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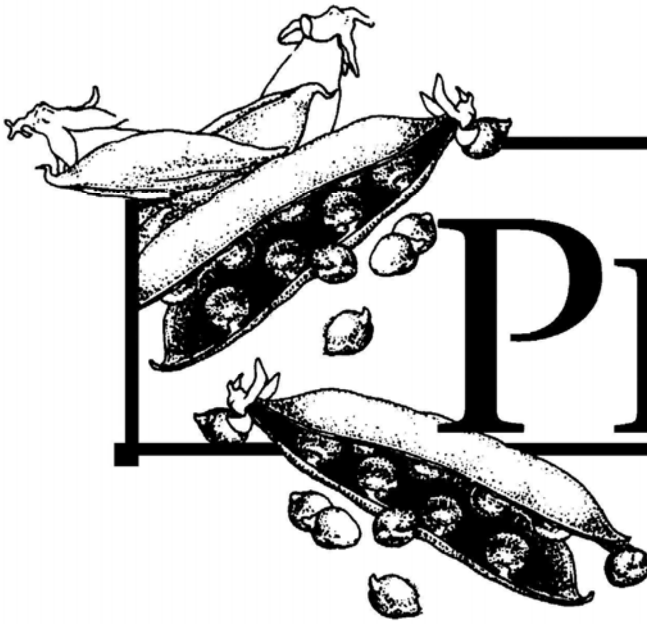

PEA

VARIETY TRIAL RESULTS

2008

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Participating Seed Companies
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Pure Line Seeds, Inc.
Brotherton Seed Co.
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2008 University of Delaware Pea Variety Trial

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Introduction

The 2008 Pea Variety Trials were conducted at the University of Delaware Research and Education Center. The purpose of these trials is to evaluate and identify varieties best adapted for our production region. Yield, quality and maturity are important characteristics that can vary for any one variety between production regions. Similar trials have been conducted annually since 1994, except in 1998, 2001, 2004, and 2007.

This year the trials were planted on two dates, March 14 and April 15, to place the varieties in the planting season appropriate for their maturity classification. Early maturing varieties are generally planted during the first half of the planting season and longer maturing varieties are planted in the second half. Later plantings are exposed to warmer conditions, which generate quicker accumulations of heat units. Thus, longer maturing varieties are used in later plantings.

Materials and Methods

Planting and Crop Management

Thirteen varieties were planted in the early trial and fourteen varieties were planted in the late trial. The trials were irrigated as needed, and grown under standard commercial management practices. Weed control was good and insect control was not necessary because insect populations were low or non-existent in both trials. Rainfall was below average for March and April but above average for May. Some irrigation was necessary. Complete weather and irrigation data and heat unit accumulation for the trials is included in Appendices A & B.

Planting Date: **Early Trial –** March 14, 2008; 13 varieties;
Late Trial – April 15, 2008; 14 varieties

Herbicide: **Early Trial –** Pursuit @ 2 oz/A + Dual II Magnum @ 0.75 pts/A, preemergence pre-plant incorporated with 30% UAN at 15 gallons per acre
Late Trial – Pursuit @ 2 oz/A + Dual II Magnum @ 1.00 pts/A, preemergence pre-plant incorporated with 30% UAN at 15 gallons per acre

Planting: Trials were planted using an Almaco drill with 9 rows spaced 8 inches apart. Eight seeds per foot of row were planted of each variety. Final stand counts are reported in the results.

Plot Design: 6 x 30 foot plots arranged in a randomized complete block design with 3 replications

Varieties Entered in the 2008 Pea Trials

Variety	Company	Trial
BSC 3735	Brotherton, Seed Co., Inc.	Early Trial
PLS-1*	Pure Line Seeds, Inc	Early Trial
PLS-12	Pure Line Seeds, Inc	Early Trial
PLS-286	Pure Line Seeds, Inc	Early Trial
EX 0702 (085 2 0702)	Seminis	Early Trial
EX 0819 (085 1 0819)	Seminis	Early Trial
EX 0821 (085 5 0821)	Seminis	Early Trial
EX 0824 (082 5 0824)	Seminis	Early Trial
CMG 416 AF*	Crites-Moscow	Early Trial
CMG 407 AF*	Crites-Moscow	Early Trial
CMG 417 AF*	Crites-Moscow	Early Trial
FP 2292	Syngenta	Early Trial
EF 680	Check Variety	Early Trial
BSC 5697	Brotherton, Seed Co., Inc.	Late Trial
PLS-W92	Pure Line Seeds, Inc	Late Trial
PLS-W90	Pure Line Seeds, Inc	Late Trial
PLS-134*	Pure Line Seeds, Inc	Late Trial
EX 0899 (085 6 0899)*	Seminis	Late Trial
EX 0793 (085 4 0793)*	Seminis	Late Trial
EX 0794 (085 4 0794)*	Seminis	Late Trial
EX 0727 (085 3 0727)	Seminis	Late Trial
CMG 410 AF*	Crites-Moscow	Late Trial
CMG 378 F	Crites-Moscow	Late Trial
CMG 413 AF*	Crites-Moscow	Late Trial
Grundy	Syngenta	Late Trial
Ricco*	Syngenta	Late Trial
Bolero	Check Variety	Late Trial

*****Afila Variety

Harvest Procedure

Each variety was harvested as near to a tenderometer reading of 100 as possible. Pre-harvest samples were taken two to three days prior to reaching this maturity level whenever possible. All three replications for each variety were harvested on the same day.

Plants were pulled from a 6 x 25 foot section of the plot (150 ft^2). The vines were weighed and fed into a stationary FMC viner. Shelled peas were collected and cleaned (removing leaves, stones, and other trash). The clean, shelled peas were weighed. A 700 g sub-sample was put through a size separator that segregated peas into the following sizes according to their diameter: 12/32 inch or greater (#4 sieve size); between 11/32 and 12/32 inch (#3 sieve size); between 9/32 and 11/32 inch (#1 and #2 sieve size); and peas smaller than 9/32 inch (trash). Three tenderometer readings were taken from each sample. The average is reported.

Ten plants were taken from each variety on the day of harvest and the following measurements were taken: vine length; number of nodes setting usable pods; number of pods per plant; pod length; and peas per pod. Statistics for pod length and number of peas per pod were calculated ten pods that were randomly selected from the ten sampled plants.

