	0.24	0.25	0.23	0.52
16	0.25	0.26	0.24	0.55
17	0.26	0.27	0.25	0.58
18	0.27	0.28	0.26	0.60
19	0.28	0.29	0.27	0.63
20	0.30	0.31	0.28	0.66
21	0.31	0.32	0.29	0.68
22	0.32	0.33	0.30	0.70
23	0.34	0.35	0.31	0.73
24	0.35	0.36	0.33	0.75
25	0.37	0.38	0.34	0.77
26	0.38	0.39	0.35	0.79
27	0.40	0.41	0.37	0.81
28	0.41	0.43	0.38	0.83
29	0.43	0.44	0.40	0.85
30	0.45	0.46	0.41	0.87
31	0.46	0.48	0.43	0.89
32	0.48	0.50	0.44	0.91
33	0.50	0.52	0.46	0.92
34	0.52	0.53	0.47	0.94
35	0.53	0.55	0.49	0.96
36	0.55	0.57	0.51	0.97
37	0.57	0.59	0.52	0.98
38	0.59	0.61	0.54	1.00
39	0.61	0.63	0.56	1.00
40	0.62	0.65	0.57	1.00
41	0.64	0.67	0.59	1.00
42	0.66	0.69	0.61	1.00
43	0.68	0.71	0.62	1.00
44	0.70	0.73	0.64	1.00
45	0.71	0.75	0.66	1.00
46	0.73	0.77	0.67	1.00
47	0.75	0.78	0.69	1.00

Table 2. *Continued*

Days Post Emergence	Corn	Soybeans	Grain Sorghum	Sunflower
48	0.76	0.80	0.71	1.00
49	0.78	0.82	0.72	1.00
50	0.79	0.84	0.74	1.00
51	0.81	0.86	0.75	1.00
52	0.82	0.88	0.77	1.00
53	0.84	0.89	0.78	1.00
54	0.85	0.91	0.80	1.00
55	0.87	0.93	0.81	1.00
56	0.88	0.94	0.82	1.00
57	0.89	0.96	0.84	1.00
58	0.90	0.98	0.85	1.00
59	0.91	0.99	0.86	1.00
60	0.92	1.00	0.87	1.00
61	0.93	1.00	0.89	1.00
62	0.94	1.00	0.90	1.00
63	0.95	1.00	0.91	1.00
64	0.95	1.00	0.92	1.00
65	0.96	1.00	0.92	1.00
66	0.96	1.00	0.93	1.00
67	0.96	1.00	0.94	1.00
68	0.97	1.00	0.95	1.00
69	0.97	1.00	0.95	1.00
70	0.97	1.00	0.96	1.00
71	0.98	1.00	0.96	1.00
72	0.98	1.00	0.96	1.00
73	0.98	1.00	0.97	1.00
74	0.99	1.00	0.97	1.00
75	0.99	1.00	0.97	1.00
76	0.99	1.00	0.98	1.00
77	1.00	1.00	0.98	1.00
78	1.00	1.00	0.98	1.00
79	1.00	1.00	0.99	1.00
80	1.00	0.99	0.99	1.00
81	1.00	0.99	0.99	0.98
82	1.00	0.98	1.00	0.96
83	0.99	0.97	1.00	0.95
84	0.99	0.96	1.00	
85	0.99	0.96	1.00	
86	0.98	0.95	1.00	
87	0.98	0.94	1.00	
88	0.98	0.93	0.99	
89	0.97	0.92	0.99	
90	0.96	0.91	0.99	
91	0.96	0.90	0.98	
92	0.95	0.89	0.98	
93	0.94	0.88	0.98	
94	0.93	0.86	0.97	

Table 2. *Continued*

Days Post Emergence	Corn	Soybeans	Grain Sorghum	Sunflower
95	0.93	0.85	0.96	
96	0.92	0.84	0.96	
97	0.91	0.83	0.95	
98	0.90	0.82	0.94	
99	0.89	0.81	0.93	
100	0.88	0.79	0.93	
101	0.87	0.78	0.92	
102	0.85	0.77	0.91	
103	0.84	0.75	0.90	
104	0.83	0.74	0.89	
105	0.82	0.73	0.88	
106	0.81	0.71		
107	0.79	0.70		
108	0.78	0.69		
109	0.77	0.67		
110	0.75	0.66		
111	0.74	0.65		
112	0.73	0.63		
113	0.71	0.62		
114	0.70	0.60		
115	0.68	0.59		
116	0.67	0.58		
117	0.66	0.56		
118	0.64	0.55		
119	0.63	0.53		
120	0.61	0.52		
121	0.60	0.50		
122	0.58	0.49		
123	0.57	0.48		
124	0.55	0.46		
125	0.54	0.45		