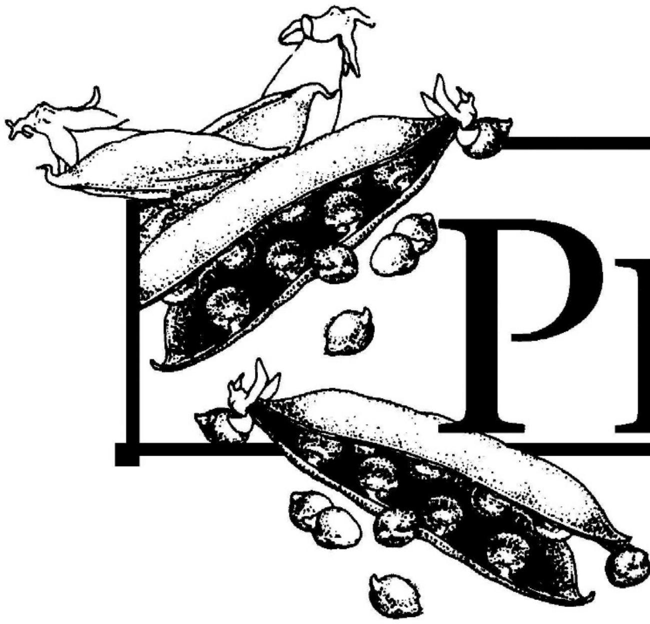
University of Delaware



Pea

Variety Trial Results

2022

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Brotherton Seed Co., Inc.
Crites Seeds, Inc.
Seminis Vegetable Seeds
Gallatin Valley Seeds

Seed of standard varieties was provided by collaborating vegetable processors Seabrook Brothers & Sons, Hanover Foods, and The Pictsweet Company.

Thank you to the farm staff at the University of Delaware Research & Education Center, Georgetown, for their assistance in planting and irrigating the trial, as well as maintaining the viner.

Thank you to my 2022 student summer crew, Aaron Doll, Amber Green, Austin Truitt, Emily Jones, Jenna Anger and Maya Jones.

2022 University of Delaware Pea Variety Trial

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Introduction

The 2022 Pea Variety Trial was conducted at the University of Delaware Research and Education Center. The purpose of the trial 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 on the Georgetown research farm since 1994. This year's trial was planted on April 13, 2022

Materials and Methods

Planting and Crop Management

There were 22 varieties in the trial, which was located in Field 25-B at the University of Delaware Research Farm in Georgetown, DE. The field was limed and potassium was applied according to soil test results prior to planting. The trial was irrigated as needed, and grown under standard commercial management practices. Weed control in the trial was fair.

Planting Date: April 13, 2022

Herbicide: Pursuit @ 2 oz/A + Dual Magnum @ 1 pt/A with N-SUL 33 (27-0-0-6) at 28 gal/A (80 lbs/A of N) applied preemergence

Planting: The trial was planted using an Almaco drill with 9 rows spaced 8 inches apart. Seeding rate was 8 to 9 seeds per foot of row.

Insecticide: None

Plot Design: Plots were arranged in a randomized complete block design with 3 replications.

Varieties in the 2022 Pea Variety Trial

Name	Company
CS-492AF	Crites Seed, Inc.
CS-464AF	Crites Seed, Inc.
CS-500F	Crites Seed, Inc.
CS-494DAF	Crites Seed, Inc.
EXP461	Brotherton
EXP773	Brotherton
BSC737	Brotherton
BSC599	Brotherton
SV1231QF	Seminis
SV0371QF	Seminis
SV0823QG	Seminis

Name	Company
SV6844QG	Seminis
Saltingo	Pure Line
PLS 576	Pure Line
PLS 586	Pure Line
PLS 602	Pure Line
Dakota	Gallatin Valley
435	Gallatin Valley
GVS 1451	Gallatin Valley
M-14	Pure Line (check)
BSC 712	Brotherton (check)
Dancer	Brotherton (check)

Pre Harvest Data
The date of first flower and peak flowering was noted for each plot.

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 (Table 12). All three replications for each variety were harvested on the same day.

Plants were pulled from a 6 x 20 foot section of the plot (120 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). After each size was weighed, peas with sieve sizes 1 through 4 were recombined into a bulk sample with the smallest (trash) peas removed. Three tenderometer readings were taken from this bulked sample. The average is reported.