Discussion of Trial Results

The results for the early and late trials are reported in two separate sections. Each section consists of thirteen tables of results. In most tables the variety means are listed in descending order. Means followed by the same letter are not significantly different as determined by Fischer's protected LSD with 5% error (α=0.05). The LSD value and p-value for the effect of the independent variable are included at the bottom of each table.

Tables 4E and 4L report the net and gross yields adjusted to a tenderometer reading of 100. The adjustment calculation procedure is described in Appendix C: Adjusting Pea Yields to a T-Reading of 100. The net yield is calculated by subtracting the percent of peas smaller than 9/32 inch, trash, (as determined by sizing of a 700 g sub-sample) from the gross yield.

Pea yields in the early trial were comparable to those from the 2005 trial. Plant stands were reduced in the early trial (Table 2E) due to seed corn maggot. Stands for the check variety, EF 680 (seed was treated only with captan), were so poor that it was not harvested. Statistically significant differences in yield were observed in both the early and late trials. The variety with the highest adjusted net yield in the early trial (Table 4E) was BSC 3735. The varieties with the highest adjusted net yield in the late trial (Table 4L) were EX 0727 and CMG 378 F. The late trial check variety, Bolero, ranked third in yield in that trial.

Early Trial Harvest Results

Table 1E: Flowering Data

Variety	First Flower		Full Flower	
	DAP	Heat Units	DAP	Heat Units
EX 0702	45	568	53	720
PLS-12	47	590	54	747
EX 0819	47	590	54	747
EX 0824	47	590	54	747
FP 2292	47	590	52	699
EX 0821	49	633	54	747
PLS-1	50	659	54	747
PLS-286	50	659	54	747
CMG 416 AF	51	682	54	747
EF 680 (check)	51	682	56	796
CMG 407 AF	52	699	54	747
BSC 3735	53	720	56	796
CMG 417 AF	53	720	56	796

Table 2E: Stand Counts (Plants/Yard)

Variety	Plants/Yd	
EX 0702	19.4	a
CMG 417 AF	18.3	ab
EX 0819	18.1	ab
CMG 407 AF	16.7	abc
EX 0821	16.6	abc
EX 0824	16.1	abcd
PLS-1	16.0	bcd
PLS-12	16.0	bcd
BSC 3735	15.8	bcd
CMG 416 AF	15.7	bcd
FP 2292	13.9	cd
PLS-286	13.0	de
EF 680	9.9	e
LSD	3.38	
p-value	<0.0001	

Table 3E: Weight of Vines from 150 ft^2 Harvest Area (Lbs.)

Variety	Vine Weight (lbs.)	
BSC 3735	101	a
CMG 407 AF	91	ab
CMG 416 AF	87	abc
CMG 417 AF	85	abcd
PLS-1	74	bcde
PLS-286	73	bcde
EX 0824	71	bcdef
EX 0819	70	cdef
EX 0702	66	def
FP 2292	59	ef
EX 0821	59	ef
PLS-12	52	f
LSD	19.79	
p-value	0.0010	

Table 4E: Net Yields (% Trash Subtracted) and Gross Yields Adjusted to a Tenderometer Reading of 100 (Lbs/A)

Variety	Adj. Net Yield (lbs/A)		Adj. Gross Yield (lbs/A)	
BSC 3735	6511	a	6590	a
EX 0824	4346	b	4583	b
CMG 407 AF	4278	b	4675	b
CMG 416 AF	4101	bc	4168	bc
CMG 417 AF	3927	bcd	4100	bc
FP 2292	3686	bcde	3722	cd
PLS-286	3395	cde	3438	cde
EX 0821	3360	cde	3441	cde
EX 0819	3323	def	3723	cd
EX 0702	3261	def	3559	cde
PLS-1	3145	ef	3236	de
PLS-12	2568	f	2730	e
LSD	763.27		836.08	
p-value	<0.0001		<0.0001	

Table 5E: Pea Size (% peas by weight in each class) and Tenderometer Reading at Harvest

Variety	% #4		% #3		% #1 & #2		% Trash		T-reading at Harvest	
BSC 3735	69.5	a	20.9	f	8.4	g	1.1	e	97	f
CMG 416 AF	44.5	b	37.4	cde	16.6	ef	1.6	de	108	cd
PLS-286	43.2	bc	43.7	abc	11.9	fg	1.2	e	131	a
FP 2292	34.3	cd	48.0	a	16.7	ef	1.0	e	109	c
PLS-1	33.2	de	43.1	abcd	20.8	de	2.8	cde	114	b
EX 0821	29.1	de	43.8	abc	25.0	cd	2.1	de	103	e
CMG 417 AF	28.7	de	42.6	abcd	24.5	cd	4.2	cd	103	e
CMG 407 AF	24.8	ef	36.9	de	29.7	bc	8.6	ab	92	g
PLS-12	16.8	fg	40.7	bcd	36.6	b	6.0	bc	98	f
EX 0824	15.5	g	44.8	ab	34.7	b	5.0	cd	104	e
EX 0702	9.6	gh	33.7	e	48.3	a	8.5	ab	93	g
EX 0819	5.5	h	32.8	e	51.5	a	10.1	a	104	de
LSD	9.05		6.79		7.09		3.45		3.92	
p-value	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001	

Table 6E: Tenderometer Reading at Harvest

Variety	Tenderometer Reading	
CMG 407 AF	92	g
EX 0702	93	g
BSC 3735	97	f
PLS-12	98	f
CMG 417 AF	103	e
EX 0821	103	e
EX 0824	104	e
EX 0819	104	de
CMG 416 AF	108	cd
FP 2292	109	c
PLS-1	114	b
PLS-286	131	a
LSD	3.92	
p-value	<0.0001	

Plant Characteristics for Early Trial Varieties Based on a 10-Plant Sample

Table 7E: Vine Length in Centimeters

Variety	Vine Length (cm)	
CMG 407 AF	64.2	a
FP 2292	59.8	ab
CMG 416 AF	56.5	bc
BSC 3735	55.1	bcd
PLS-286	54.0	bcde
CMG 417 AF	52.8	cdef
PLS-1	49.9	def
EX 0824	49.7	def
EX 0702	47.6	efg
EX 0819	46.7	fg
EX 0821	46.4	fg
PLS-12	42.2	g
LSD	6.44	
p-value	<0.0001	

