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Department of Soil and Crop Sciences

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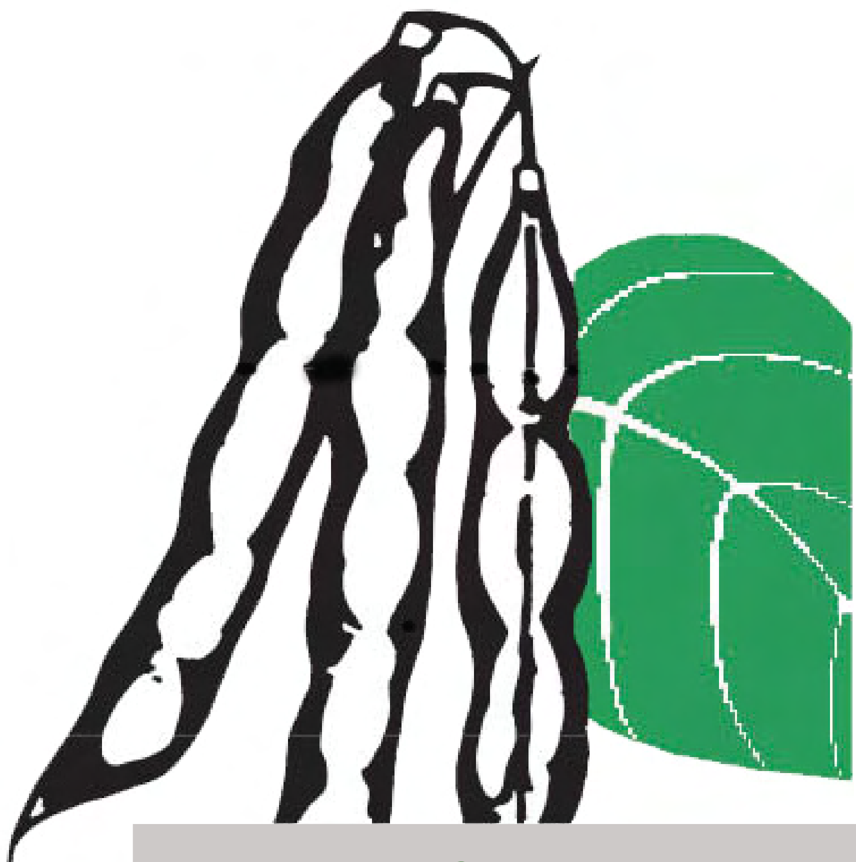

MAKING BETTER DECISIONS

2008 Dry Bean Variety Performance Trials

Acknowledgments

The authors wish to express their gratitude to the Colorado farmers who generously contributed the use of their land, equipment, and time to facilitate these trials for the benefit of all. Colorado dry bean producers and bean dealers: Yuma – Richard Wacker and Proctor – Bob Duncan. We also acknowledge the participation of the Agricultural Research, Development and Education Center - Fort Collins. The success of the 2008 season is due to research support provided by The Colorado Dry Bean Administrative Committee, and publication of this report by The Colorado Bean Network. We are especially grateful to Bill Newth (Trinidad/Benham Bean Co. – Sterling, CO) for his assistance in identifying trial collaborators and hosting bean field days.

Trials conducted by Colorado State University Crops Testing, funded by the Colorado Dry Bean Administrative Committee and reported by the Colorado Bean Network

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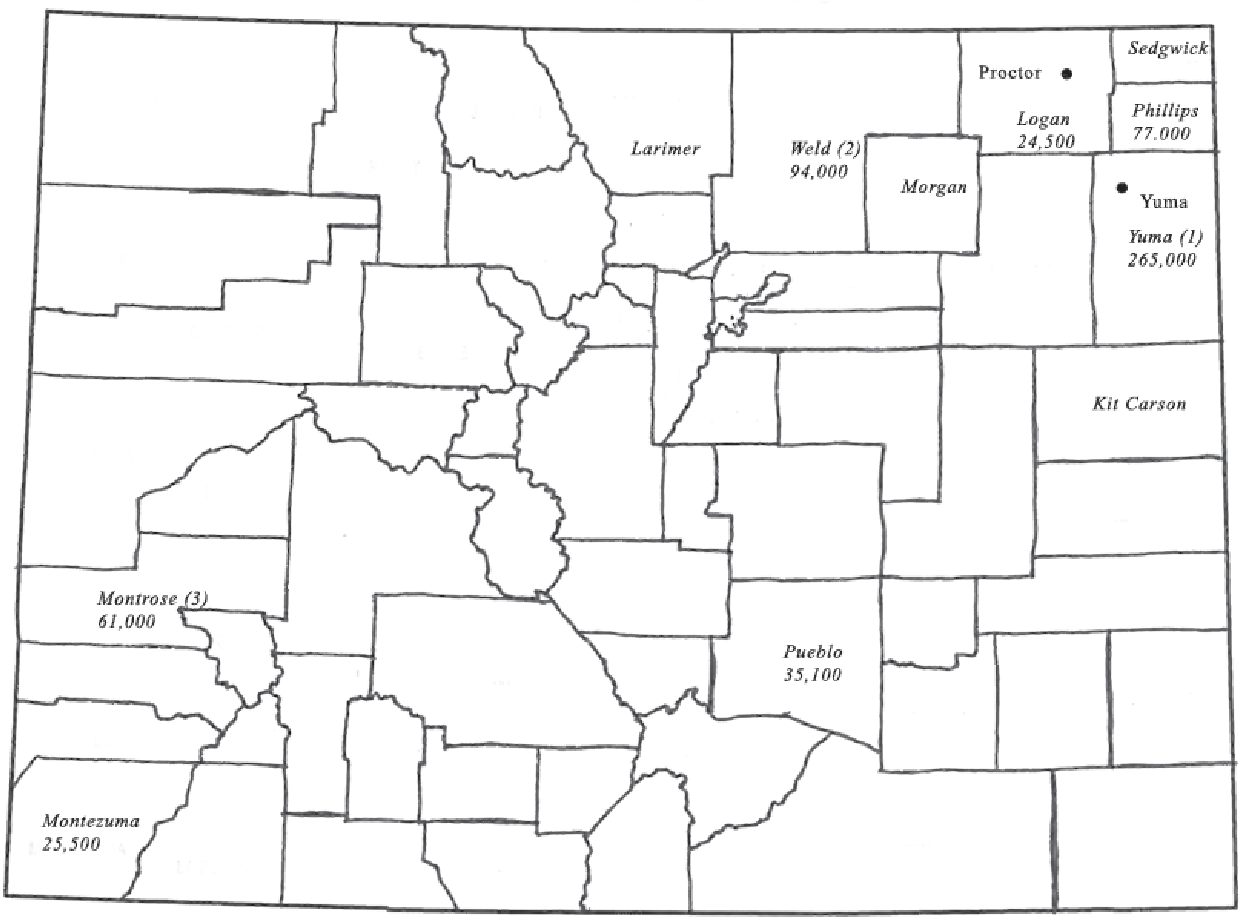
2008 Colorado Dry Bean Performance Trial

Introduction

Colorado producers annually spend millions of dollars on pinto bean seed. Variety decisions can have a big effect on yields. Colorado State University Crops Testing, the bean breeding program, and the bean pathology research program collaborate to conduct uniform variety trials annually to provide unbiased and reliable performance results from uniform variety trials to help Colorado dry bean producers make more informed variety decisions. The uniform variety trial serves a dual purpose of screening experimental lines from CSU's bean breeding program and to compare commercial variety performance for making variety recommendations to Colorado bean producers. The uniform variety trial is made possible by funding received from Colorado dry bean producers and handlers via the Colorado Dry Bean Administrative Committee. In 2008, two eastern Colorado trials were funded and planted at Yuma and Proctor. Varieties tested in 2008 are described in the following tables. Seed yields, in pounds per acre, are adjusted to 14% moisture content.

