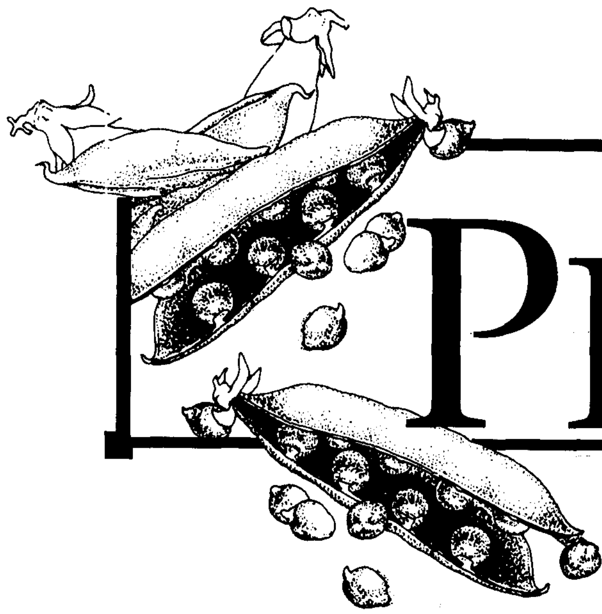
1999

DELAWARE



PEA

VARIETY

TRIAL

RESULTS

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Seed Companies

Asgrow Seed Co.	Kalamazoo, Michigan
W. Brotherton Seed Co.	Moses Lake, Washington
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Upper Valley Seed Co.	Shelley, Idaho
Pure-Line Seed, Inc.	Moscow, Idaho
Novartis Seed Co. - Rogers Brand	Boise, Idaho
Agri Sales, Inc.	Ordbend, California
Sharpes Int. Seeds, Inc.	Sleaford, Lincolnshire, England

Processing Companies

Del Monte	Napierville, Illinois
Hanover Foods, Inc.	Clayton, Delaware
Saulsbury Bros., Inc.	Ridgely, Maryland
J.G. Townsend's, Inc.	Georgetown, Delaware
Charles H. West Farm	Milford, Delaware
Agri-Link Foods	Bridgeville, Delaware
Seabrook Bros.	Seabrook, New Jersey

We wish to thank Victor Green and the staff at the University of Delaware Research & Education Center, Georgetown for their assistance in planting and irrigating the variety trials.

The plots could not have been harvested without the assistance of the following University of Delaware students: Rusty Tressler, John Gordy, Molly Daisey, Derrick Dickerson, and Andy Turner.

Special acknowledgement to our co-author of this report, Dr. Jim Glancey, Department of Bioresources Engineering, who built or re-built the viner and other equipment that facilitated the successful completion of the trials.

I. Pea Variety Trials - Summary, Materials & Methods, Results & Discussion

1999 University of Delaware Pea Variety Trials

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The 1999 Pea Variety Trials were planted at the University of Delaware Research & Education Center, Georgetown, Delaware. 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 between production regions. Similar trials have been planted since 1994, with the exception of 1998. This year, the trials were planted on two planting dates, reflecting our commercial situation. Growers and processors generally use early maturing varieties during the first half of the planting season, and longer maturing varieties on later plantings. Of course, later plantings are exposed to warmer conditions, thus generating quicker accumulations of heat units, which is why longer maturity varieties are used in later plantings. The early trial was planted on March 19 with 22 varieties; the late trial was planted on April 27 with 27 varieties.

Materials and Methods

Planting Dates: Early - March 19
Late - April 27

Fertilizer: 60 lbs. N – 0 lbs. P – 40 lbs. K (total), broadcast per acre, preplant

Herbicide: Pursuit at 3 ounces per acre, pre-plant incorporated

Planting Rate: An Almaco drill with 9 rows, spaced 8 inches apart was used. Eight seeds per foot of row were planted of each variety. Final stand counts are reported in the results.

Plot Design: 6' x 50' randomized block design

Replications: 3

Irrigation: Solid set overhead sprinkler; 1 to 1½ inches of water per week as needed.

Harvest Procedure:

Each variety was harvested as near to a tenderometer reading of 100 as possible. Pre-harvest samples were taken 2-3 days prior to reaching this maturity level whenever possible. All three replicates were harvested for each variety on the same day.

Plants were pulled from a 25 foot section. Vines were weighed and fed into a stationary FMC combine. Shelled peas were collected and washed (removing leaves, stones, and other trash). The clean, shelled peas were weighed. A sub-sample was put through a size separator that segregated peas with a diameter of 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&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 (cm), useable pods/node, pods/plant, and pod length. The data reported is the average of ten plants. The number of peas/pod is the average of ten pods.

Weather data is included in the appendix. The tenderometer was checked and calibrated by Dr. Charles McClurg, Unversity of Maryland.