Ten plants were taken from each variety 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 based on ten pods that were randomly selected from the ten sampled plants.

Discussion of Trial Results
The results of this trial are summarized in eleven tables and one chart. 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, p-value for the effect of the independent variable and the coefficient of variation (CV) are included at the bottom of each table.

Temperatures were warmer than average in across the season for this trial with a very unusually hot period in early June. Rainfall levels were slightly below average for across the season but especially in April. Irrigation was applied as necessary via an overhead linear irrigation system. Harvest began on June 6. Chart 2 is a summary of the season's weather.

Stand emergence in the trial was good. All seed was treated with insecticide and seedcorn maggot damage was not apparent.

Table 3 reports the net and gross yields adjusted to a tenderometer reading of 100. The adjustment calculation procedure is based on the method described by Pumphrey *et al.* (see Appendix A: Adjusting Pea Yields to a T-Reading of 100). Briefly, the adjustment factor (Y) is the percent of yield at a T-reading of 100 for the T-reading at harvest (X).

$$Y = -1059.1 - 8.405X + 200X^{1/2}$$

and

$$\text{Yield adjusted to a T-reading of 100} = \frac{\text{Yield at T-reading } X}{(Y/100)}$$

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.

Yields in this trial were below average compared to what has been observed in past years for April-planted trials. Average yield for the previous nine April trials is 3470 lbs/A for all varieties trialed. The average yield for the 2022 trial was 2705 lbs/A. Three varieties that are being used by regional processors were included in the trial as checks: BSC 712, Dancer and M-14. The highest yielding varieties in the trial were BSC 712, Dakota, GVS 1451, SV6844QG, and SV0823QG. The check variety BSC 712 was the highest yielding variety; this variety was a top yielding variety in past Delaware trials. SV6844QG was among the top varieties in this trial and also in the 2020 and 2018 Delaware trials. SV6844QG is also among the latest maturing varieties in the trial. Dakota is an earlier maturing variety that was the highest yielding variety in the 2018 March-planted trial which also performed well in this April-planted trial.

Pre-Harvest Data

Table 1: Flowering Data

Variety	First Flower		Full Flower	
	DAP	Heat Units	DAP	Heat Units
Dakota	33	576	38	733
GVS 1451	36	656	40	798
GVS 435	37	691	40	798
M-14	38	733	40	798
EXP773	39	771	45	927
EXP461	40	798	44	896
Saltingo	40	798	46	957
CS-492AF	43	863	47	990
PLS 586	43	863	47	990
PLS 576	44	896	48	1030
PLS 602	45	927	48	1030
SV0371QF	45	927	49	1068
CS-464AF	45	927	49	1068
CS-500F	46	957	49	1068
BSC599	46	957	49	1068
CS-494DAF	46	957	48	1030
BSC 712	47	990	49	1068
SV6844QG	47	990	51	1135
BSC737	47	990	51	1135
SV1231QF	47	990	50	1105
SV0823QG	48	1030	51	1135
Dancer	48	1030	51	1135

Harvest Data

Table 2: Weight of Vines from 120 ft^2 Harvest Area (lbs.)

Variety	Vine Weight (lbs.)	
BSC 712	87	a
BSC599	71	ab
PLS 602	69	b
SV1231QF	67	bc
BSC737	62	bcd
Dancer	62	bcde
SV0823QG	61	bcdef
Saltingo	61	bcdefg
SV6844QG	58	bcdefgh
EXP461	57	bcdefgh
GVS 435	56	bcdefgh
PLS 586	50	cdefghi
CS-500F	49	defghi
PLS 576	47	defghi
EXP773	46	defghi
M-14	45	efghi
GVS 1451	45	efghi
CS-492AF	44	fghi
CS-494DAF	44	ghi
Dakota	43	hi
SV0371QF	37	i
CS-464AF	34	i
p-value	*<0.0001*	
LSD	17.27	
CV	19.3	

Table 3: Gross Yields and Net Yields (% Trash Subtracted) Adjusted to a Tenderometer Reading of 100, T-Reading at Harvest