2008 Colorado Dry Bean Trial Locations



2007 production (cwt) for the highest producing counties in Colorado.

Table 1. 2008 Pinto Bean Variety Performance Trial at Yuma.

Variety	Source	Yield	Test Weight	Seed/lb
		lb/ac	lb/bu	No.
PT 99195MR	AmeriSeed	5046	64.5	1215
Bill Z	Colorado State University	4910	63.1	1182
Montrose	Colorado State University	4854	61.7	1075
P35161	ADM-Seedwest	4564	62.1	1187
P252215	ADM-Seedwest	4519	61.9	1108
PT 99217	AmeriSeed	4482	63.5	1038
Lariat	North Dakota State University	4472	63.1	1025
PT Durango	AmeriSeed	4457	62.5	1068
Grand Mesa	Colorado State University	4450	61.6	1208
PT Poncho	Syngenta Seeds, Inc	4432	63.4	1058
PT Sonora	AmeriSeed	4356	63.1	1307
Shoshone	University of Idaho	4316	58.7	1162
Kimberly	University of Idaho	4298	64.3	1283
PT 06189	AmeriSeed	4192	63.5	1227
PT 05200	AmeriSeed	4181	63.2	1177
P232219	ADM-Seedwest	4140	61.6	1167
P223217	ADM-Seedwest	4100	62.6	1132
PT 06185	AmeriSeed	4029	64.2	1232
PT Buckskin	Syngenta Seeds, Inc	4024	62.4	1142
Santa Fe	Michigan Crop Improvement Assn.	4018	59.8	1070
Stampede	North Dakota State University	4015	61.9	1083
CO 34142	Colorado State University	4002	62.7	1086
PT La Paz	AmeriSeed	3804	63.9	1325
PT Baja	AmeriSeed	3730	62.7	1145
Croissant	Colorado State University	3700	62.7	1108
CO 33911	Colorado State University	3667	61.3	1135
GTS-903	Gentec Inc	3564	63.1	1138
CO 24601	Colorado State University	3551	62.0	1072
GTS-904	Gentec Inc	3513	63.1	1045
CO 48049	Colorado State University	3512	62.4	1222
PT 06203	AmeriSeed	3485	63.1	1270
PT 06206	AmeriSeed	3443	62.5	1155
CO 33546	Colorado State University	3365	58.0	1008
PT 01223	AmeriSeed	3130	61.8	1325
CO 24940	Colorado State University	2996	60.9	1045
CO 29258	Colorado State University	2868	60.9	1117
	Average	**4005**	**62.3**	**1148**
	LSD $_{(0.30)}$	406		

Previous crop: corn
Fertilizer: N-P-K-S-Zn = 74-73-37-23-12 lbs/ac
Pre-plant herbicide: Eptam (3 pints/ac); Sonalan (2 pints/ac)
Post-emergence herbicide: Raptor (3g/ac); Basagram (12g/ac); Outlook (14g/ac)
Fungicide: Headline (8g/ac); Capture (3g/ac)
Copper: 2 treatments (1.5 pints/ac each application)
Irrigation: pivot
Plot Size: 10' x 31'
Seeding Rate: 85,000 seeds/acre
Date of Planting: 6/10/2008
Date of Harvest: 9/25/2008

Table 2. 2008 Pinto Bean Variety Performance Trial at Proctor.

Variety	Source	Yield[1]	Test Weight	Seed/lb	Stand[2]
		lb/ac	lb/bu	No.	
GTS-904	Gentec Inc	2401	69.2	1085	7
PT 06189	AmeriSeed	2334	59.3	1262	8
GTS-903	Gentec Inc	2327	58.8	1255	8
PT 99195MR	AmeriSeed	2303	61.6	1305	8
P252215	ADM-Seedwest	2192	59.7	1203	7
Montrose	Colorado State University	2189	61.1	1230	7
P35161	ADM-Seedwest	2172	58.5	1353	8
PT Sonora	AmeriSeed	1977	60.5	1400	7
PT 06203	AmeriSeed	1960	61.3	1305	9
P223217	ADM-Seedwest	1945	59.2	1240	7
PT Poncho	Syngenta Seeds, Inc	1922	60.1	1153	8
CO 33546	Colorado State University	1882	58.2	1155	7
Bill Z	Colorado State University	1881	59.5	1212	9
Santa Fe	Michigan Crop Improvement Assn.	1862	58.0	1113	7
Grand Mesa	Colorado State University	1852	60.3	1378	8
Kimberly	University of Idaho	1851	60.0	1327	7
PT 06185	AmeriSeed	1790	60.5	1318	8
P232219	ADM-Seedwest	1787	59.3	1252	7
CO 48049	Colorado State University	1768	56.9	1248	8
PT La Paz	AmeriSeed	1767	56.5	1387	8
Lariat	North Dakota State University	1764	57.5	1095	7
CO 33911	Colorado State University	1732	58.3	1358	8
PT 99217	AmeriSeed	1677	60.1	1145	8
CO 24940	Colorado State University	1643	55.2	1163	8
PT 05200	AmeriSeed	1554	59.8	1280	8
PT 06206	AmeriSeed	1545	59.0	1173	7
Stampede	North Dakota State University	1529	57.4	1598	6
PT 01223	AmeriSeed	1525	55.4	1432	10
PT Baja	AmeriSeed	1520	59.0	1245	8
Croissant	Colorado State University	1501	58.1	1345	9
PT Durango	AmeriSeed	1440	58.1	1107	8
CO 29258	Colorado State University	1413	58.6	1183	8
CO 24601	Colorado State University	1397	59.0	1202	8
Shoshone	University of Idaho	1308	54.6	1285	8
PT Buckskin	Syngenta Seeds, Inc	1278	58.5	1177	7
	Average	**1800**	**59.1**	**1256**	**8**

Previous Crop: corn
Fertilizer: none
Herbicide: Valor, Parrallel, Raptor, Basagram
Fungicide: Nucop
Plot Size: 10' x 31'
Seeding Rate: 85,000 seeds/acre
Irrigation: pivot
Date of Harvest: 9/23/2008
Date of Planting: 6/2/2008

Yield[1] Yield results are indicative of yield trends only as yield could not be interpreted statistically due to field variation. Variable plant stands led to serious weed infestation in parts of some plots so overall yields were low. Consequently a fair comparison of variety performance could not be made.

Stand establishment[2]: plant stands were visually evaluated mid-season for percent of plot stand establishment. Some plots resulted in acceptable stands, many did not and those plots were most seriously invaded by weeds. Stand establishment evaluation scale: 1= 0-10%; 2= 10-20%; 3= 20-30%; 4= 30-40%; 5= 40-50%; 6= 50-60%; 7= 60-70%; 8= 70-80%; 9= 80-90%; 10= 90-100%.

Table 3. 2-Year and 3-Year Summaries of Pinto Bean Variety Performance in Colorado Variety Trials

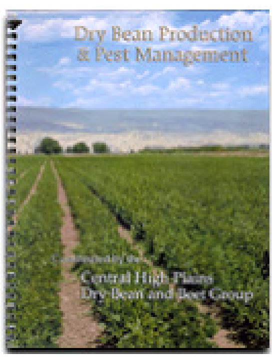
2-Yr Average[1]			3-Yr Average[1]		
Variety[2]	Yield 2007-08	Seeds/lb 2007-08	Variety[2]	Yield 2007-08	Seeds/lb 2007-08
	bu/ac	No.		bu/ac	No.
Poncho	3597	1229	Bill Z	3294	1339
Bill Z	3501	1412	Poncho	3204	1181
Montrose	3343	1294	Montrose	3090	1244
99217	3286	1319	99195 MR	3011	1402
GTS-904	3250	1239	Buckskin	2973	1264
Buckskin	3177	1314	01223	2903	1443
Lariat	3176	1294	La Paz	2898	1312
05200	3169	1379	99217	2852	1211
99195 MR	3166	1438	Durango	2840	1218
Grand Mesa	3103	1451	Grand Mesa	2770	1375
P223217	3085	1353	Baja	2675	1262
Durango	3079	1280	Average	2955	1295
Sonora	3066	1535			
06185	3050	1404			
Stampede	3007	1286			
La Paz	2992	1412			
06206	2881	1297			
Baja	2795	1334			
CO24601	2778	1267			
01223	2719	1564			
CO33911	2549	1431			
Average	3084	1359			

[1]2-yr and 3-yr average yield and test weight are based on 1 2008 trial, 2 2007 trials and 2 2006 trials.