Results & Discussion

Yield, maturity, size distribution, and plant characteristics are reported in Tables 1 and 2. Gross yields include small peas on the trash tray (less than 9/32 inch). Net yields have subtracted the percentage of trash. Net yield adjusted to a tenderometer reading of 100 is determined using the procedure and chart developed by Pumphrey et. al., which is included. Adjusting the yield to a common maturity is important when making yield comparisons. The inverse relationship between yield and quality is well-known with peas. Therefore, it is important to consider maturity, as indicated by the tenderometer reading, and size distribution when evaluating the data in these tables. T- readings increase with maturity, as does yield. Size distribution data reflect not only patterns of maturity, but also the basic size characteristics of a variety. Certain varieties have an inherently smaller sieve size than others, e.g. petit peas are smaller than standard peas. There are also gradations between the petit peas and standard size peas.

The varieties are ranked in Tables 1 and 2 according to the Adjusted Net Yield results. EX (85) 0414 (8) produced the highest yields in the early trial, although the commercial standard EF-680 ranked second and the difference between the two was not statistically significant. Oasis produced the highest yields in the late trial. The reader is cautioned to recognize and utilize the LSD values (least signficant difference) in understanding true yield differences.

Final stand counts are reported in Tables 3 and 4. Plants per yard ranged from 18 to 24 in the early trial and 20 to 28 in the late trial. There were statistically different populations in the both trials, which should be taken into consideration when comparing yield data between varieties.

The size distribution data in the sieve size columns reveal whether the variety produces predominately large or small peas. This is important as processors determine the possible utilization of a variety.

Heat unit data, when coupled with the tenderometer readings indicate the relative maturity for each variety. In general, predicted heat units as reported by the seed company are close to the actual heat units. However, differences as large as 100 heat units between predicted and actual did occur in some cases. The progression of maturity as reflected by pre-harvest sampling and final harvest tenderometer readings is reported in Tables 5 and 6.

We hope you find this data informative and useful. If you have questions, please feel free to contact us. We are planning on conducting another variety trial in 2000, a notice will be mailed out in November.

II. Early & Late Pea Variety Trial Results –

Table 3. Final Stand Counts of the 1999 University of Delaware Early Pea Variety Trial.
(Average number of plants per 3 foot of row)

Variety	Average
CMG-322F	25 a
XP 368	23 a,b
FP 2230	23 a,b,c
Tonic	23 a,b,c,d
168	23 a,b,c,d
CMG-330F	22 b,c,d,e
4124	22 b,c,d,e,f
FP 2135	22 b,c,d,e,f
EX (85) 0414 (8)	21 b,c,d,e,f,g
8925	21 b,c,d,e,f,g
CMG-324F	21 c,d,e,f,g
876	20 c,d,e,f,g
FP 2237	20 d,e,f,g
EF 680	20 d,e,f,g
FP 2192	20 e,f,g
EX 357	19 f,g,h
13046	19 g,h
FR698	19 g,h
87	19 g,h
FR637	17 h,i
4120	17 h,i
FR647	16 i
$LSD_{0.05}$	2.7

Table 4. Final Stand Counts of the 1999 University of Delaware Late Pea Variety Trial.
(Average number of plants per 3 foot of row)

Variety	Average
V21	28 a
EX 385	27 a,b
FR384	25 a,b,c
462-2	25 a,b,c,d
Oasis	24 a,b,c,d,e
FR720	24 b,c,d,e
2094	23 b,c,d,e,f
R98 525	23 b,c,d,e,f
105-1	23 b,c,d,e,f
Snake	22 b,c,d,e,f,g
Griffin	22 b,c,d,e,f,g
Balmoral	21 c,d,e,f,g
152R	21 c,d,e,f,g
SH1130.1	21 c,d,e,f,g
Bingo	21 c,d,e,f,g
CMG-340F	20 c,d,e,f,g
12094	20 d,e,f,g
Gemini	20 d,e,f,g
EX (85) 0001 (7)	20 d,e,f,g
84	20 d,e,f,g
Barle	20 d,e,f,g
XP 374 (Durango)	19 e,f,g
Rigo	19 f,g
EX (85) 0060 (7)	19 f,g
Samish	18 f,g
FR637	18 f,g
SH 1531.2	17 g
$LSD_{0.05}$	5.2

Table 5. 1999 Tenderometer Readings for the 1999 University of Delaware Early Pea Variety Trial