Table 8E: Number of Pods per Plant

Variety	Pods/Plant	
FP 2292	7.2	a
CMG 407 AF	6.4	ab
PLS-286	6.3	abc
PLS-1	5.5	bcd
CMG 416 AF	5.2	bcde
EX 0702	5.0	bcde
EX 0824	4.9	cde
BSC 3735	4.5	def
EX 0821	4.5	def
CMG 417 AF	4.3	def
EX 0819	3.8	ef
PLS-12	3.2	f
LSD	1.43	
p-value	<0.0001	

Table 9E: Number of Pod-Bearing Nodes per Plant

Variety	Nodes w/ Pods/Plant
PLS-286	6.3 a
FP 2292	4.5 b
CMG 407 AF	4.2 bc
EX 0702	3.6 bcd
PLS-1	3.5 cde
CMG 416 AF	3.5 cde
CMG 417 AF	3.4 cde
BSC 3735	3.2 de
PLS-12	2.8 def
EX 0824	2.8 def
EX 0821	2.6 ef
EX 0819	2.2 f
LSD	0.95
p-value	<0.0001

Table 10E: Average Pod Length in Centimeters

Variety	Pod Length (cm)
CMG 416 AF	8.8 a
BSC 3735	8.5 ab
PLS-286	8.2 bc
EX 0821	8.2 bcd
CMG 407 AF	8.0 cde
FP 2292	7.8 cde
CMG 417 AF	7.8 cdef
PLS-12	7.7 def
EX 0824	7.6 efg
EX 0819	7.3 fgh
PLS-1	7.2 gh
EX 0702	6.9 h
LSD	0.49
p-value	<0.0001

Table 11E: Average Number of Peas per Pod

Variety	Peas/Pod
EX 0824	7.6 a
EX 0821	7.4 a
BSC 3735	6.3 b
PLS-12	6.3 b
CMG 416 AF	6.3 b
EX 0819	6.2 b
FP 2292	6.2 b
CMG 407 AF	6.1 b
CMG 417 AF	6.0 b
EX 0702	5.7 b
PLS-286	5.5 b
PLS-1	3.9 c
LSD	0.91
p-value	<0.0001

Early Trial Maturity Data

Table 12E: Tenderometer Readings Leading Up To and Including Harvest

	Date and Accumulated Heat Units															
	19-May	20-May	21-May	22-May	23-May	24-May	25-May	26-May	27-May	28-May	29-May	30-May	31-May	1-Jun	2-Jun	3-Jun
Variety	**981**	**996**	**1013**	**1029**	**1045**	**1067**	**1088**	**1115**	**1151**	**1172**	**1191**	**1220**	**1256**	**1290**	**1318**	**1347**
EX 0702	89		87		98	**93***										
EX 0819					96			**104**								
PLS-12					89			**98**								
EX 0824					91			91	**104**							
EX 0821					81			83		**103**						
FP 2292									84	85		**109**				
PLS-1												105	**114**			
CMG 416 AF												111	**108**			
CMG 407 AF												90	**92**			
PLS-286															**131**	
CMG 417 AF															**103**	
BSC 3735												79			90	**97**

*****Bold numbers indicated the day on which the variety was harvested and are an average of three samples from each of three replications

Table 13E: Summary of Maturity Information for Early Trial Varieties

Variety	Reported Heat Units	Heat Units at Harvest	T-reading at Harvest
EX 0702	1140	1067	93
EX 0819	1140	1115	104
PLS-12	1200	1115	98
EX 0824	1200	1151	104
EX 0821	1220	1172	103
FP 2292	1188	1220	109
CMG 407 AF	1260	1256	92
CMG 416 AF	1210	1256	108
PLS-1	1250	1256	114
CMG 417 AF	1260	1318	103
PLS-286	1180	1318	131
BSC 3735	1330	1347	97

Late Trial Harvest Results

Table 1L: Flowering Data

Variety	First Flower		Full Flower	
	DAP	Heat Units	DAP	Heat Units
PLS-W92	42	844	49	1041
PLS-W90	42	844	50	1075
EX 0793	43	865	47	984
BSC 5697	44	885	48	1012
EX 0899	44	885	50	1075
EX 0794	46	950	48	1012
Ricco	46	950	49	1041
CMG 410 AF	47	984	50	1075
CMG 378 F	47	984	52	1136
Grundy	47	984	50	1075
Bolero	47	984	50	1075
PLS-134	48	1012	52	1136
EX 0727	48	1012	52	1136
CMG 413 AF	48	1012	52	1136

Table 2L: Stand Counts (Plants/Yard)

Variety	Plants/Yd	
CMG 413 AF	23.1	a
CMG 410 AF	22.3	ab
PLS-W92	20.3	abc
EX 0727	19.9	bcd
PLS-134	19.8	bcd
Grundy	19.4	bcde
EX 0794	18.4	cde
EX 0793	17.8	cde
CMG 378 F	17.2	cde
Bolero	17.2	cde
BSC 5697	17.1	de
PLS-W90	17.1	de
EX 0899	16.4	e
Ricco	16.4	e
LSD	3.13	
p-value	<0.0001	

Table 3L: Weight of Vines from 150 ft^2 Harvest Area (Lbs.)