[2]Varieties ranked according to average 2-yr yield and according to average 3-yr yield.

Summary of Pinto Bean Variety Performance in Colorado Variety Trials from 1999-2008

Every year CSU personnel conduct pinto bean variety performance trials in different locations. Both varieties and locations change from year to year so this table summarizes varieties that have been tested over the years. In the following table, yield performance by variety has been averaged over locations within each of ten years. Entries reported are public and commercial named varieties common to all trials for a year. Public and private experimental lines were not included in this summary. The number of locations per year varied from two to six. The trial average at bottom of each year's yield column is a simple average of the yields of reported varieties for that year. The second column is the yield for each reported variety expressed as a percent of the trial average for each year. Average yield over years and average percent of trial average are shown in the columns at the extreme right.



http: //www.csuag.com

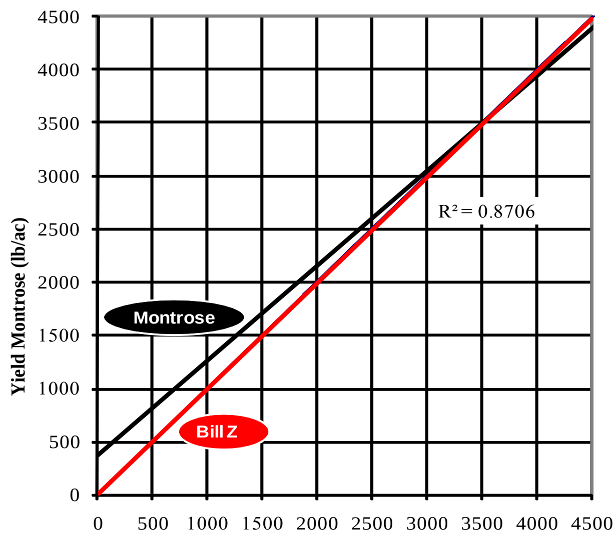
Table 4. 10-Year Summary of Pinto Bean Variety Performance in Colorado Variety Trials from 1999-2008.

Variety	1999 Yield		2000 Yield		2001 Yield		2002 Yield		2003 Yield		2004 Yield		2005 Yield		2006 Yield		2007 Yield		2008 Yield		Long Term Yield	
	lb/ac	% ave	lb/ac	% ave	lb/ac	% ave	lb/ac	% ave	lb/ac	% ave	lb/ac	% ave	lb/ac	% ave	lb/ac	% ave	lb/ac	% ave	lb/ac	% ave	lb/ac	% ave
00218													2557	103	2868	90					2713	97
01223													2388	97	3384	106	2513	97			2762	100
Baja													2629	106	2963	93	2328	90	3730	86	2912	94
99217															3080	97	2406	93	4482	104	3323	98
Durango															3170	99	2390	92	4457	103	3339	98
99195 MR													2374	96	3437	108	2508	97	5046	117	3341	104
Bill Z	2617	103	3212	106	2621	101	2613	110	2463	95	2253	106	2454	99	3689	116	2796	108	4910	114	2963	106
Buckskin	2475	97	2769	91			2184	92	2382	92	2090	98	2428	98	3090	97	2754	106	4024	93	2688	96
Burke	2464	97	2713	90	2426	93															2534	93
Buster	2672	105	3087	102	2654	102					2185	102			3286	103					2777	103
Chase	2584	101	3049	101																	2817	101
Cisco	2775	109	3280	108																	3028	109
Elizabeth	2178	86	2780	92																	2479	89
Grand Mesa	2631	103	2902	96	2458	95	2329	98	2283	88	1865	87	2265	92	2944	92	2429	94	4450	103	2656	95
GTS-900					2339	90					1989	93									2164	92
Kodiak	2542	100	2749	91																	2646	95
La Paz													2490	101	3164	99	2586	100	3804	88	3011	97
Montrose	2821	111	3213	106	2705	104	2586	109	2956	114	2562	120	2449	99	3466	109	2587	100	4854	112	3020	108
Othello	2265	89	3044	101							1936	91			3033	95					2570	94
Poncho	2613	103	3332	110	2862	110	2371	100	2826	109	2398	112	2676	108	3033	95	3179	123	4432	103	2972	107
Rally					2312	89	2134	90			1935	91									2127	90
USPT-73	2418	95	3230	107	2825	109	2374	100													2712	103
Vision	2604	102			2790	107															2697	105
Lariat																	2528	98	4472	103	3500	101
GTS-904																	3118	120	3513	81	3316	101
Stampede																	2502	97	4015	93	3259	95
Sonora																	2421	94	4356	101	3389	97
Trial Average	**2547**		**3028**		**2599**		**2370**		**2582**		**2135**		**2471**		**3186**		**2589**		**4322**		2783	

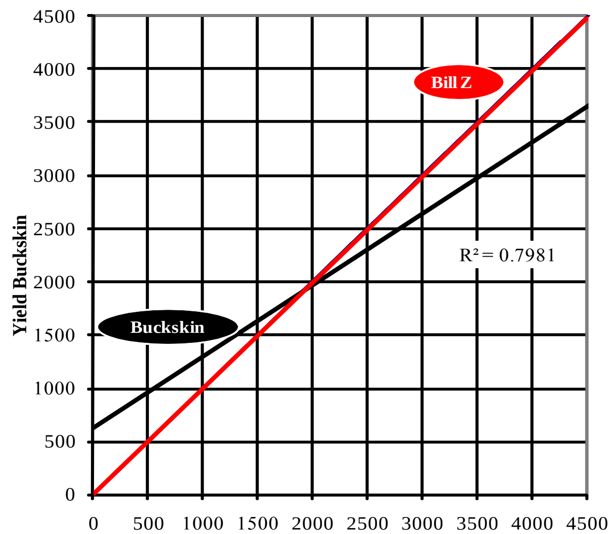
*These varieties were each only tested for one year during the ten year period and are not included in this performance summary: 01242, 03250, 06185, 06206, 03261, 05200, 6I13, 6I15, 6I7, 6I9, Apache, Canyon, COB-2576-99, COB-2585-99, Frontier, GTS Cob 502-94, Maverick, ROG 214, ROG 261, UI 320, USPT 72, USPT 74, Winchester, P250215, P251215, P131423, P223217, GTS-905, GTS-906.