Trt.	Variety	Suggested Heat Units													
Days After Planting:			68	69	70	71	72	73	74	75	76	77	78	79	80
Date:			26-May	27-May	28-May	29-May	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	6-Jun	7-Jun
Actual Heat Units:			1010	1033	1060	1092	1128	1164	1200	1238	1275	1303	1327	1354	1393
19	FR 647	1400													**118***
21	FR637	1400										**101**			
11	4120		87	89	95	**95**									
13	13046					88		**98**							
15	8925	1240				87		**101**							
9	FR2192	1290								93	109	**107**			
22	EF680	1220			<82	84		91	**100**						
2	CMG-324F	1250				82		87	88	**97**					
10	FP2135	1400													**104**
14	876	1150			89	87		**100**							
16	87	1300								95	**106**				
1	CMG-322F	1250							92	**121**					
18	Tonic	1300								108	**103**				
7	FP 2230	1220			<82	82		92	**103**						
8	FP 2237	1310									90	**100**			
6	EX 357	1330									101	**103**			
20	FR 698	1500													**104**
3	CMG-330F	1280								88	100	**107**			
17	168	1340										84			**113**
12	4124										104	**106**			
4	EX (85) 0414 (8)	1225	<82	84	82	84		91	**111**						
5	XP 368	1280								**120**					

* Bold=average t-reading at harvest for three replications

Table 6. 1999 Tenderometer Readings for the 1999 University of Delaware Late Pea Variety Trial

Days After Planting:			52	53	54	55	56	57	58	59	60	61	62	63
Date:			17-Jun	18-Jun	19-Jun	20-Jun	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun
Actual Heat Units:			1289.5	1315	1338	1358	1381	1408	1436	1463	1495.5	1533.5	1573	1613.5
Trt.	Variety	Suggested Heat Units												
1	Bingo	1520							91	**108***				
2	FR637	1400	84	93	**100**									
3	Griffin	1370						84	84	102	**105**			
4	Oasis	1470						84	87	99	**99**			
5	SH1531.2	1450							<82		<82			**115**
6	Barle	1480						96	**93**					
7	V21	1450	84					**132**						
8	12094			<82				**113**						
9	XP374(Durango)	1475						91	**106**					
10	84	1380	<82	<82				92	**98**					
11	462-2	1400						<82	**82**		93	**113**		
12	FR720	1650									<82			**114**
13	CMG-340F	1550									<82			**107**
14	105-1	1420						<82			92 **102**			
15	R98-525	1475									97 **108**			
16	Gemini	1400						87	**101**					
17	SH1130.1	1440						<82			96 **101**			
18	Balmoral	1450						85	88	93	**104**			
19	2094	1580							93	**110**				
20	152R	1400									89	**95**		
21	Snake	1550												**145**
22	EX385	1475	<82					110	**109**					
23	FR384	1640									92	**105**		
24	EX(85)0060(7)	1525							<82					**140**
25	EX(85)0001(7)	1525									86			**115**
26	Rigo	1490						**92**						
27	Samish	1465						107	**119**					

*Bold =average t-reading at harvest for three replications

Table 7. 1999 University of Delaware Early Pea Variety Trial Flowering Data.

Variety	Date of First Flower	Date of Full Flower	First Flowering Node
FR 647	5/17	5/21	13
FR 637	5/13	5/20	13
4120	5/8	5/12	7
13046	5/10	5/15	9
8925	5/9	5/16	10
FR2192	5/12	5/20	11
EF680	5/10	5/17	10
CMG-324F	5/11	5/17	10
FP2135	5/17	5/23	12
876	5/10	5/15	9
87	5/11	5/17	10
CMG-322F	5/10	5/17	9
Tonic	5/12	5/17	11
FP2230	5/8	5/14	10
FP2237	5/13	5/23	11
EX357	5/14	5/21	11
FR698	5/20	5/27	9
CMG-330F	5/13	5/20	11
168	5/14	5/21	10
4124	5/12	5/17	10
EX(85) 0414(8)	5/8	5/13	10
XP368	5/11	5/17	10

Table 8. 1999 University of Delaware Late Pea Variety Trial Flowering Data.

Variety	Date of First Flower	Date of Full Flower	First Flowering Node
Bingo	6/5	6/9	14
FR637	6/2	6/9	12
Griffin	6/5	6/8	13
Oasis	6/6	6/9	12
SH1531.2	6/7	6/10	12
Barle	6/4	6/8	13
V21	6/2	6/7	11
12094	6/2	6/8	12
XP374 Durango	6/5	6/8	12
84	6/5	6/8	11
462-2	6/6	6/9	13
FR720	6/7	6/10	12
CMG-340F	6/8	6/10	12
105-1	6/7	6/11	11
R98-525	6/6	6/10	12
Gemini	6/4	6/8	13
SH1130	6/4	6/8	12
Balmoral	6/5	6/8	12
2094	6/4	6/8	13
152R	6/7	6/10	12
Snake	6/6	6/10	13
EX385	6/4	6/8	14
FR384	6/7	6/10	13
EX(85) 0060(7)	6/6	6/10	12
EX(85) 0001(7)	6/7	6/10	12
Rigo	6/5	6/8	13
Samish	6/4	6/8	11

III. Appendix

Table 9. T-Reading Adjustment Using Pumphery et.al. Systems*

Actual T Reading	Adj. 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

*Pumphrey, F.V., Ramig, R.E., Allmoras, R.R., "Yield Tenderness Relationships in 'Dark Skinned Perfection' Peas". J. Amer. Soc. Hort. Sci. 100(5): 507-509. 1975.