Variety	Vine Weight (lbs.)	
CMG 410 AF	117	a
PLS-W92	114	a
EX 0727	111	ab
Grundy	107	abc
Ricco	104	abcd
PLS-134	103	abcd
CMG 378 F	101	abcd
EX 0899	99	abcde
PLS-W90	99	abcde
CMG 413 AF	93	bcdef
EX 0794	91	cdef
EX 0793	87	def
Bolero	81	ef
BSC 5697	81	f
LSD	18.26	
p-value	0.0046	

Table 4L: Net Yields (% Trash Subtracted) and Gross Yields Adjusted to a Tenderometer Reading of 100 (Lbs/A)

Variety	Adj. Net Yield (lbs/A)		Adj. Gross Yield (lbs/A)	
EX 0727	5186	a	5583	a
CMG 378 F	4486	ab	4546	b
Bolero	4435	b	4499	bc
CMG 410 AF	4374	b	4501	bc
EX 0793	4299	bc	4372	bcd
Grundy	4237	bc	4266	bcd
BSC 5697	4181	bc	4428	bc
PLS-134	4037	bcd	4197	bcde
PLS-W92	3927	bcd	3986	bcde
EX 0794	3805	bcd	3825	cde
EX 0899	3626	cd	3696	de
PLS-W90	3414	de	3489	ef
CMG 413 AF	2716	e	2970	f
Ricco	1969	f	1999	g
LSD	708.63		714.95	
p-value	<0.0001		<0.0001	

Table 5L: Pea Size (% peas by weight in each class) and Tenderometer Reading at Harvest

Variety	% #4		% #3		% #1 & #2		% Trash		T-reading at Harvest	
EX 0899	54.4	a	25.6	c	18.1	cde	1.9	de	142	c
Ricco	53.3	a	30.5	c	14.7	def	1.5	de	141	c
EX 0794	52.1	a	39.9	b	7.4	f	0.6	e	154	a
Bolero	48.4	ab	39.3	b	10.8	ef	1.5	e	151	ab
Grundy	42.4	b	42.3	ab	14.6	def	0.7	e	127	e
CMG 378 F	32.0	c	44.2	ab	22.6	cd	1.2	e	121	f
PLS-W92	28.6	c	48.7	a	21.2	cd	1.5	e	129	de
PLS-W90	27.3	c	45.1	ab	25.4	c	2.1	de	127	e
PLS-134	16.0	d	39.4	b	40.8	b	3.8	cd	116	g
EX 0793	12.8	de	48.9	a	36.5	b	1.7	de	148	b
EX 0727	12.6	de	41.5	ab	38.8	b	7.1	ab	100	h
CMG 410 AF	8.8	def	44.1	ab	44.3	b	2.8	de	127	e
BSC 5697	4.9	ef	45.2	ab	44.3	b	5.6	bc	132	d
CMG 413 AF	0.0	f	9.6	d	81.9	a	8.6	a	121	f
LSD	9.29		7.93		8.02		2.32		5.25	
p-value	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001	

Table 6L: Tenderometer Reading at Harvest

Variety	Tenderometer Reading	
EX 0727	100	h
PLS-134	116	g
CMG 378 F	121	f
CMG 413 AF	121	f
Grundy	127	e
PLS-W90	127	e
CMG 410 AF	127	e
PLS-W92	129	de
BSC 5697	132	d
Ricco	141	c
EX 0899	142	c
EX 0793	148	b
Bolero	151	ab
EX 0794	154	a
LSD	5.25	
p-value	<0.0001	

Plant Characteristics for Late Trial Varieties Based on a 10-Plant Sample

Table 7L: Vine Length in Centimeters

Variety	Vine Length (cm)	
CMG 413 AF	65.2	a
Ricco	61.5	a
CMG 410 AF	57.0	b
CMG 378 F	56.4	bc
EX 0899	55.3	bcd
PLS-134	54.0	bcde
Grundy	53.4	bcde
Bolero	52.9	cde
EX 0794	52.3	de
PLS-W92	51.3	e
PLS-W90	51.0	e
EX 0727	47.0	f
BSC 5697	45.4	f
EX 0793	45.1	f
LSD	3.88	
p-value	<0.0001	

Table 8L: Number of Pods per Plant

Variety	Pods/Plant	
EX 0794	6.0	a
CMG 413 AF	5.9	ab
EX 0899	5.7	ab
BSC 5697	5.3	abc
EX 0727	5.3	abc
PLS-W90	5.0	abcd
Ricco	5.0	abcd
PLS-134	4.8	abcde
EX 0793	4.7	bcde
Bolero	4.3	cde
CMG 378 F	4.2	cde
PLS-W92	4.1	cde
CMG 410 AF	3.8	de
Grundy	3.6	e
LSD	1.21	
p-value	0.0005	

Table 9L: Number of Pod-Bearing Nodes per Plant

Variety	Nodes w/ Pods/Plant
EX 0899	3.7 a
BSC 5697	3.5 ab
PLS-W90	3.4 abc
CMG 413 AF	3.3 abc
PLS-W92	3.1 abcd
EX 0727	3.1 abcd
PLS-134	3.0 bcde
EX 0794	3.0 bcde
Ricco	2.8 cde
EX 0793	2.6 def
CMG 378 F	2.6 def
Bolero	2.4 ef
CMG 410 AF	2.1 f
Grundy	2.0 f
LSD	0.61
p-value	<0.0001

Table 10L: Average Pod Length in Centimeters

Variety	Pod Length (cm)
PLS-W90	10.0 a
PLS-W92	9.2 b
Grundy	9.0 b
Ricco	8.9 bc
CMG 378 F	8.2 cd
PLS-134	7.7 de
EX 0899	7.5 e
Bolero	7.4 e
EX 0793	7.3 e
EX 0727	7.1 e
BSC 5697	7.0 e
CMG 410 AF	7.0 e
EX 0794	7.0 e
CMG 413 AF	6.1 f
LSD	0.72
p-value	<0.0001

Table 11L: Average Number of Peas per Pod

Variety	Peas/Pod
PLS-W90	8.2 a
BSC 5697	7.3 ab
PLS-W92	7.2 abc
PLS-134	7.1 abc
EX 0727	6.9 abc
CMG 378 F	6.9 abc
Bolero	6.3 bcd
CMG 410 AF	5.9 cd
Grundy	5.9 cd
CMG 413 AF	5.5 de
EX 0793	5.0 def
EX 0899	4.5 ef
Ricco	4.4 ef
EX 0794	3.8 f
LSD	1.32
p-value	<0.0001

Late Trial Maturity Data

Table 12L: Tenderometer Readings Leading Up To and Including Harvest

	Date and Accumulated Heat Units					
	13-Jun	14-Jun	15-Jun	16-Jun	17-Jun	18-Jun
Variety	**1421**	**1460**	**1496**	**1531**	**1562**	**1588**
EX 0793	90			**148***		
Ricco	89			**141**		
PLS-W92	83			**129**		
PLS-W90	84			**127**		
EX 0794				128	**154**	
EX 0899				116	**142**	
BSC 5697				119	**132**	
CMG 410 AF				120	**127**	
Grundy				109	**127**	
CMG 378 F				106	**121**	
Bolero				105		**151**
CMG 413 AF				106		**121**
PLS-134				93		**116**
EX 0727				89		**100**