Variety	Gross Yield (lbs/A)		Net Yield (lbs/A)		T-Reading @ Harvest	
BSC 712	3,923	a	3,834	a	119.2	cde
Dakota	3,786	a	3,734	ab	137.3	b
GVS 1451	3,492	ab	3,344	abc	121.7	cd
SV6844QG	3,224	abcd	3,158	abcd	104.8	gh
SV0823QG	3,232	abcd	3,145	abcd	121.2	cd
SV1231QF	3,229	abcd	3,036	bcd	117.3	def
M-14	3,142	abcd	2,929	cde	119.3	cde
EXP773	3,206	abcd	2,921	cde	96.4	i
PLS 576	2,943	bcde	2,865	cde	102.6	gh
BSC599	2,910	bcde	2,790	cdef	120.6	cd
PLS 602	3,412	abc	2,783	cdef	101.9	ghi
GVS 435	2,772	bcde	2,597	cdef	105.3	gh
CS-500F	2,682	cdefg	2,589	cdef	150.0	a
Dancer	2,805	bcde	2,582	cdef	104.8	gh
Saltingo	2,498	defg	2,425	defg	122.7	cd
EXP461	2,737	bcdef	2,420	defg	106.7	g
PLS 586	2,488	defg	2,394	defg	120.0	cd
SV0371QF	2,710	bcdef	2,240	efg	136.3	b
BSC737	2,273	efg	2,212	efg	114.0	ef
CS-494DAF	2,153	efg	2,035	fg	112.6	f
CS-492AF	1,896	g	1,746	g	123.4	c
CS-464AF	1,944	fg	1,726	g	99.9	hi
p-value	***0.0001***		***<0.0001***		***<0.0001***	
LSD	***809.2***		***791.6***		***5.51***	
C.V.	***17.0***		***17.8***		***5.1***	

Table 4: Pea Size (% peas by weight in each class) and Tenderometer Reading at Harvest

Variety	% #4	% #3	% #1 & #2	% Trash	T-reading at Harvest
BSC599	48.8 a	34.9 fgh	12.6 k	3.7 fgh	120.6 cd
BSC 712	44.9 a	39.0 efg	13.5 k	2.5 gh	119.2 cde
PLS 576	36.3 b	39.5 efg	21.7 j	2.5 gh	102.6 gh
CS-500F	34.2 b	40.8 def	21.5 j	3.5 fgh	150.0 a
SV6844QG	30.5 b	41.5 def	25.1 ij	2.8 gh	104.8 gh
SV1231QF	21.9 c	38.4 efgh	33.7 fgh	6.0 defg	117.3 def
PLS 586	19.5 cd	50.3 bc	26.6 hij	3.6 fgh	120.0 cd
Saltingo	19.4 cd	49.1 bcd	28.7 hij	2.8 gh	122.7 cd
Dakota	17.9 cde	58.9 a	21.9 j	1.3 h	137.3 b
BSC737	16.3 cdef	49.1 bcd	32.0 ghi	2.6 gh	114.0 ef
SV0823QG	16.1 cdef	52.7 ab	28.4 hij	2.9 gh	121.2 cd
CS-492AF	12.9 defg	41.5 def	38.1 efg	7.5 cdef	123.4 c
CS-464AF	10.8 efg	29.9 h	45.7 bcd	13.5 b	99.9 hi
EXP773	10.6 efg	35.1 fgh	45.3 bcde	8.9 cd	96.4 i
M-14	10.5 efg	41.0 def	41.5 cde	6.9 cdefg	119.3 cde
CS-494DAF	10.1 efg	35.3 efgh	48.7 bc	5.9 defg	112.6 f
GVS 1451	9.8 fg	43.8 cde	42.4 cde	4.0 efgh	121.7 cd
GVS 435	9.2 fgh	43.4 cdef	41.1 def	6.3 defg	105.3 gh
Dancer	6.8 gh	37.3 efgh	47.6 bcd	8.3 cde	104.8 gh
EXP461	6.7 gh	31.5 gh	50.7 b	11.1 bc	106.7 g
PLS 602	1.8 h	14.3 i	65.4 a	18.5 a	101.9 ghi
SV0371QF	1.4 h	14.0 i	66.1 a	18.4 a	136.3 b
p-value	***<0.0001***	***<0.0001***	***<0.0001***	***<0.0001***	***<0.0001***
LSD	7.82	8.62	7.62	4.49	5.51
CV	26.3	13.4	12.7	41.8	5.1