Pair-wise Yield Regressions With Bill Z And Four Other Varieties

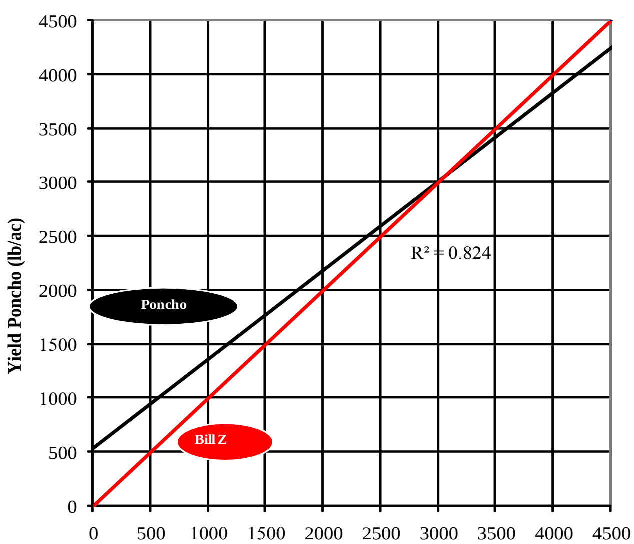
(From 1999-2008 in 40 trials where all five varieties were tested)



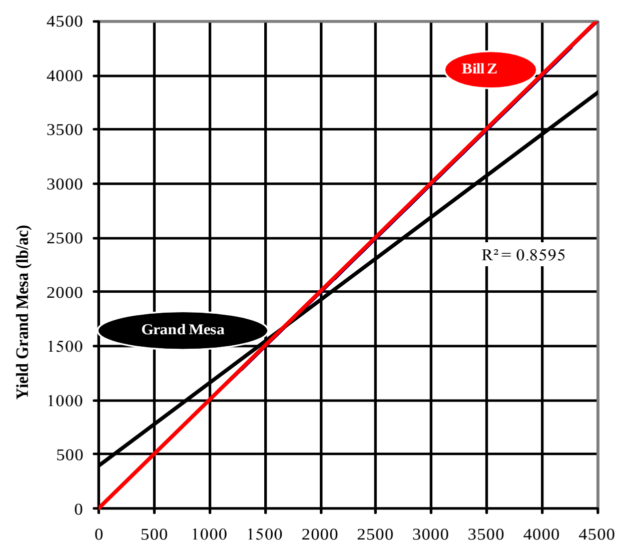
There is no expected difference in yield between Bill Z and Montrose in high yield environments but Montrose is expected to yield better in lower to average yield environments.



Bill Z is expected to be higher yielding than Buckskin in average to higher yielding environments



Poncho would be expected to yield better than Bill Z in lower yield environments. Bill Z would be expected to out yield Poncho in higher yield environments. No difference in yield between these varieties would be expected between approximately 2500 and 3500 lb/ac.



Bill Z would be expected to be higher yielding than Grand Mesa in average to higher yield environments.

Pinto Bean Variety Descriptions:

99195 MR An AmeriSeed Inc. variety from ProVita, Inc. with intermediate resistance to rust and *Bean common mosaic virus (BCMV)*. It is a late maturing variety with a 2B plant type.

99217 An AmeriSeed Inc. variety from ProVita, Inc. with intermediate resistance to rust and *BCMV*. It is a late maturing variety with a 2B plant type.

Baja An AmeriSeed Inc. variety from ProVita, Inc. with intermediate resistance to rust and *BCMV*. It is early maturing with a 2B plant type.

Bill Z A medium maturity (95-96 days) pinto variety released by Colorado State University in 1985. It has a vine Type III growth habit with resistance to *BCMV* and moderate tolerance to bacterial brown spot. It is a very productive variety with good seed color. It is susceptible to white mold, common bacterial blight and strains of rust in the Hi-Plains region.

Buckskin An medium season (89-91 d) pinto variety released by Rogers/Syngenta Seeds, Inc. It is a vine Type III growth habit with resistance to *BCMV*, but susceptible to white mold, rust, and bacterial brown spot.

Croissant A new release from Colorado State University. It was formerly tested as CO23704 and Foundation seed was sold in 2008. It has semi-upright plant growth habit in most environments, bright pinto seed color, resistance to rust, field tolerance to common bacterial blight and resistance some strains of *BCMV*. Maturity is somewhat longer than Bill Z at 97-98 days.

Durango An AmeriSeed Inc. variety from ProVita, Inc. with intermediate resistance to rust and *BCMV*. It is a full season maturing variety with a 2B plant type.

Grand Mesa A medium maturity (94-96 day) pinto variety from Colorado State University released in 2001. Grand Mesa combines resistance to rust, *BCMV*, semi-upright Type II plant architecture and field tolerance to white mold, but is susceptible to common bacterial blight and bacterial brown spot. It has moderate yield potential and good seed color.

Kimberly Released in 2007 by the University of Idaho, Kimberly is a broadly adapted, and full-season pinto cultivar that has resistance or tolerance to *BCMV*, rust, *Beet curly top virus (BCTV)*, and Fusarium root rot as well as tolerance to heat and drought. Kimberly has an indeterminate semi-prostrate growth habit Type III with medium to large vine. Kimberly is a full-season cultivar, 2 to 6 days longer maturity than Bill Z and 8 days longer maturity than Othello under Idaho conditions. Kimberly, Bill Z, and Othello have similar 100-seed weight in the range of 34-35 g.

La Paz An AmeriSeed Inc. variety from ProVita, Inc. with intermediate resistance to rust and *BCMV*. It is a full season maturing variety with a 2B plant type.

Lariat A pinto line, tested as ND020069, was recently released by the North Dakota Agricultural Experiment Station in 2008. It has Type II upright, short vine, with good lodging resistance. In Colorado, it is a full season variety at approximately 99-100 days. It is resistant to rust and bean common mosaic virus.

Montrose A medium maturity (96-97 day) pinto variety released by Colorado State University in 1999. It has resistance to rust and *BCMV*. It has high yield potential and excellent seed quality. It is highly susceptible to white mold.

P223217 A medium season (maturity 95-97 d) pinto variety tested by ADM Edible Beans Specialties Research for 3 years. It has a Type II semi-erect growth habit and demonstrates tolerance to common blight, tolerance to root rot, resistance to rust and white mold avoidance. It carries dominant resistance to most biotypes of *BCMV* found in North America.

Poncho A medium maturity (94-96 day) pinto variety released by Rogers/Syngenta Seeds, Inc. in 1998 with resistance to *BCMV*, high yield potential and excellent seed quality. It has Type III growth habit. It is susceptible to rust and bacterial brown spot.

Santa Fe Released in 2008 by Michigan State University, Santa Fe has Type-II upright, short vine growth habit with resistance to rust, lodging, white mold (avoidance due to upright growth habit), and *BCMV*. Favorably high pod placement in the canopy makes Santa Fe a candidate variety for direct cutting. Santa Fe is dark and large seeded and early maturing (5 days later than Othello and 6 days earlier than La Paz under Michigan conditions).

Shoshone Released in 2007 by the University of Idaho, Shoshone is a broadly adapted, and medium maturing cultivar that has resistance or tolerance to *BCMV*, and rust. Shoshone is moderately tolerant to Fusarium root rot, *BCTV*, heat and drought. Shoshone has an indeterminate semi-prostrate growth habit Type III with small to medium length vine. Shoshone is a medium maturing cultivar, similar to Bill Z and about 4 days longer than Othello under Idaho conditions.

Sonora An AmeriSeed Inc. variety from ProVita, Inc. with intermediate resistance to rust. It is a full season maturing variety with a 2B plant type.

Stampede A pinto line, tested as ND020351, was recently released by the North Dakota Agricultural Experiment Station in 2008. It has full season maturity in the Hi-Plains (96-99 days), high yield capacity and excellent seed size, shape, and appearance. Stampede is an erect variety, with very good lodging resistance. It is resistant to rust and *BCMV*.

Pinto Bean Experimental lines:

01223	An AmeriSeed Inc. experimental line from ProVita, Inc.
05200	An AmeriSeed Inc. experimental line from ProVita, Inc.
06185	An AmeriSeed Inc. experimental line from ProVita, Inc.
06206	An AmeriSeed Inc. experimental line from ProVita, Inc.
CO24601	An experimental pinto line from Colorado State University.
CO24940	An experimental pinto line from Colorado State University.
CO29258	An experimental pinto line from Colorado State University.
CO33911	An experimental pinto line from Colorado State University.
CO33546	An experimental pinto line from Colorado State University.
CO34142	An experimental pinto line from Colorado State University.
CO48049	An experimental pinto line from Colorado State University.
CO54150	An experimental pinto line from Colorado State University.
GTS-903	Upright, mid-season experimental lines from Gentec, Inc.
GTS-904	Upright, mid-season experimental lines from Gentec, Inc.
GTS-905	An experimental pinto line from Gentec, Incorporated.
P232219	An experimental pinto line from ADM-Seedwest
P252215	An experimental pinto line from ADM-Seedwest
P35161	An experimental pinto line from ADM-Seedwest
PT06189	An AmeriSeed Inc. experimental line from ProVita, Inc.
PT06203	An AmeriSeed Inc. experimental line from ProVita, Inc.