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: $Y = a + bX + cX^2$, 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

[1] Received for publication December 12, 1974. Contribution from the Oregon Agricultural Experiment Station in cooperation with the Agricultural Research Service, USDA. OR Agr. Expt. Sta. Techn. Paper No. 3891.

[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.

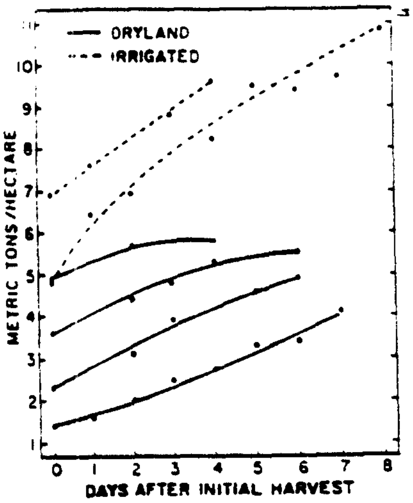

Fig. 1. Yield versus time of harvest for fresh peas in 6 typical experiments.

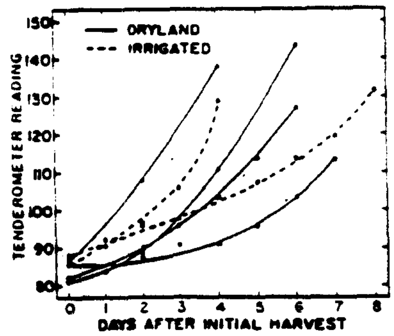

Fig. 2. Tenderometer of fresh peas as affected by time of harvest in 6 typical experiments.

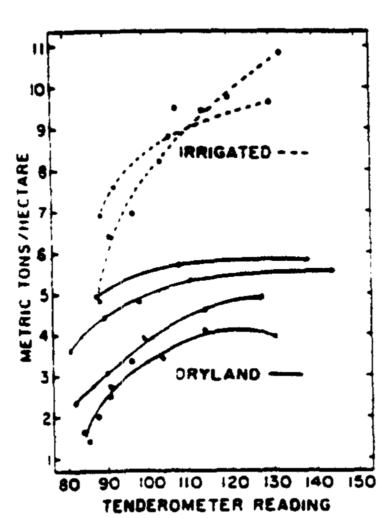

Fig. 3. Yield of fresh peas and associated tenderometer reading in 6 typical experiments.

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

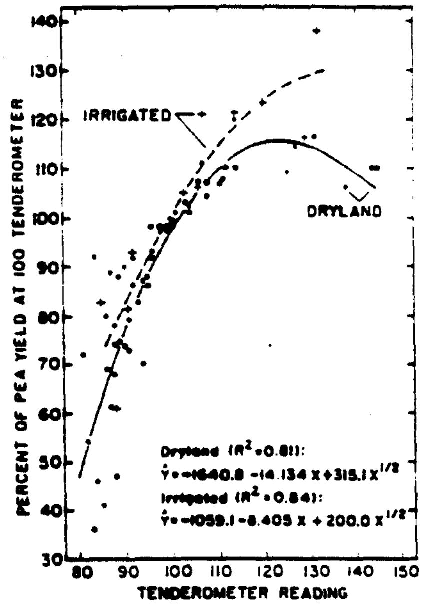

Fig. 4. Percent yield-tenderometer reading relationship for 'Dark Skinned Perfection' pea in irrigated and dryland experiments.

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 each treatment at 2 or more times and interpolating the yield at 100 tenderometer is preferred. When only 1 harvest is possible, yields can be adjusted to 100 tenderometer by using a percent yield-tenderometer scale (Fig. 4) which provides more reliable data than merely using the unadjusted yields.