Table 5: Tenderometer Reading at Harvest

Variety	Tenderometer Reading		Standard Deviation of T-Reading
CS-500F	150.0	a	10.3
Dakota	137.3	b	10.2
SV0371QF	136.3	b	6.8
CS-492AF	123.4	c	8.6
Saltingo	122.7	cd	5.6
GVS 1451	121.7	cd	8.3
SV0823QG	121.2	cd	2.5
BSC599	120.6	cd	12.3
PLS 586	120.0	cd	8.4
M-14	119.3	cde	10.8
BSC 712	119.2	cde	6.6
SV1231QF	117.3	def	7.0
BSC737	114.0	ef	7.5
CS-494DAF	112.6	f	3.8
EXP461	106.7	g	9.7
GVS 435	105.3	gh	7.3
SV6844QG	104.8	gh	6.2
Dancer	104.8	gh	2.5
PLS 576	102.6	gh	8.2
PLS 602	101.9	ghi	4.7
CS-464AF	99.9	hi	3.3
EXP773	96.4	i	1.6
p-value	<0.0001		
LSD	5.51		
CV	5.1		

Plant Characteristics Based on a 10-Plant Sample

Table 6: Vine Length in Centimeters

Variety	Vine Length (cm)	
BSC 712	81	a
BSC599	67	b
SV1231QF	66	bc
Saltingo	65	bc
PLS 586	64	bcd
SV0823QG	63	bcde
Dancer	62	bcde
BSC737	61	bcde
EXP773	60	cde
CS-500F	60	cde
SV0371QF	58	def
SV6844QG	58	def
CS-464AF	57	efg
PLS 602	53	fgh
GVS 435	51	gh
CS-492AF	50	hi
PLS 576	49	hi
Dakota	49	hi
CS-494DAF	49	hi
GVS 1451	45	ij
M-14	44	ij
EXP461	41	j
p-value	<0.0001	
LSD	6.1	
CV	12.2	

Table 7: Number of Pods per Plant

Variety	Pods/Plant	
Dakota	3.7	a
Saltingo	3.6	a
EXP773	3.4	a
SV1231QF	3.4	a
SV0371QF	3.3	a
Dancer	3.3	a
SV6844QG	3.1	a
GVS 435	3.0	a
CS-464AF	2.9	a
CS-500F	2.9	a
BSC 712	2.9	a
SV0823QG	2.8	a
BSC737	2.6	a
PLS 602	2.6	a
CS-492AF	2.5	a
EXP461	2.5	a
PLS 586	2.5	a
CS-494DAF	2.4	a
M-14	2.4	a
PLS 576	2.3	a
BSC599	2.2	a
GVS 1451	2.2	a
p-value	0.0741	
LSD	NA	
CV	41.5	

Table 8: Number of Pod-Bearing Nodes per Plant

Variety	Nodes w/ Pods/Plant
EXP773	2.9 a
CS-500F	2.3 ab
SV6844QG	2.3 ab
Saltingo	2.3 ab
Dakota	2.3 ab
SV1231QF	2.1 bc
BSC 712	2.1 bc
GVS 435	2.1 bc
SV0823QG	2.0 bcd
GVS 1451	2.0 bcd
CS-492AF	1.9 bcd
SV0371QF	1.9 bcd
Dancer	1.9 bcd
EXP461	1.8 bcd
PLS 586	1.8 bcd
CS-464AF	1.7 bcd
M-14	1.7 bcd
PLS 576	1.6 cd
PLS 602	1.6 cd
CS-494DAF	1.5 cd
BSC737	1.4 d
BSC599	1.4 d
p-value	0.0030
LSD	0.68
CV	39.6

Table 9: Average Number of Peas/Pod

Variety	Peas/Pod
SV1231QF	6.7 a
BSC 712	6.5 a
CS-464AF	6.2 ab
BSC737	6.1 abc
BSC599	6.0 abc
GVS 435	5.9 abc
SV0823QG	5.8 abcd
PLS 586	5.8 abcd
Saltingo	5.7 abcd
PLS 602	5.7 abcd
Dancer	5.7 abcd
GVS 1451	5.6 abcd
EXP773	5.3 abcde
CS-500F	5.2 abcde
EXP461	4.9 bcde
PLS 576	4.9 bcde
M-14	4.9 bcde
SV0371QF	4.8 bcde
CS-492AF	4.6 cde
SV6844QG	4.3 de
Dakota	4.0 e
CS-494DAF	3.8 e
p-value	0.0149
LSD	1.59
CV	33.6

Table 10: Average Pod Length (cm)