Release of 'Croissant' Pinto Bean

Mark A. Brick, J. Barry Ogg, Howard F. Schwartz, Jerry J. Johnson, Fred Judson[1], Phil Miklas[2], and Shree P. Singh[3]. [1]Colorado State University, Fort Collins, CO, [2]USDA-ARS Pullman, WA, and [3]Univ. of Idaho, Kimberly, ID.

The Colorado Agricultural Experiment Station announces the release of 'Croissant', pinto bean (*Phaseolus vulgaris L.*) variety. Croissant was developed at Colorado State University and tested in the Western Regional Bean Trials, Midwest Regional Performance Nursery, and Colorado State University Dry Bean Variety Testing Program as CO23704.

Croissant was derived from a single F_5 plant selection in 2001 from the pedigree BelDakMi-RR-3/CO07010-2//WM2-93-5. BelDakMiRR-3 is a pinto line released by the USDA-ARS for resistance to rust; CO07010-2, is a pinto line from the Colorado State University Breeding Project that has semi-upright architecture, resistance to rust caused by *Uromyces appendiculatus,* and excellent pinto seed quality; and WM2-93-5 is an experimental pinto line from Dr. Dermot Coyne, University of Nebraska Dry Bean Breeding Project. WM2-93-5 possesses resistance to rust, field tolerance to common bacterial blight caused by *Xanthomonas campestris* pv. *phaseoli* and has semi-upright architecture. Hybridization of parental lines was made at the Colorado State University greenhouse, Fort Collins, CO. The line was selected at the Agricultural Research, Demonstration, and Education Center, Fort Collins, and pure seed was increased at the Western Colorado Research Center, Fruita, Colorado.

Croissant has semi-upright architecture (IIb) in most environments however, in high yield environments it expresses semi-vine architecture (IIIa). It possesses resistance to the prevalent races of rust in the High Plains and BCMV caused by *Bean common mosaic virus* (a potyvirus), and medium harvest maturity (92 to 95 d). The specific rust resistant gene(s) has not been characterized but appears to be conditioned by either the Ur-3 allele from WM2-93-5 or UR-11 from BelDakMi-RR3. Resistance to BCMV appears to be conditioned by the recessive allele $bc2^2$. Mean seed yield was 2900 and 2915 kg ha^{-1} over four locations in the Midwest Regional Performance Nursery and Western Regional Bean Trials, and mean seed weights were 37.1 and 34.8 g 100 $seed^{-1}$, respectively. In Colorado, mean seed yield was 2841 kg ha^{-1} averaged over two locations in 2007.

Foundation seed of Croissant will be released to seed producers in May 2008. Application for Foundation Seed can be made to Mr. Fred Judson, Western Colorado Research Center, 3168 B 1/2 Road, Grand Junction, Colorado 81503-9621. Plant Variety Protection under Title V will be sought. A "Technology Fee" paid to Colorado State University, collected by the Certification agency in the state of production will be assessed on all Registered and Certified seed produced. Seed for testing is available from Mark Brick, Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO 80523, 970-491-6551 or Mark.Brick@Colostate.edu.

COAGMET Monthly Summaries from 2006-2008

Compiled by H. F. Schwartz & M. S. McMillan, Colorado State University www.coagmet.com

Monthly Daily High Temperature (F)

	2006				2007				2008			
	Holyoke	Burlington	Rocky Ford	Olathe	Holyoke	Burlington	Rocky Ford	Olathe	Holyoke	Burlington	Rocky Ford	Olathe
May	77.7	78.2	81.1	77.9	85.3	73.5	77.1	74.6	70.5	73.1	78.1	72.5
June	87.7	87.9	91.8	87.9	88.6	83.4	85.5	87.2	81.1	83.8	88.5	83.7
July	91.9	90.9	92.6	89.0	88.7	91.1	91.7	92.1	92.2	91.9	93.1	89.2
Aug	84.7	87.4	87.9	85.9	89.7	88.8	94.0	88.7	83.2	81.9	86.0	86.9
Sept	71.9	72.8	75.3	72.3	81.7	81.1	85.0	80.5	76.8	76.3	79.9	79.0
average	82.8	83.4	85.7	82.6	86.8	83.6	86.7	84.6	80.8	81.4	85.1	82.3

Number of Days Above 95 F

	2006				2007				2008			
	Holyoke	Burlington	Rocky Ford	Olathe	Holyoke	Burlington	Rocky Ford	Olathe	Holyoke	Burlington	Rocky Ford	Olathe
May	0	2	1	0	0	0	0	0	0	0	0	0
June	5	6	12	1	4	3	2	4	0	3	7	1
July	11	10	13	4	5	8	8	0	10	11	14	1
Aug	5	8	6	0	6	5	16	0	4	4	5	1
Sept	0	0	0	0	0	0	1	0	0	0	0	0
total	21	26	32	5	15	16	27	4	14	18	26	3

Monthly Rainfall (inches)

	2006				2007				2008			
	Holyoke	Burlington	Rocky Ford	Olathe	Holyoke	Burlington	Rocky Ford	Olathe	Holyoke	Burlington	Rocky Ford	Olathe
May	0.7	1.6	1.3	0.0	0.2	1.6	1.4	1.2	2.3	0.9	0.5	0.7
June	2.3	3.1	0.2	0.1	0.2	0.9	3.0	0.3	3.2	1.7	0.4	0.5
July	1.8	3.7	2.8	1.3	2.9	3.0	0.3	1.6	1.6	2.6	0.6	1.0
Aug	4.9	3.8	3.6	1.2	1.4	4.4	1.9	1.6	4.9	8.0	4.4	1.3
Sept	2.2	1.4	2.6	1.8	1.2	0.5	0.5	2.0	1.4	1.5	0.0	0.4
total	11.8	13.5	10.6	4.4	5.9	10.4	7.1	6.7	13.3	14.7	5.9	3.9

Summary: 2007 had higher daily temperatures in southern and western Colorado during July and August
Days above 95 F were greater during July, and could have affected flowering and pod set
Rainfall patterns were comparable in 2006 & 2007; higher in eastern Colorado in 2008 // **CSU Veg Path Web Sites:**

http://www.colostate.edu/Orgs/VegNet/

http://www.alliumnet.com/

Evapotranspiration And Irrigation Requirements Of Dry Beans

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Among other factors, the consumptive water requirement (crop evapotranspiration, ET_c) of dry beans must be satisfied to achieve yield potentials. The ET_c of dry beans is due to a combination of two processes – evaporation of water from the ground surface or wet surfaces of plants; and transpiration of water through the stomates of leaves. The water requirement can be supplied by stored soil moisture, precipitation, and irrigation. Irrigation is required when ET_c (water demand) exceeds the supply of water from soil moisture and precipitation. As ET_c varies with plant growth stage and weather conditions, both the amount and timing of irrigation are important. The water balance (checkbook) method of irrigation scheduling is one method of estimating the required amount and timing of irrigation for dry beans. This method can be used if initial soil water content in the root zone, daily ET_c, daily precipitation, and the available water capacity of the soil are available.

The soil in the root zone has an upper as well as a lower limit of storing water that can be used by crops. The upper limit is called the field capacity (FC), which is the amount of water that can be held by the soil against gravity after being saturated and drained. The lower limit is called permanent wilting point (PWP), which is the amount of water remaining in the soil when the plant permanently wilts because it can no longer extract water. The available water capacity (AWC) of the soil is the amount of water between these two limits (AWC = FC – PWP) and is the maximum amount of soil moisture that can be used by the plants. The AWC of soil is typically expressed in terms of inches of water per inch of soil depth. Values of AWC for specific soils can be obtained from county soil surveys or online at http://websoilsurvey.nrcs.usda.gov/app/.