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Influence of the Multiflora-Grandiflora Genotypes of Petunia on Seed Germination, Seedling Growth, and Elemental Foliar Composition[1]

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Abstract. Three sets of *Petunia hybrida* Vilm. lines were used with each set comprised of the 3 genotypes, multiflora (*gg*), grandiflora (*GG*), and heterozygote (*Gg*). Seed germination was consistently high for the hybrid *Gg* (92%), intermediate for *gg* (77%) and low for *GG* (45%). The fresh and dry wt of 28-day-old seedlings was inconsistent but the *Gg* hybrid was the most vigorous at 49 days followed by the *gg* and *GG* genotypes. No differences were observed in N, P, K, Na, Mn, Fe, Cu, Zn, or Al in vegetative leaves of the 3 genotypes. Differences in Ca, Mg, and B occurred, but they were not uniform with respect to genotype or to genotypes within a set. Calcium and Mg were generally highest in *gg* and lowest in *GG*. Boron in 1 of 2 experiments showed the same pattern. The physiological roles of the observed differences in elemental composition with respect to chlorophyll composition, sugar metabolism, and vigor as indicated by an increase in fresh and dry wt, in the 3 genotypes are discussed.

Petunia cultivars are classified by plant and flower characteristics either as grandiflora or multiflora. Multiflora plants generally have dark green foliage, a large number of small flowers with small calyces and long, narrow sepals and slender filaments; in contrast, the typical grandiflora has light green foliage, fewer flowers, and calyces with short, broad sepals and short, thick anther filaments (6). It has been shown (1, 6, 12) that the grandiflora and multiflora types are determined by the *G* and *g* alleles, at a single locus respectively, and the homozygous *GG* showed degrees of sub-lethality due, perhaps, to low chlorophyll content. In addition, Bianchi (1) observed a certation effect which he concluded arose by linkage of self-sterility alleles with those determining flower size.

Reimann-Philipp (12) found no linkage between the self-sterility alleles and flower size and ascribed the reduced number of seeds to a zygotic lethal factor *l* (normal allele *L*) which often reduced fertilization in *l* pollen grains; so its function could also be explained as certation. He concluded that the low number of grandiflora homozygotes was due to sublethality of the genotype *GG* caused by a chlorophyll defect linked to the zygotic lethal factor. Ewart (6) also concluded that lethal and sub-lethal alleles may be closely linked with *G* resulting in a class of weak homozygous dominant petunias. He suggested also, that alleles of gene(s) controlling vigor may interact with the large flower-viability gene linkage.

Seidel (13) showed that the *G* locus determining large flower in superbissima petunias (tetraploids) and in diploid grandifloras was the same. The genes determining flower size in *P. hybrida* grandiflora and in *P. axillaris* were found by Chlebowski (3) to be at the same locus. Petals with green margins in *P. hybrida* grandiflora and *P. hybrida* vulgaris (multiflora) also appeared to be linked with the grandiflora character (4). This linkage, like that involving lethality and fimbriate borders (4), is not universal to the species but is found only in certain genetic lines. Ewart (personal communication) indicated the linkage between *G* and the lethal gene(s) has been broken in breeding lines.

Hence, the grandiflora character is a monogenic inherited characteristic resulting from action of the genes *G* and *g* which control, by some as yet unknown physiological action, the flowering and growth type of petunia plants. We undertook to determine the influence of

[1] Received for publication December 14, 1974. MI Agricultural Experiment Station Journal No. 7052.

Appendix A

Monthly Weather Summary for 1999 Growing Season

University of Delaware — College of Agriculture and Natural Resources

Date	Julian Day	High Temperature (F)	Low Temperature (F)	RainFall (in)	Maximum Soil Temperature (F)	Minimum Soil Temperature (F)	
March 1,1999	60	48	36	0.00	47	37	
2	61	53	29	0.00	49	35	
3	62	66	40	0.15	55	37	
4	63	49	32	0.03	49	36	
5	64	44	27	0.00	46	34	
6	65	60	35	0.07	50	36	
7	66	45	24	0.00	45	34	
8	67	36	18	0.00	37	32	
9	68	30	20	0.00	33	32	
10	69	38	27	0.25	33	33	4" Snow
11	70	41	25	0.00	39	33	
12	71	43	29	0.00	42	33	
13	72	48	28	0.00	49	33	
14	73	43	32	1.54	41	35	
15	74	42	34	0.30	40	35	
16	75	52	31	0.00	49	34	
17	76	70	37	0.00	56	35	
18	77	74	44	0.00	61	43	
19	78	52	38	0.00	54	41	
20	79	51	30	0.00	58	36	
21	80	57	31	0.99	51	39	
22	81	52	36	0.31	51	39	
23	82	54	27	0.00	51	36	
24	83	64	43	0.00	56	43	
25	84	54	41	0.00	58	43	
26	85	47	29	0.00	57	37	
27	86	48	29	0.22	45	37	
28	87	49	37	0.10	46	40	
29	88	67	38	0.00	59	38	
30	89	63	35	0.00	62	37	
31	90	68	39	0.00	67	38	
Average		52	32		50	37	
Total				3.96			