*****Bold numbers indicated the day on which the variety was harvested and are an average of three samples from each of three replications

Table 13L: Summary of Maturity Information for Late Trial Varieties

Variety	Reported Heat Units	Heat Units at Harvest	T-reading at Harvest
EX 0793	1420	1531	148
Ricco	1566	1531	141
PLS-W92	1420	1531	129
PLS-W90	1420	1531	127
EX 0794	1470	1562	154
EX 0899	1405	1562	142
BSC 5697	1460	1562	132
CMG 410 AF	1500	1562	127
Grundy	1595	1562	127
CMG 378 F	1525	1562	121
Bolero	1460	1588	151
CMG 413 AF	1550	1588	121
PLS-134	1500	1588	116
EX 0727	1600	1588	100

Appendix A: Weather Data for the 2008 Early Pea Variety Trial

Date	DAP	High	Low	Daily Heat Units	Accumulated Heat Units	Daily Rainfall/ Irrigation*	Accumulated Rainfall/ Irrigation
14-Mar-08	0	68	42	0	0	0.00	0.00
15-Mar-08	1	60	45	12	12	0.09	0.09
16-Mar-08	2	49	42	5	18	0.13	0.22
17-Mar-08	3	49	32	0	18	0.00	0.22
18-Mar-08	4	51	37	4	22	0.00	0.22
19-Mar-08	5	71	47	19	41	0.00	0.22
20-Mar-08	6	69	42	15	56	0.09	0.31
21-Mar-08	7	53	32	2	58	0.00	0.31
22-Mar-08	8	50	32	1	59	0.00	0.31
23-Mar-08	9	49	27	0	59	0.00	0.31
24-Mar-08	10	50	25	0	59	0.00	0.31
25-Mar-08	11	51	27	0	59	0.00	0.31
26-Mar-08	12	67	44	16	75	(0.50)	0.81
27-Mar-08	13	56	38	7	83	0.00	0.81
28-Mar-08	14	78	43	21	103	0.00	0.81
29-Mar-08	15	49	31	0	103	0.00	0.81
30-Mar-08	16	46	30	0	103	0.00	0.81
31-Mar-08	17	63	42	13	115	0.00	0.81
1-Apr-08	18	74	58	26	141	0.06	0.87
2-Apr-08	19	67	34	10	152	0.00	0.87
3-Apr-08	20	51	29	0	152	0.25	1.12
4-Apr-08	21	70	44	17	169	0.36	1.48
5-Apr-08	22	64	50	17	186	0.09	1.57
6-Apr-08	23	50	43	7	192	0.47	2.04
7-Apr-08	24	45	42	4	196	0.00	2.04
8-Apr-08	25	48	42	5	201	0.00	2.04
9-Apr-08	26	52	42	7	209	0.02	2.06
10-Apr-08	27	73	48	21	229	0.00	2.06
11-Apr-08	28	78	51	25	254	0.00	2.06
12-Apr-08	29	73	58	26	279	0.04	2.10
13-Apr-08	30	60	47	14	293	0.00	2.10
14-Apr-08	31	55	39	7	300	0.00	2.10
15-Apr-08	32	57	35	6	306	0.00	2.10
16-Apr-08	33	64	29	6	313	0.00	2.10
17-Apr-08	34	75	30	13	325	0.00	2.10
18-Apr-08	35	86	41	23	348	(0.50)	2.60
19-Apr-08	36	86	47	26	375	0.00	2.60
20-Apr-08	37	74	56	25	400	0.00	2.60
21-Apr-08	38	60	55	18	418	0.04	2.64
22-Apr-08	39	69	52	21	438	0.00	2.64
23-Apr-08	40	74	53	24	462	0.00	2.64
24-Apr-08	41	78	52	25	487	(0.60)	3.24
25-Apr-08	42	78	46	22	509	0.00	3.24
26-Apr-08	43	79	55	27	536	0.00	3.24
27-Apr-08	44	58	49	13	550	0.07	3.31
28-Apr-08	45	67	49	18	568	0.76	4.07
29-Apr-08	46	60	44	12	579	0.03	4.10
30-Apr-08	47	59	41	10	590	0.00	4.10

1-May-08	48	66	43	14	604	0.00	4.10
2-May-08	49	80	58	29	633	0.00	4.10
3-May-08	50	79	52	25	659	0.00	4.10
4-May-08	51	74	53	24	682	0.00	4.10
5-May-08	52	67	46	17	699	0.00	4.10
6-May-08	53	77	45	21	720	0.00	4.10
7-May-08	54	82	51	27	747	(0.40)	4.50
8-May-08	55	72	65	28	775	0.03	4.53
9-May-08	56	71	51	21	796	0.96	5.49
10-May-08	57	62	49	15	811	0.08	5.57
11-May-08	58	66	43	14	826	0.88	6.45
12-May-08	59	57	46	11	837	1.78	8.23
13-May-08	60	69	42	15	853	0.00	8.23
14-May-08	61	74	45	20	872	0.00	8.23
15-May-08	62	76	57	27	899	0.00	8.23
16-May-08	63	72	54	23	922	0.55	8.78
17-May-08	64	72	49	20	942	0.00	8.78
18-May-08	65	72	54	23	965	0.00	8.78
19-May-08	66	65	47	16	981	0.00	8.78
20-May-08	67	64	46	15	996	0.23	9.01
21-May-08	68	66	48	17	1013	0.03	9.04
22-May-08	69	67	44	15	1029	0.00	9.04
23-May-08	70	69	44	17	1045	0.00	9.04
24-May-08	71	72	51	22	1067	0.00	9.04
25-May-08	72	76	46	21	1088	0.00	9.04
26-May-08	73	82	53	27	1115	0.00	9.04
27-May-08	74	83	67	35	1151	(0.35)	9.39
28-May-08	75	73	49	21	1172	0.00	9.39
29-May-08	76	76	43	20	1191	(0.50)	9.89
30-May-08	77	84	53	28	1220	0.00	9.89
31-May-08	78	88	64	36	1256	1.02	10.91
1-Jun-08	79	84	65	34	1290	0.68	11.59
2-Jun-08	80	78	59	28	1318	0.00	11.59
3-Jun-08	81	80	58	29	1347	0.14	11.73