As the crop grows and extracts water from the soil to satisfy its ET_c requirement, the stored soil moisture is gradually depleted. In general, the net irrigation requirement is the amount of water required to refill root zone soil water back up to field capacity. This amount corresponds to the soil water deficit (D) at the time of irrigation. In irrigation practice, only a percentage of AWC is allowed to be depleted because plants start to experience water stress even before soil moisture is depleted down to PWP. Therefore, a management allowed depletion (MAD) of the AWC must be specified. For dry beans, MAD ranges from 50% to 70% of soil AWC, depending on the developmental stage. On a daily basis, the soil water deficit (D; same as net irrigation requirement) can be estimated using the following accounting equation:

$$D_i = D_{i-1} + ET_c - P - Irr \qquad \text{(if } D_i \text{ is negative, then set it to 0.0)} \qquad [1]$$

where D_i is the soil water deficit (net irrigation requirement) in the root zone on day i, D_{i-1} is the previous day's soil water deficit, ET_c is the crop evapotranspiration for the current day, P is the precipitation for the current day, and Irr is the irrigation amount for the day. Take note that D_i is set equal to zero if its value becomes negative. This will occur if (P + Irr) exceeds (D_{i-1} + ET_c) and means that water added to the root zone already exceeds field capacity. Any excess water is assumed to be lost via surface runoff or deep percolation. The amounts of water used in the equation are typically expressed in depths of water per unit area (e.g. inches of water per acre). Equation 1 is a simplified version of the soil water balance with several underlying assumptions. First, any water additions (P or Irr) are assumed to readily infiltrate into the soil surface and the rates of P or Irr are assumed to be less than the infiltration rate of the soil. Actually, some water is lost to surface runoff if precipitation or irrigation rates exceed the soil infiltration rate. Thus, equation 1 will under-estimate the soil water deficit or the net irrigation requirement if P or Irr rates are higher than the soil infiltration rate. Knowledge of precipitation, irrigation, and soil infiltration rates (e.g. inches per hour) are required to obtain more accurate estimates of D_i. Secondly, water added to the root zone from a shallow water table (e.g. capillary rise of water) is not considered. Groundwater contributions to soil water in the root zone must be subtracted from the right hand side of the equation in case of a shallow water table. Equation 1 will over-estimate D_i if any actual soil water additions from groundwater are neglected. However, the two assumptions are reasonable for many situations in the semi-arid environment of Colorado.

Equation 1 can easily be entered as a formula into a spreadsheet, with columns for daily values of ET_c, P, Irr, and D. Daily values of ET_c for dry beans and P can be obtained online from the Colorado Agricultural Meteorological Network (CoAgMet) crop ET access page (http://ccc.atmos.colostate.edu/cgi-bin/extended_etr_form.pl) for different locations in Colorado. A network of 69 weather stations across Colorado provide daily values of ET_c and P that are made available at this webpage.

An Example from Yuma, Colorado

The example below is for a hypothetical dry bean field in Yuma, Colorado having Kuma silt loam soil with an available water capacity (AWC) of 0.20 inches of water per inch of soil for the top 30 inches. The AWC for this soil was taken from the online Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/app/. The Web Soil Survey is an online soils database maintained by USDA-Natural Resources Conservation Service. Instructions on how to use the tool are given on the home page. The following steps can be followed to reproduce the soils report used in this example. Note that although this example used soils information from an actual field near Yuma, the selection of this site was arbitrary and was only done to serve as an example.

1.Click on the large green button (Start WSS) to use the tool. Take note that there are four tabs near the top. You should be in the "Area of Interest (AOI)" tab for this step. On the left hand side, click on "Navigate by … PLSS(Section, Township, Range)" and input "Colorado" for the state, "Sixth Principal" for the principal meridian, "16" for the section, "2" and "North" for the township, and "48" and "West" for the range. Select "View" after typing in the information. The AOI map to the right should now show a map centered on the specified location, with four center-pivot circles in view.

2.Using the "Define AOI by Rectangle" tool at the top of the map, draw a rectangular box around the four center-pivot circles. Once you have selected the area, AOI information should be shown on the left hand side (Figure 1).

3.Click on the "Soil Map" tab (top of page) to see the soil names in the selected area. Click on the "Soil Data Explorer" tab. Click on the "Soil Reports" sub-tab (next row of tabs from top) and select "Soil Physical Properties", click on "Physical Soil Properties", and "View Soil Report". A tabular report of soil physical properties should appear below the map (Figure 2). At the upper right hand corner of the webpage, click on "Printable Version", click on "View", and a portable digital format (pdf) version of the report should be generated. The report may come up in a new window of your browser.
The available water capacity for Kuma silt loam can be located in the soil properties table. Take note that a range (0.18 – 0.21) is given for the top 30 inches. For simplicity, this example assumed a mid-range AWC value of 0.20 inch of water per inch of soil.

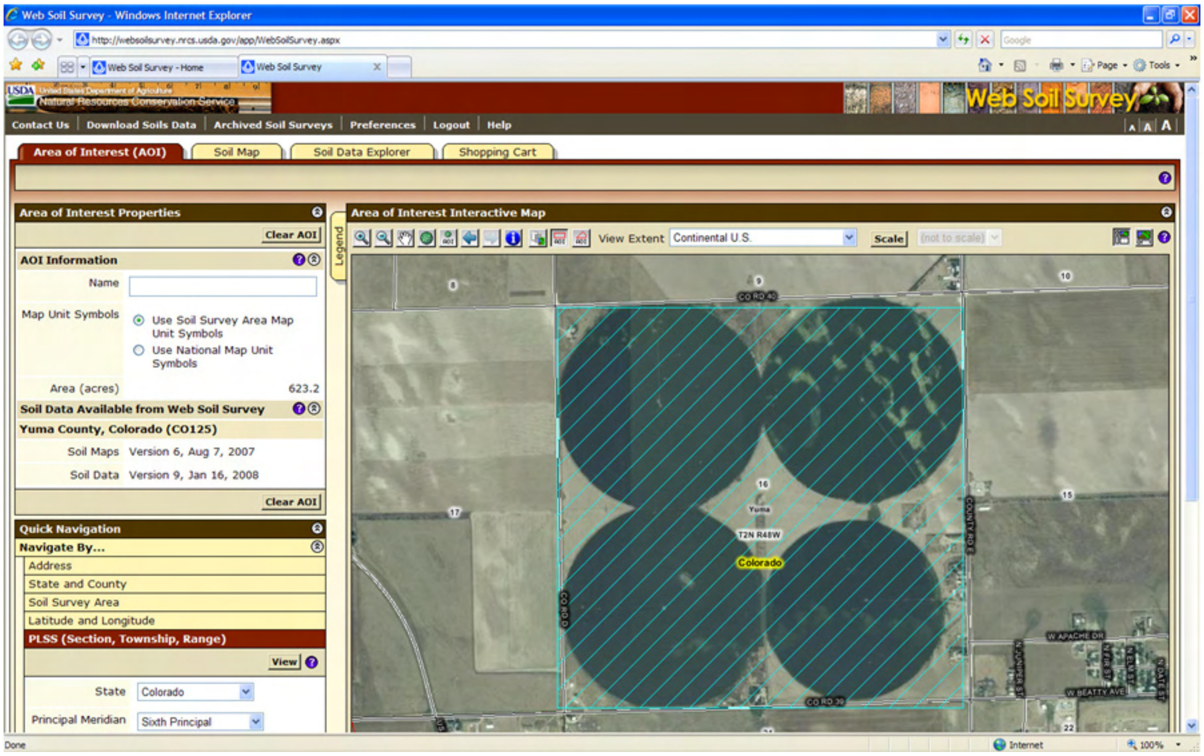

Figure 1. Selected area of interest in Web Soil Survey for the Yuma, Colorado example.