Variety	Pod Length (cm)	
PLS 586	8.4	a
Saltingo	8.1	ab
BSC599	7.7	abc
Dancer	7.7	abc
GVS 435	7.6	bcd
BSC 712	7.5	bcd
SV1231QF	7.3	cde
PLS 576	7.2	cdef
SV0823QG	7.1	cdefg
CS-464AF	7.0	cdefg
CS-494DAF	7.0	cdefg
CS-500F	6.9	cdefg
BSC737	6.9	defgh
EXP773	6.7	efgh
PLS 602	6.6	efghi
EXP461	6.4	fghi
Dakota	6.4	ghi
GVS 1451	6.4	ghi
SV6844QG	6.3	ghi
CS-492AF	6.1	hij
M-14	5.8	ij
SV0371QF	5.3	j
p-value	<0.0001	
LSD	0.811	
CV	13.3	

Trial Maturity Data

Table 11: Tenderometer Readings Leading Up To and Including Harvest

Variety	Reported Heat Units	Observed Heat Units	T-Readings Up to and Including Harvest by Date and Accumulated Heat Units											
			1213	1242	1282	1317	1345	1372	1403	1442	1472	1504	1539	1582
			6-Jun	7-Jun	8-Jun	9-Jun	10-Jun	11-Jun	12-Jun	13-Jun	14-Jun	15-Jun	16-Jun	17-Jun
Dakota	1190	1150	**137***											
GVS 1451	1230	1190	**122**											
435	1200	1210	**105**											
M-14	1330	1280	87			**119**								
EXP461	1290	1310				**107**								
EXP773	1360	1320				96								
Saltingo	1300	1400								**123**				
CS-492AF	1450	1400								**123**				
SV0371QF	1480	1400								**136**				
BSC599	1600	1400								**121**				
PLS 586	1460	1440								101	**120**			
PLS 602	1500	1440								**102**				
CS-494DAF	1470	1470								89	98	**113**		
BSC737	1560	1470										**114**		
CS-464AF	1565	1470									**100**			
CS-500F	1500	1480										112	**150**	
PLS 576	1480	1500										**103**		
BSC 712	1480	1500										98	**119**	
SV0823QG	1525	1510										96	**121**	
SV1231QF	1480	1540									68	79	99	**117**
Dancer	1550	1540										93	103	**105**
SV6844QG	1600	1580										84	90	**105**

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

Chart 1: Adjusted Net Yield (lbs/A) by Heat Units Accumulated at T-Reading of 100