*Parenthesis denote irrigation applied by traveling linear system

Appendix B: Weather Data for the 2008 Late Pea Variety Trial

Date	DAP	High	Low	Daily Heat Units	Accumulated Heat Units	Daily Rainfall/ Irrigation*	Accumulated Rainfall/ Irrigation
15-Apr-08	0	57	35	0	0	0.00	0.00
16-Apr-08	1	64	29	6	6	0.00	0.00
17-Apr-08	2	75	30	13	19	0.00	0.00
18-Apr-08	3	86	41	23	42	(0.50)	0.50
19-Apr-08	4	86	47	26	69	0.00	0.50
20-Apr-08	5	74	56	25	94	0.00	0.50
21-Apr-08	6	60	55	18	112	0.04	0.54
22-Apr-08	7	69	52	21	132	0.00	0.54
23-Apr-08	8	74	53	24	156	0.00	0.54
24-Apr-08	9	78	52	25	181	(0.60)	1.14
25-Apr-08	10	78	46	22	203	0.00	1.14
26-Apr-08	11	79	55	27	230	0.00	1.14
27-Apr-08	12	58	49	13	243	0.07	1.21
28-Apr-08	13	67	49	18	261	0.76	1.97
29-Apr-08	14	60	44	12	273	0.03	2.00
30-Apr-08	15	59	41	10	284	0.00	2.00
1-May-08	16	66	43	14	298	0.00	2.00
2-May-08	17	80	58	29	327	0.00	2.00
3-May-08	18	79	52	25	352	0.00	2.00
4-May-08	19	74	53	24	376	0.00	2.00
5-May-08	20	67	46	17	392	0.00	2.00
6-May-08	21	77	45	21	414	0.00	2.00
7-May-08	22	82	51	27	441	(0.40)	2.40
8-May-08	23	72	65	28	469	0.03	2.43
9-May-08	24	71	51	21	490	0.96	3.39
10-May-08	25	62	49	15	505	0.08	3.47
11-May-08	26	66	43	14	520	0.88	4.35
12-May-08	27	57	46	11	531	1.78	6.13
13-May-08	28	69	42	15	546	0.00	6.13
14-May-08	29	74	45	20	566	0.00	6.13
15-May-08	30	76	57	27	593	0.00	6.13
16-May-08	31	72	54	23	616	0.55	6.68
17-May-08	32	72	49	20	636	0.00	6.68
18-May-08	33	72	54	23	659	0.00	6.68
19-May-08	34	65	47	16	675	0.00	6.68
20-May-08	35	64	46	15	690	0.23	6.91
21-May-08	36	66	48	17	707	0.03	6.94
22-May-08	37	67	44	15	723	0.00	6.94
23-May-08	38	69	44	17	739	0.00	6.94
24-May-08	39	72	51	22	761	0.00	6.94
25-May-08	40	76	46	21	782	0.00	6.94
26-May-08	41	82	53	27	809	0.00	6.94
27-May-08	42	83	67	35	844	(0.35)	7.29
28-May-08	43	73	49	21	865	0.00	7.29
29-May-08	44	76	43	20	885	(0.50)	7.79
30-May-08	45	84	53	28	914	0.00	7.79
31-May-08	46	88	64	36	950	1.02	8.81
1-Jun-08	47	84	65	34	984	0.68	9.49

2-Jun-08	48	78	59	28	1012	0.00	9.49
3-Jun-08	49	80	58	29	1041	0.14	9.63
4-Jun-08	50	84	63	34	1075	1.08	10.71
5-Jun-08	51	75	62	29	1103	0.01	10.72
6-Jun-08	52	85	61	33	1136	0.00	10.72
7-Jun-08	53	97	69	43	1179	0.00	10.72
8-Jun-08	54	94	72	43	1223	0.00	10.72
9-Jun-08	55	97	72	44	1267	0.00	10.72
10-Jun-08	56	99	75	47	1314	(0.50)	11.22
11-Jun-08	57	86	69	38	1351	0.00	11.22
12-Jun-08	58	87	64	35	1387	(0.60)	11.82
13-Jun-08	59	86	63	34	1421	(0.80)	12.62
14-Jun-08	60	90	67	39	1460	0.05	12.67
15-Jun-08	61	85	67	36	1496	0.03	12.70
16-Jun-08	62	88	62	35	1531	0.23	12.93
17-Jun-08	63	82	61	31	1562	0.04 (0.80)	13.77
18-Jun-08	64	78	53	25	1588	0.11	13.88

*Parenthesis denote irrigation applied by traveling linear system

Appendix C: Adjusting Pea Yields to a T-reading of 100

T-Reading Adjustment Using Pumphery et al. Systems*

Actual T-Reading	Adjustment Factor
150	130.0
145	130.4
140	130.6
135	130.0
130	128.6
129	128.3
128	127.4
127	127.5
126	126.9
125	126.5
124	125.8
123	125.2
122	124.6
121	123.9
120	123.2
119	122.5
118	121.7
117	120.9
116	120.0
115	119.1
114	118.2
113	117.2
112	116.2
111	115.1
110	113.9
109	112.8
108	111.7
107	110.4
106	109.1
105	107.8
104	106.4
103	105.0
102	103.5
101	102.0
100	100.0
99	98.8
98	97.1
97	95.4
96	93.6
95	91.8
94	89.9
93	88.0
92	86.0
91	83.9
90	81.9

*Pumphery FV, RE Ramig, RR Allmoras. 1975 "Yield tenderness relationships in 'Dark Skinned Perfection' peas. Journal of the American Society of Horticultural Science. 100:507-509.

Yield-Tenderness Relationships in 'Dark Skinned Perfection' Peas[1]

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Abstract. Maturity effects on yield of fresh peas (*Pisum sativum* L.) were identified by yield-tenderometer measurements. A percent yield-tenderometer reading relationship was shown to be a useful means for yield adjustment to a common maturity—100 tenderometer reading. Analysis of random error in the predicted percent yield, as a function of tenderometer reading, indicates the need to plan harvests within the 90 to 110 tenderometer range. Alternatively, the yield-tenderometer reading relationships show the possible magnitude of errors incurred in comparing green pea yields when no adjustment is made for dissimilar tenderometer ratings.