Date	Julian Day	High Temperature (F)	Low Temperature (F)	RainFall (in)	Maximum Soil Temperature (F)	Minimum Soil Temperature (F)
1-Apr-99	91	67	55	0.26	61	50
2	92	66	44	0.00	69	49
3	93	68	44	0.00	70	48
4	94	79	47	0.33	74	52
5	95	54	34	0.00	66	44
6	96	65	30	0.00	65	38
7	97	72	47	0.00	72	51
8	98	81	41	0.00	80	46
9	99	73	46	0.64	76	50
10	100	60	43	0.01	70	46
11	101	47	36	0.31	51	42
12	102	56	43	0.06	57	43
13	103	60	38	0.00	63	38
14	104	67	41	0.00	69	38
15	105	63	39	0.09	61	42
16	106	66	45	0.01	67	48
17	107	62	36	0.00	71	40
18	108	60	37	0.00	71	42
19	109	61	33	0.00	69	40
20	110	62	38	0.01	68	45
21	111	60	34	0.08	64	40
22	112	80	49	0.04	81	50
23	113	76	51	0.74	79	54
24	114	58	39	0.00	69	43
25	115	61	35	0.00	76	39
26	116	74	43	0.00	81	43
27	117	63	45	0.00	85	47
28	118	59	39	0.00	83	46
29	119	64	36	0.00	84	43
30	120	59	42	0.00	80	45
Average		65	41		71	45
Total				2.58		

University of Delaware

College of Agriculture and Natural Resources

Date	Julian Day	High Temperature (F)	Low Temperature (F)	RainFall (in)	Maximum Soil Temperature (F)	Minimum Soil Temperature (F)
1-May-99	121	59	39	0.00	81	45
2	122	61	45	0.00	71	47
3	123	56	51	0.08	60	53
4	124	69	52	0.01	78	53
5	125	74	48	0.00	88	51
6	126	63	56	0.02	66	58
7	127	82	56	0.00	91	59
8	128	83	58	0.00	89	62
9	129	78	52	0.00	93	57
10	130	76	49	0.00	93	55
11	131	68	48	0.00	94	55
12	132	80	49	0.00	93	58
13	133	67	53	0.00	91	61
14	134	60	48	0.00	81	56
15	135	63	44	0.00	85	51
16	136	68	47	0.00	84	53
17	137	71	55	0.00	93	60
18	138	71	55	0.00	87	62
19	139	67	60	0.79	72	64
20	140	75	56	0.00	81	56
21	141	78	44	0.00	89	50
22	142	86	52	0.00	98	56
23	143	80	64	0.04	89	66
24	144	75	55	0.45	77	58
25	145	72	48	0.00	76	52
26	146	77	51	0.00	90	53
27	147	72	54	0.00	85	56
28	148	83	51	0.00	97	54
29	149	88	55	0.00	101	60
30	150	91	62	0.00	105	64
31	151	91	60	0.00	102	66
Average		74	52		86	57
Total				1.39		

University of Delaware

College of Agriculture and Natural Resources

Date	Julian Day	High Temperature (F)	Low Temperature (F)	RainFall (in)	Maximum Soil Temperature (F)	Minimum Soil Temperature (F)
1-Jun-99	152	87	66	0.00	102	68
2	153	88	67	0.00	101	69
3	154	85	69	0.01	99	73
4	155	78	59	0.00	102	66
5	156	78	50	0.00	98	61
6	157	85	49	0.00	103	61
7	158	95	63	0.00	106	68
8	159	96	73	0.00	107	75
9	160	94	66	0.00	108	73
10	161	67	57	0.00	80	67
11	162	74	57	0.00	97	67
12	163	73	58	0.00	79	66
13	164	75	66	0.47	82	69
14	165	88	67	0.05	92	68
15	166	77	63	0.02	81	68
16	167	70	63	0.02	77	66
17	168	66	61	0.00	70	65
18	169	74	57	0.00	75	62
19	170	76	50	0.00	88	57
20	171	64	56	1.00	69	63
21	172	65	61	0.11	69	63
22	173	78	56	0.00	84	60
23	174	84	52	0.00	88	59
24	175	83	51	0.00	87	60
25	176	83	62	0.00	85	68
26	177	91	65	0.00	91	69
27	178	91	68	0.00	90	72
28	179	86	75	0.00	87	76
29	180	94	73	0.16	92	76
30	181	76	71	0.28	80	74
Average		81	62		89	67
Total				2.12		