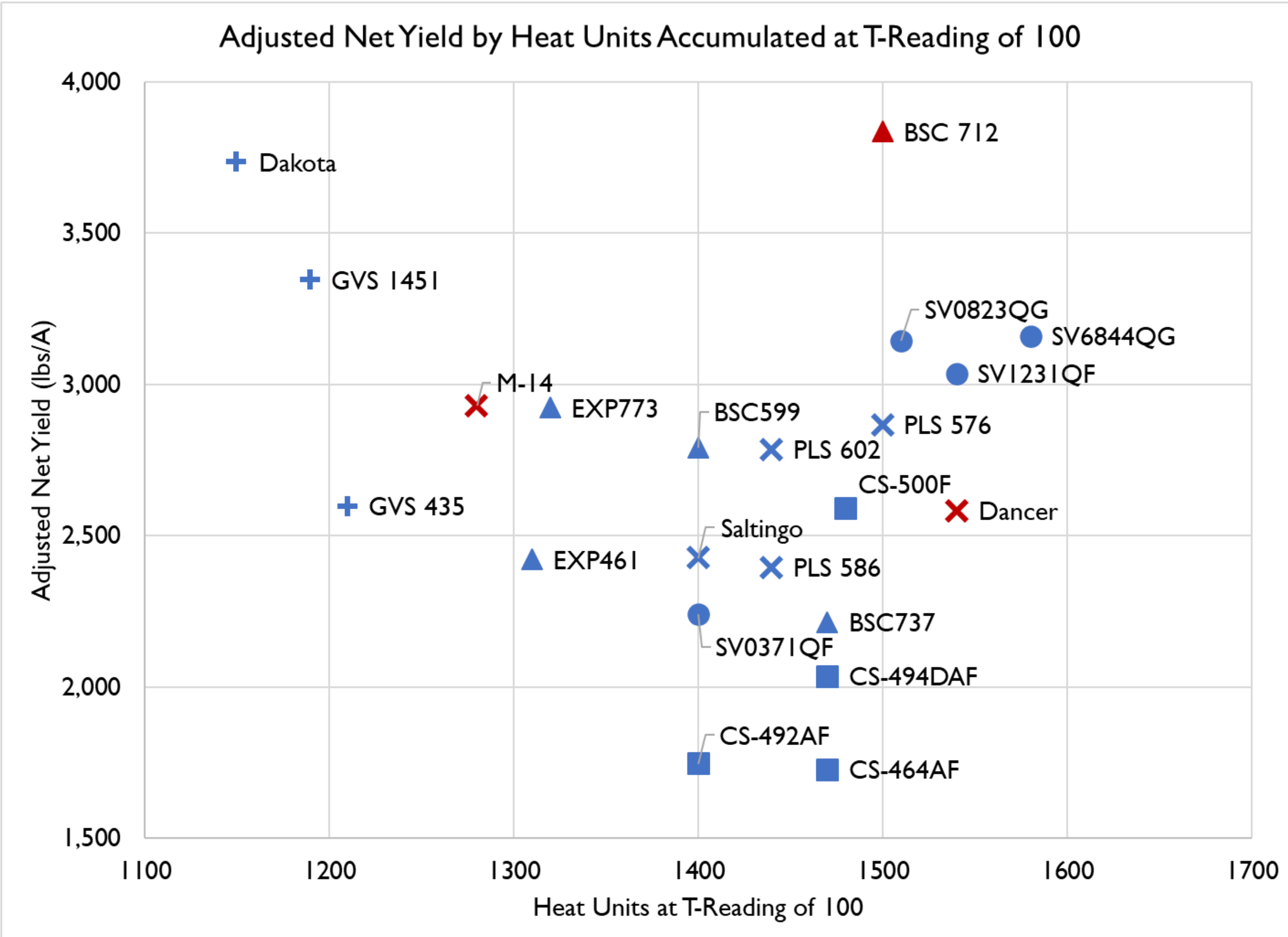

Chart 2: 2022 Pea Trial Temperature and Rainfall

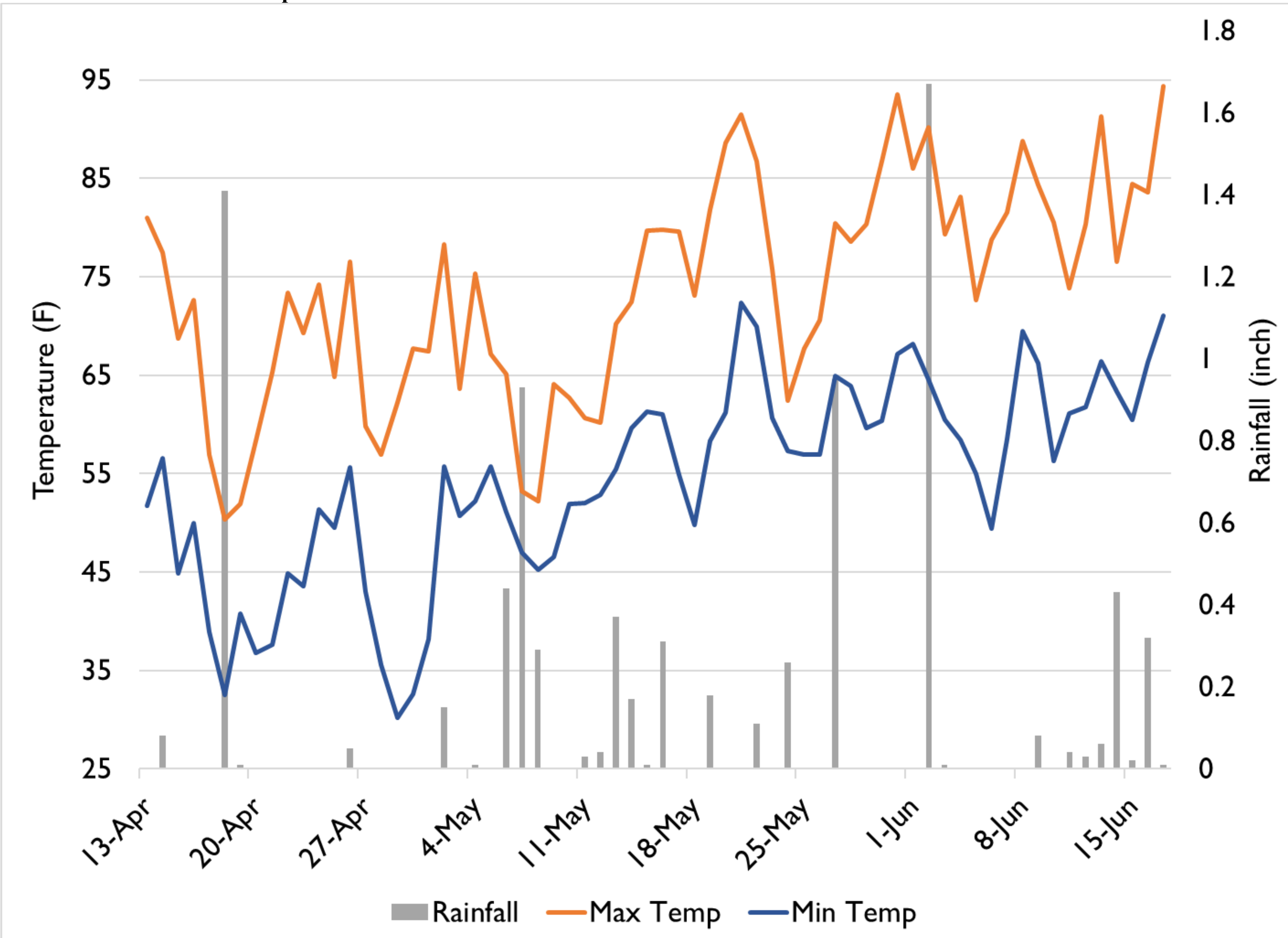

Figure 1. Delaware Pea Trial on May 31, 2022

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

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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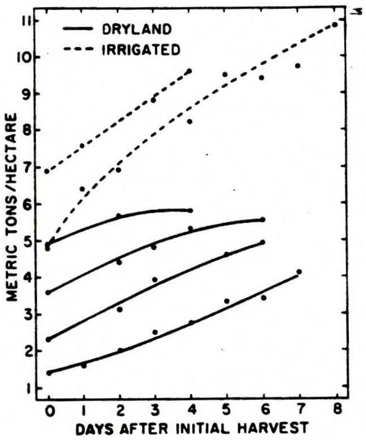

Fig. 1. Yield versus time of harvest for fresh peas in 6 typical experiments.

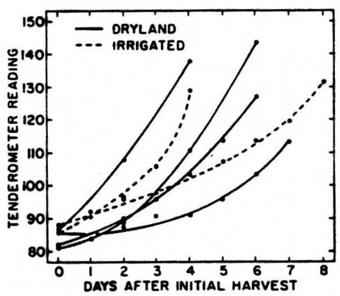

Fig. 2. Tenderometer of fresh peas as affected by time of harvest in 6 typical experiments.