Improved techniques are needed for determining and comparing fresh pea (*Pisum sativum* L.) yields. Expressions of fresh pea yields are generally not precise because of harvest at a growth stage when fresh pea wt is increasing rapidly while tenderness may decrease even more rapidly. Pea yields may increase as much as 900 kg/ha daily when growth conditions are favorable. Such a yield increase often causes yield differences between treatments only because the treatments affected maturity. Examples of such treatments are comparisons involving cultivars, tillage, fertilizer, irrigation, or herbicides.

The need for comparing yields of processing peas at a common tenderometer rating, such as 100, has been suggested repeatedly, but, unfortunately there is little published information. Yield and tenderness are inversely related; i.e., yield increases as tenderness decreases (tenderometer readings increase). However, changes in yield and tenderometer readings are generally not a linear function of time (2, 3, 4, 6). Yield increases per unit of increase in tenderometer readings are generally greater when tenderometer values are below 100 to 120 than at higher tenderometer values. Hagedorn et al. (1) reported an unusual linear relationship between yield and tenderometer reading up through readings of 150.

Adjustments of absolute yield to a common base of 100 tenderometer reading is complicated, because temporal changes in yield and tenderometer reading vary between years, fields, and cultivars. Some of the factors influencing increase of fresh pea wt and associated change in tenderness are temperature, wind, humidity, available soil moisture, and soil fertility. However, temperature and moisture are the dominating factors. Yield differences produced by these factors, along with seasonal and field variations preclude direct adjustments of yield based on tenderness rating, i.e., *x* pounds of peas per unit change in tenderometer reading. Norton et al. (4) presented yield-tenderness relationships indirectly in terms of percent yield at a given tenderometer reading. The method for adjusting fields was developed by H. K. Schultz and M. W. Carstens. They used the yield at 100 tenderometer reading as 100 percent yield. Kramer (2) and Sayre (7) used percent of maximum yield as their expression of the observed yields at various tenderometer readings.

Our objectives were to emphasize the need for comparing yields of fresh peas at a common tenderometer reading, and to present additional data in support of the Norton et al. (4) method for adjusting yields.

Methods and Procedures

Dark Skinned Perfection peas were grown in 17 field experiments from which fresh pea yields and tenderness evaluations were made. The experiments were conducted on or near the Columbia Basin Research Center, Pendleton, Oregon. Seeding rates varied from about 130 to 230 kg/ha, in row spacings varying from 15 to 20 cm. Plant environment varied considerably because the data were collected during 11 years from experiments testing fertilizers, herbicides, and tillage—all 3 factors alone or in various combinations. All experiments were dryland, except 2 which were irrigated. In the dryland experiments, about 61 percent of the evapotranspiration was derived from soil water stored prior to pea planting. Longterm rainfall averages during the growing season for peas are 3.9, 3.7, 3.4, and 3.5 cm, respectively, for March, April, May, and June at the Columbia Basin Research Center. Corresponding average monthly temperatures are 6.1, 10.0, 13.3, and 17.2°C.

Fresh pea harvests were made to provide tenderometer readings below 100 at the earliest harvest, near 100 at the middle harvest, and above 100 at the latest harvest. Usually 3 or more harvests were necessary and the interval between harvests was generally 1 or 2 days in each of the 17 experiments. Harvests in the dryland experiments occurred in late June and only rarely in early June, while those under irrigation occurred about 5 days later.

From the data obtained in each experiment, pea yield at 100 tenderometer reading was interpolated. Then the ratio of measured to interpolated yield at 100 tenderometer reading was used to obtain "percent yield" (when multiplied by 100). All percent yields and corresponding tenderometer readings were plotted to obtain a scattergram of percent yield versus tenderometer reading, from which a least squares fit was made using the model: $Y = a + bX + cX^n$, where Y is percent yield, X is tenderometer reading; a, b, and c are parameters to be estimated statistically.

Results and Discussion

Six experiments typify green pea development observed in the 17 experiments. They are presented herein (Figs. 1, 2, and 3) because their greater number of harvests more precisely defined trends. These relationships were typical, also, of those found in the literature.

Yields varied from experiment to experiment, but yields within experiments were usually nonlinear functions of time (Fig. 1). In some experiments rates of yield change (change in slope) were positive throughout all harvests, while in others they became negative soon after the harvest series was initiated.

Tenderometer readings increased as a function of time (Fig. 2), but the tenderometer readings increased more rapidly after tenderometer readings had reached 100. An exponentially increasing tenderness function of time was suggested for both dryland and irrigated peas in Fig. 2.

Pea yields are distinctly nonlinear functions of tenderometer reading (Fig. 3). Field to field variation also caused large separation of curves. These 2 features of the yield-tenderness curves emphasize a critical need for comparing experimental yields within an experiment on a common tenderometer rating basis. We have not found a feasible direct adjustment of yields.

Pea yields expressed as a percent of the yield expected at 100 tenderometer are plotted versus tenderometer reading (Fig. 4), and the estimated equations are shown separately for irrigated and

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[2] Associate Professor of Agronomy, Columbia Basin Research Center, and Soil Scientists, Columbia Plateau Conservation Research Center, Pendleton, OR. Appreciation is given to Leslie G. Ekin, Agricultural Research Technician, for expert field assistance given in this study.

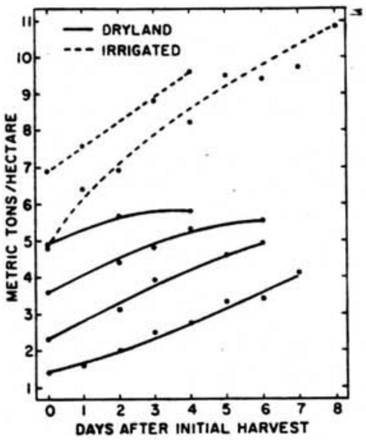

Fig. 1. Yield versus time of harvest for fresh peas in 6 typical experiments.