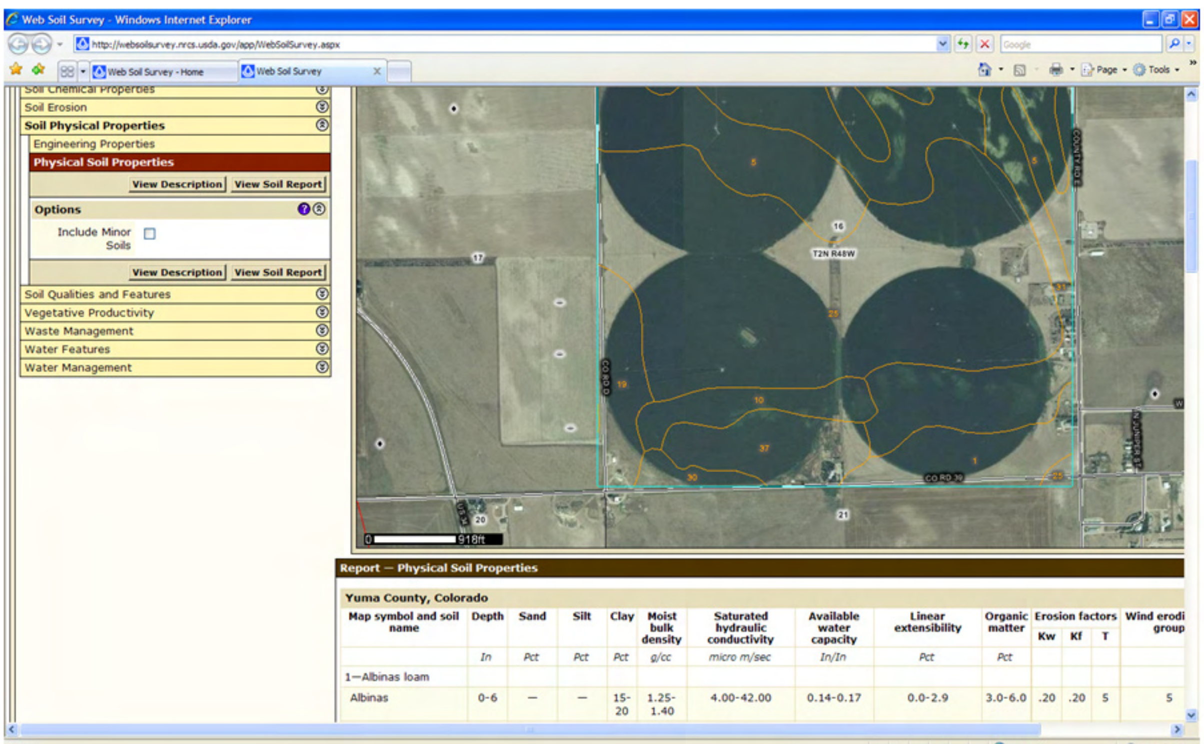

Figure 2. Physical soil properties shown below the soil map. Available water capacity is given in the eighth column from the left. Scroll down to view AWC for Kuma silt loam (map symbol 25).

The dry beans were planted on May 31, 2008 and the initial soil moisture was assumed to be at field capacity (profile was full). This meant that the soil water deficit (D) was zero at the start of the growing season. This assumption was reasonable because actual precipitation from January 15 to May 30, 2008 was 2.56 inches, which was greater than AWC for the top foot of soil (root zone during stand establishment phase).

Water requirements of dry beans change throughout the season because rooting depth (access to available soil water) and the rate of ETc change as the crop develops and weather varies. Table 1 shows the assumed management rooting depths and corresponding values of root zone AWC and MAD for different growth phases of dry beans (Bauder and Schneekloth).

Table 1. Assumed rooting depths and MAD at different developmental phases of dry beans.

Dates	Phase	Depth of roots, in	Total AWC, in	MAD, %	MAD, in
6/1 – 6/30	stand establishment	12	2.4	60	1.4
7/1 – 7/21	rapid vegetative	20	4.0	60	2.4
7/22 – 8/15	flowering; pod dev't.	30	6.0	50	3.0
8/16 – 9/10	pod fill and maturation	30	6.0	70	4.2

Before using equation 1, an irrigator must pre-determine the allowable water deficit (D) that corresponds to the MAD for dry beans at a particular growth stage. The MAD values in the right-most column of Table 1 were obtained using the following equations.

$$Total\ AWC = depth\ of\ roots\ x\ AWC(inch\ of\ water\ per\ inch\ of\ soil) \qquad [2]$$

$$MAD, in = \frac{MAD,\%}{100}(Total\ AWC, in) \qquad [3]$$

For example, total AWC of the root zone during stand establishment is: 12 inches soil x 0.20 inches of water/inch soil = 2.4 inches of water. Then, MAD expressed in inches of water is 60/100 x 2.4 inches of water = 1.4 inches of water. This means that during the stand establishment phase (June 1 to June 30), when the soil water deficit (Di) becomes equal to or greater than 1.4 inches, then irrigation water must be applied. Similar calculations were done for the other growth phases in Table 1.

Daily evapotranspiration values for dry beans and daily precipitation in 2008 were obtained from a CoAgMet weather station at Yuma, Colorado (http://ccc.atmos.colostate.edu/cgi-bin/extended_etr_form.pl). Instructions on how to use the tool are given at the top of the webpage. For this example, the following options were selected on the webpage:

Select a Start Date: 2008 May 31;
Select days (# to do): 120;
Station: yum02 – Yuma;
Select Crops and Planting Date: Drybeans, m = 05, d = 31;
Reference ET Model: Penman-Kimberly.

The "Submit" button was clicked once the above selections were made.

From the planting date of May 31, 2008 to the maturity date of September 10, 2008, the dry bean crop consumed a total of 22.78 inches of water by evapotranspiration, but only received a total of 14.31 inches of precipitation (Figure 3). It is interesting to note that until July 2, 2008, cumulative precipitation exceeded the cumulative ETc requirement of dry beans. However, precipitation could not keep up with the cumulative ETc requirement after this date.

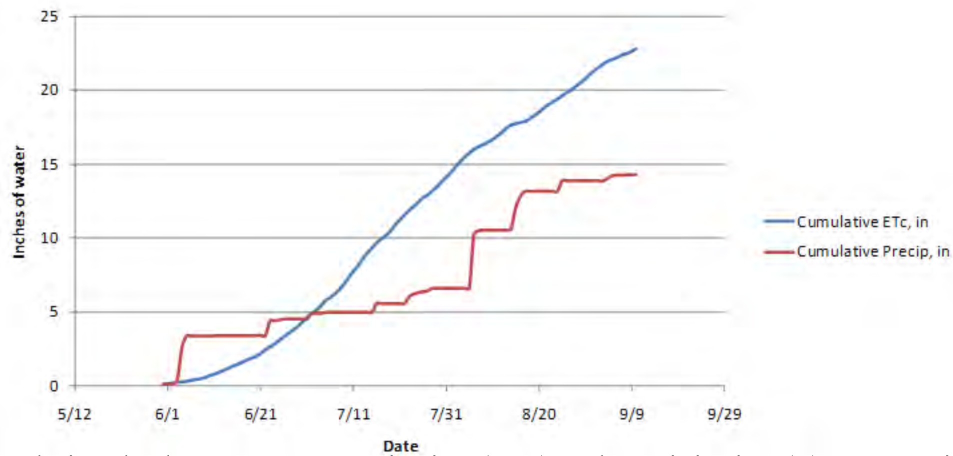

Figure 3. Cumulative dry bean evapotranspiration (ETc) and precipitation (P) at Yuma in 2008.