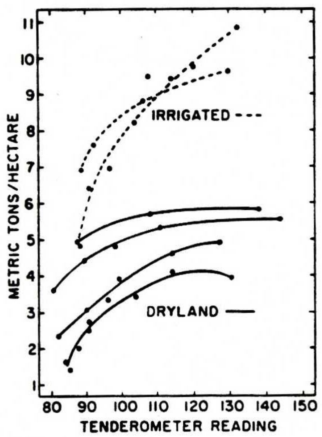

Fig. 3. Yield of fresh peas and associated tenderometer reading in 6 typical experiments.

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

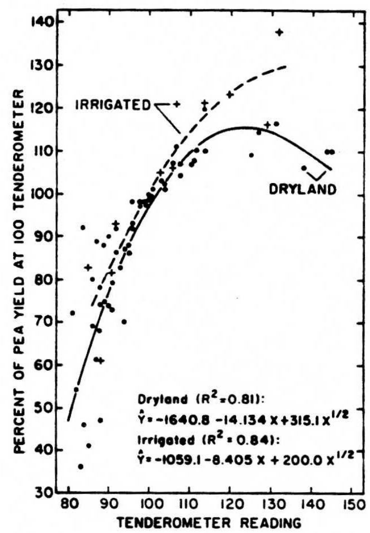

Fig. 4. Percent yield-tenderometer reading relationship for 'Dark Skinned Perfection' pea in irrigated and dryland experiments.

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 ca 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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