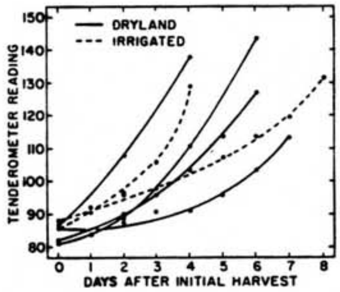

Fig. 2. Tenderometer of fresh peas as affected by time of harvest in 6 typical experiments.

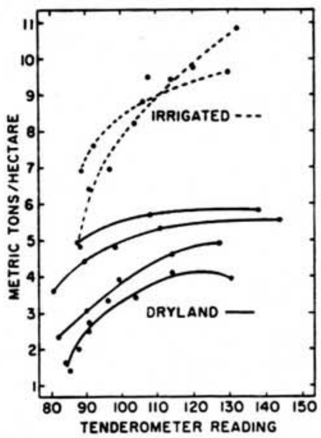

Fig. 3. Yield of fresh peas and associated tenderometer reading in 6 typical experiments.

dryland peas. These equations (Fig. 4) were slightly modified for easy use in adjusting percent yield when tenderometer readings were not 100. The modification involved estimation of Y at 100 tenderometer using equations in Fig. 4. This estimate of Y was then designated as the mean of Y when the mean of X was designated as 100. The equations are shown as follows:

Dryland peas: $(Y-97.21) = -14.134\,(X-100) + 315.14\,(X^{1/2}-10)$

Irrigated peas: $(Y-100.43) = -8.405\,(X-100) + 200.00\,(X^{1/2}-10)$

In these equations, Y is percent yield to be calculated, and X is observed tenderometer reading.

The scatter diagram of Fig. 4 (a composite over the 17 experiments) can be used to adjust yields to a common maturity (100 tenderometer). Such a calibration adjusts for maturity differences. However, the increasing scatter in Fig. 4 as the tenderometer reading deviates from 100 suggests strongly that harvests should be planned to achieve tenderometer readings within the 90 to 110 range. Ordinarily in regression, where the variance of the dependent variable is assumed independent of the independent variable, the precision of predicted dependent variable decreases as the dependent variable becomes larger or smaller than the mean (5). The scatter distribution in Fig. 4 shows a variance dependent on tenderometer reading. We have combined this variance estimate with that of regression in Table 1 to emphasize the true variability characteristics of the calibration in Fig. 4, and the need to plan harvests within the 90 to 110 tenderometer range.

The curves and data points for dryland and irrigated peas were

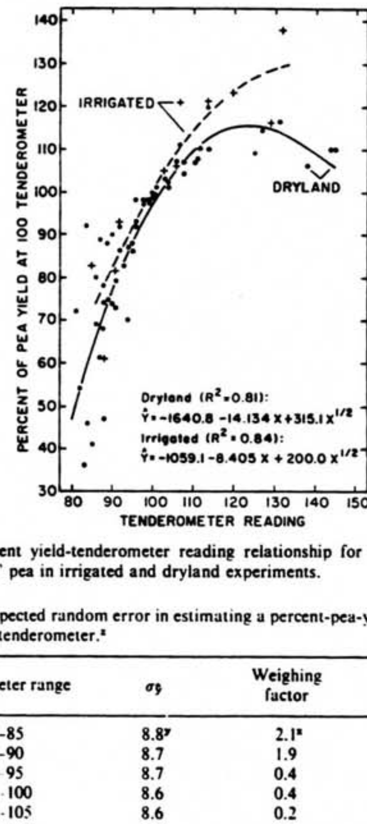

Fig. 4. Percent yield-tenderometer reading relationship for 'Dark Skinned Perfection' pea in irrigated and dryland experiments.

Table 1. Expected random error in estimating a percent-pea-yield at different ranges of tenderometer.[z]

Tenderometer range	$\sigma_{\hat{y}}$	Weighing factor	Estimated true $\sigma_{\hat{y}}$
80-85	8.8[y]	2.1[x]	18.5[w]
85-90	8.7	1.9	16.6
90-95	8.7	0.4	3.5
95-100	8.6	0.4	3.3
100-105	8.6	0.2	1.5
105-110	8.7	0.5	4.5
110-115	8.7	0.5	4.5
115-120	8.8	1.4	12.3

[z] Computations were made using regression composited over irrigated and dryland conditions.

[y] $\sigma_{\hat{y}}$ is the random error expected from multiple regression assuming a variance of y independent of x.

[x] *Weighing factor* is a ratio in which the numerator is the standard error of estimate within the indicated tenderometer range and the denominator is the standard error of estimate for the whole tenderometer range. This ratio approximates the nonuniform variance of percent pea yield at different tenderometer readings.

[w] Estimated true $\sigma_{\hat{y}}$ is the product, (weighing factor) ($\sigma_{\hat{y}}$).

maintained separate in Fig. 4. Above about 110 tenderometer reading the percent yields separate distinctly. This separation of yields indicates a major influence of available soil water on the development of fresh peas in their later stages of growth. We suggest that this factor be carefully evaluated for experiments where irrigation or stored soil water is an experimental variable.

In passing, we note the failure of an appealing normalization procedure involving both yield and tenderometer reading. For each experiment, the maximum and minimum yield or tenderometer readings were noted and the normalized observation computed as $(u-u_{min})/(u_{max}-u_{min})$. The symbol u indicates the variable to be normalized. Nearly the whole range of normalized yield was noted for normalized tenderometer readings <0.5. Furthermore, there was much scatter providing little basis for a calibration.

Norton et al. (4) and Sayre (7) point out that 1 scale is not applicable to all pea cultivars. Norton et al. (4) add that the use of a well-developed scale for 1 cultivar to adjust another cultivar may introduce less error than using a scale developed from only a few points. Information presented in Fig. 4 is consistent with earlier results (1, 2, 4, 7) showing a similar relationship between percent yield and tenderometer readings in the range of 90 to 110. Percent yields changed between 1 and 2 percentage units with each unit change in tenderometer reading.

Experience by the authors indicates that fresh pea yield comparison at a common maturity is essential to good research. Harvesting eac treatment at 2 or more times and interpolating the yield at 1C tenderometer is preferred. When only 1 harvest is possible, yields c: be adjusted to 100 tenderometer by using a percent yield-tenderom eter scale (Fig. 4) which provides more reliable data than merely usin the unadjusted yields.

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