Appendix B

Heat Unit Accumulation for the 1999 Growing Season

Heat Units (40 Degree Base)
For 1999 University of Delaware Pea VarietyTrials

Date	High	Low	Heat Units	Early Pea Variety	Late Pea Variety
3/19/99	Planted		0	0	
3/20/99	51	30	0.5	0.5	
3/21/99	57	32	4.5	5	
3/22/99	52	36	4	9	
3/23/99	54	27	0.5	9.5	
3/24/99	64	43	13.5	23	
3/25/99	54	41	7.5	30.5	
3/26/99	47	29	0	30.5	
3/27/99	48	29	0	30.5	
3/28/99	49	37	0	30.5	
3/29/99	67	38	12.5	43	
3/30/99	63	35	9	52	
3/31/99	68	39	13.5	65.5	
4/1/99	67	55	21	86.5	
4/2/99	66	44	15	101.5	
4/3/99	68	44	16	117.5	
4/4/99	79	47	23	140.5	
4/5/99	54	34	4	144.5	
4/6/99	65	30	7.5	152	
4/7/99	72	47	19.5	171.5	
4/8/99	81	41	21	192.5	
4/9/99	73	47	20	212.5	
4/10/99	60	43	11.5	224	
4/11/99	47	36	1.5	225.5	
4/12/99	56	43	9.5	235	
4/13/99	60	38	9	244	
4/14/99	67	41	14	258	
4/15/99	63	39	11	269	
4/16/99	66	45	15.5	284.5	
4/17/99	62	36	9	293.5	
4/18/99	60	37	8.5	302	
4/19/99	61	33	7	309	
4/20/99	62	38	10	319	
4/21/99	60	34	7	326	
4/22/99	80	49	24.5	350.5	
4/23/99	76	51	23.5	374	
4/24/99	58	39	8.5	382.5	
4/25/99	61	35	8	390.5	
4/26/99	74	43	18.5	409	0
4/27/99	63	45	14	423	14
4/28/99	59	39	9	432	23
4/29/99	64	36	10	442	33
4/30/99	59	42	10.5	452.5	43.5
5/1/99	59	39	9	461.5	52.5
5/2/99	61	45	13	474.5	65.5
5/3/99	56	51	13.5	488	79
5/4/99	69	52	20.5	508.5	99.5
5/5/99	74	48	21	529.5	120.5
5/6/99	63	56	19.5	549	140

Heat Units (40 Degree Base)
For 1999 University of Delaware Pea VarietyTrials

Date	High	Low	Heat Units	Early Pea Variety	Late Pea Variety
5/7/99	82	56	29	578	169
5/8/99	83	58	30.5	608.5	199.5
5/9/99	78	52	25	633.5	224.5
5/10/99	76	49	22.5	656	247
5/11/99	68	48	18	674	265
5/12/99	80	49	24.5	698.5	289.5
5/13/99	67	53	20	718.5	309.5
5/14/99	60	48	14	732.5	323.5
5/15/99	63	44	13.5	746	337
5/16/99	68	48	18	764	355
5/17/99	71	55	23	787	378
5/18/99	71	55	23	810	401
5/19/99	67	60	23.5	833.5	424.5
5/20/99	75	56	25.5	859	450
5/21/99	78	44	21	880	471
5/22/99	86	52	29	909	500
5/23/99	80	64	32	941	532
5/24/99	75	55	25	966	557
5/25/99	72	48	20	986	577
5/26/99	77	51	24	1010	601
5/27/99	72	54	23	1033	624
5/28/99	83	51	27	1060	651
5/29/99	88	55	31.5	1091.5	682.5
5/30/99	91	62	36.5	1128	719
5/31/99	91	60	35.5	1163.5	754.5
6/1/99	87	66	36.5	1200	791
6/2/99	88	67	37.5	1237.5	828.5
6/3/99	85	69	37	1274.5	865.5
6/4/99	78	59	28.5	1303	894
6/5/99	78	50	24	1327	918
6/6/99	85	49	27	1354	945
6/7/99	95	63	39	1393	984
6/8/99	96	73	44.5		1028.5
6/9/99	94	66	40		1068.5
6/10/99	67	57	22		1090.5
6/11/99	74	57	25.5		1116
6/12/99	73	58	25.5		1141.5
6/13/99	75	66	30.5		1172
6/14/99	88	67	37.5		1209.5
6/15/99	77	63	30		1239.5
6/16/99	70	63	26.5		1266
6/17/99	66	61	23.5		1289.5
6/18/99	74	57	25.5		1315
6/19/99	76	50	23		1338
6/20/99	64	56	20		1358
6/21/99	65	61	23		1381
6/22/99	78	56	27		1408
6/23/99	84	52	28		1436
6/24/99	83	51	27		1463
6/25/99	83	62	32.5		1495.5
6/26/99	91	65	38		1533.5
6/27/99	91	68	39.5		1573
6/28/99	86	75	40.5		1613.5
6/29/99	94	73	43.5		1657
6/30/99	76	71	33.5		1690.5

Appendix C

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Author and Internet Information

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⇒ The University of Delaware Research & Education Center Website Address Has Changed:

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⇒ The following page is a sample of the weather data available from our site.