The daily ETc and P values for 2008 were copied from the CoAgMet crop ET access page and pasted into separate columns of a spreadsheet. Equation 1 was then input as a formula for a new column to keep track of daily soil water deficits. A fourth spreadsheet column was also added for input of any irrigation amounts. Figure 4 shows a screen shot of the spreadsheet used for this example. For different growth phases of the dry bean crop, irrigation amounts equal to the current soil water deficit were entered on days when the soil water deficit (D_i) equaled or exceeded the MAD (inches of soil water) given in the right-most column of Table 1.

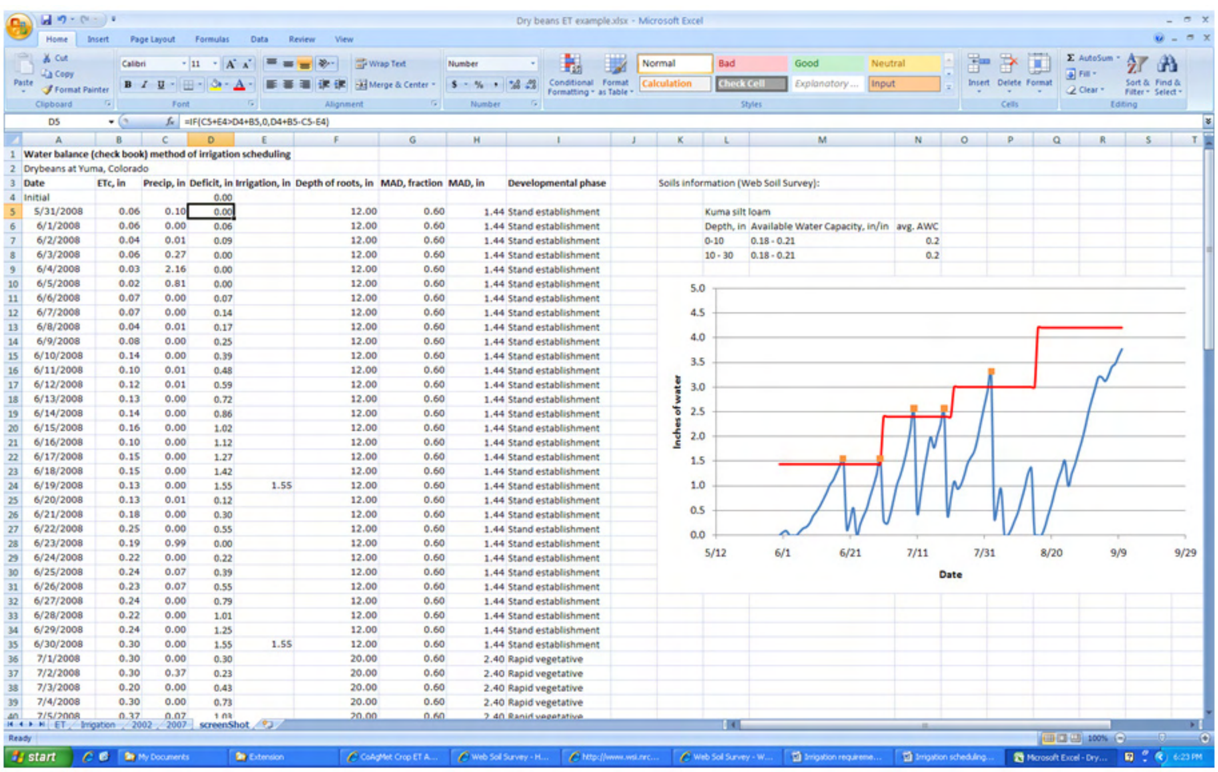

Figure 4. Spreadsheet for calculating soil water deficits (D_i) and irrigation amounts for dry beans at Yuma, Colorado in 2008. The cell information box ("fx =") just above the spreadsheet columns is showing the Excel formula used to calculate D_i.

Figure 5 shows the progression of soil water deficits, irrigation dates, and irrigation amounts through the growing season. The red line indicates the MAD (inches of soil water) values that were used as thresholds for specifying irrigation timings and amounts. Irrigations were scheduled (orange squares) when the soil water deficit curve (blue line) went above the MAD (red line) in each growth phase. For example, 2.56 inches of irrigation were required on July 10, 2008. This was when the current soil water deficit (D_i = 2.56 in) exceeded the management allowed depletion of 2.4 inches during the vegetative phase.

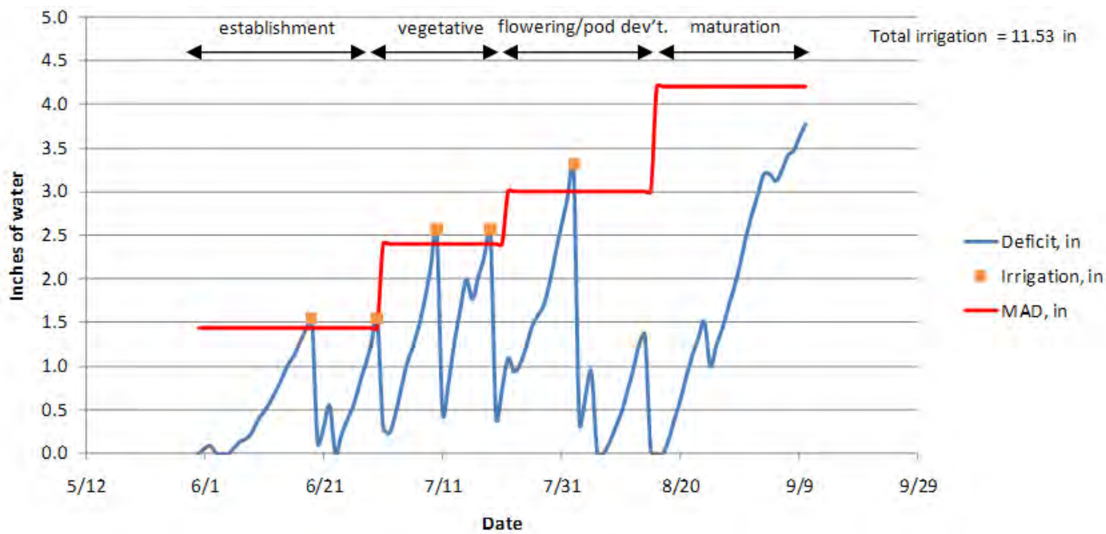

Figure 5. Soil water deficit and irrigation amounts for dry beans at Yuma in 2008.

Based on equation 1, five irrigations were required to satisfy the ETc requirements of dry beans from May 31 to September 10, 2008. Note how the soil water deficit dropped when irrigations occurred (Figure 5). In addition, the soil water deficit also dropped at times when rainfall occurred. The total net irrigation requirement for this period was 11.53 inches. The last irrigation required was 3.31 inches on August 2. After this, there were several significant rainfall events that eliminated or reduced the soil water deficit, keeping it below the MAD during pod development and maturation.

The irrigation amounts shown in Figure 5 may have to be applied in several installments or irrigation sets, depending on the type of irrigation system. Realistically, these amounts (1.6 to 3.3 inches) may be more suitable for surface systems such as furrow irrigation. Sprinkler systems such as center-pivots may not have the capacity to apply large amounts of water in one pass. Therefore, more frequent but smaller amounts of irrigation are necessary for such systems and irrigations are scheduled before the soil water deficit reaches MAD. Regardless of the type of irrigation system, the water balance approach of irrigation scheduling (Equation 1) can be used to keep track of the soil water deficit and schedule irrigations before or when management allowed depletion is reached. The approach shown in the above example can be used at other locations having nearby CoAgMet weather stations.

Reference

Bauder, T. and Schneekloth, J. Irrigated Field Record Book. Colorado State University Cooperative Extension and USDA-Natural Resources Conservation Service, Fort Collins, Colorado, pp. 46-47.

Crops Testing

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