UNIVERSITY OF DELAWARE

College of Agriculture and Natural Resources

WEATHER DATA

Research and Education Center
Georgetown, Delaware
38.38N - - - 75.27W

Current Weather Data

- Latest Hourly Weather Conditions *
- Month To Date
- Local Nexrad Radar (Ellendale Radar)
- 3-Day Forecasts (State and Dover Conditions)
- 3-Day Forecasts (Md. State and Salisbury Conditions)
- Summary of Yesterday *
- Hourly Raw Data - 7 Day History
- Salisbury Forecasts (WBOC -TV Channel 16)
- Salisbury Forecasts (WMDT -TV Channel 47)
- Other Weather Maps and Images

Historical Weather Data

Monthly Summary Data Tables		
20-Year Monthly Rainfall Averages	20-Year Monthly Temperature Averages	
Monthly Averages compared to El Niño Years (1982-1983)		
Julian Day Chart	Heat Index Chart	Wind Chill Chart

*data verified and current as of 4-2-1999

For More Information or Comments, Please e-mail:

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07/01/99

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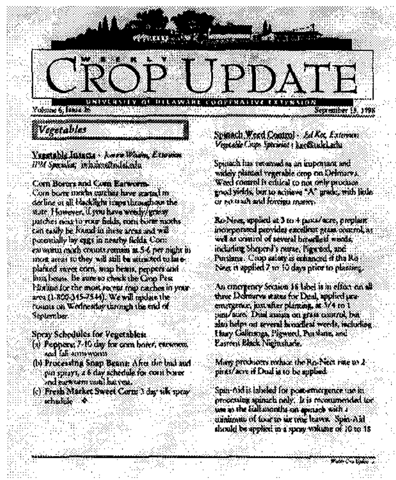
⇒ The Weekly Crop Update Newsletter produced by University of Delaware Cooperative Extension Staff is also located at this site.



WEEKLY CROP UPDATE

UNIVERSITY OF DELAWARE COOPERATIVE EXTENSION

Volume 6, Issue 26 — September 18, 1998

Vegetables

Vegetable Insects - *[illegible], Extension IPM Specialist*; [illegible]

Corn Borers and Corn Earworm-
Corn borer moth catches have started to decline in all blacklight traps throughout the state. However, if you have weedy/grassy patches next to your fields, corn borer moths can easily be found in these areas and will potentially lay eggs in nearby fields. Corn earworm moth counts remain at 5-6 per night in most areas so they will still be attracted to late-planted sweet corn, snap beans, peppers and lima beans. Be sure to check the Crop Pest Hotline for the most recent trap catches in your area (1-800-345-7544). We will update the counts on Wednesday through the end of September.

Spray Schedules for Vegetables
(a) Peppers: 7-10 day for corn borer, earworm and fall armyworm
(b) Processing Snap Beans: After the bud and pin sprays, a 6 day schedule for corn borer and earworm until harvest.
(c) Fresh Market Sweet Corn: 3 day silk spray schedule ◆

Spinach Weed Control - *Ed Kee, Extension Vegetable Crops Specialist*; kee@udel.edu

Spinach has returned as an important and widely planted vegetable crop on Delmarva. Weed control is critical to not only produce good yields, but to achieve "A" grade, with little or no trash and foreign matter.

Ro-Neet, applied at 3 to 4 pints/acre, preplant incorporated provides excellent grass control, as well as control of several broadleaf weeds, including Shepherd's purse, Pigweed, and Purslane. Crop safety is enhanced if the Ro-Neet is applied 7 to 10 days prior to planting.

An emergency Section 18 label is in effect on all three Delmarva states for Dual, applied pre-emergence, just after planting, at 3/4 to 1 pint/acre. Dual assists on grass control, but also helps on several broadleaf weeds, including Hairy Galinsoga, Pigweed, Purslane, and Eastern Black Nightshade.

Many producers reduce the Ro-Neet rate to 2 pints/acre if Dual is to be applied.

Spin-Aid is labeled for post-emergence use in processing spinach only. It is recommended for use in the fall months on spinach with a minimum of four to six true leaves. Spin-Aid should be applied in a spray volume of 10 to 15

The goal of the newsletter is to provide producers and agribusiness professionals with timely information regarding pest outbreaks, pest threshold levels and appropriate pesticide rates for control of the pest to improve timing of pesticide application and number of applications being applied as well as have economic impact for producers.

The newsletter is produced each week from April to October. Extension specialists and agents provide information for the newsletter in their area of discipline (ex. IPM management, plant pathology, weed control, cultural practices, marketing, etc.) The newsletter is mailed or faxed each Friday by 4:30 p.m. for a fee, or can be accessed on the internet for free.

⇒ University of Delaware College of Agriculture and Natural Resources website address is:

http://bluehen.ags.udel.edu

⇒ The University of Delaware website address is:

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