Project title:	Vining peas: Development of an improved standardisation procedure for the pea tenderometer
Project number:	FV 401
Project leader:	S. Belcher, PGRO
Report:	Final report, February 2013
Previous report:	
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Date project commenced:	1st March 2012
Date project completed (or expected completion date):	28 February 2013

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AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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CONTENTS

GROWER SUMMARY

Headline

The data from this project suggests that the Dodman digital tenderometer can be adopted as the industry standard and be used a reference Master tenderometer against which factory and grower group crosschecks are made.

Background

The Martin pea tenderometer has been the mainstay of the industry as a means of determining pea maturity and payment is usually made according to the tenderometer reading (TR). The tenderometer is used to assess the maturity of crops prior to harvesting and to measure the maturity of the vined produce.

The Martin tenderometer has an upper grid which is moved by means of an electric motor, through a second grid mounted on the same shaft. Peas are filled in the space between the grids and once started, the grids squash the peas and eventually shear through them. The force required is measured by the displacement of a weighted pendulum attached to the second grid and is indicated by a pointer on a scale reading from 0 to 200. There are several points at which the tenderometer can produce variable readings, including the resistance of the weighted pendulum, resistance of worn bearings, slippage between the attachment of the pointer to the grid and movement of the printed scale which is fixed to the back of the grid housing.

Because of these factors, it is necessary to continually adjust the settings on the tenderometer to maintain a standard reading and to avoid drift. PGRO operates a scheme to ensure that Master instruments give accurate results. As a back up, cross checking with the Martin tenderometer at Campden BRI is made several times over the season. Tests should be carried out at the start of the vining season, and then routine tests can be made each week. More frequent tests are made if problems are suspected with a particular tenderometer, or if the factory instrument is used for checking other tenderometers.

The Dodman tenderometer has been introduced as an alternative to the Martin and PGRO undertook some comparison trials in 2003 with the prototype digital instrument which indicated its suitability as a substitute. There were many improvements in the new instrument which resulted in a reduction of the number of moving parts, and a replacement

of the mechanical resistance mechanism with one which is directly controlled electronically thereby reducing the variability of the TR values between pea samples.

The most recent digital tenderometer (Dodman) has now been introduced by many processing factories and by larger grower groups. Standardisation is still required for the purposes of quality assurance but it is now necessary for the PGRO service to include the digital tenderometer as part of the standardisation service, and after a full validation, replace the master Martin with the Dodman instrument. It is envisaged that the time taken for the standardisation checking will be greatly reduced and the need for regular adjustment to maintain the standard will be reduced. Because of the reduction of reading drift through the season and the fact that the digital instrument can be re set electronically at the start of each season, there will be no need to carry out cross checking with the Campden Martin tenderometer. Such reductions will result in cost saving by the factory and providing growers with the assurance that the tests are comparable, reproducible and reliable through the harvest season.

The current cross check procedure is carried out on a batch of vined, washed vining peas that have been cooled to 20ºC. One half of the batch is retained by the test tenderometer operator and the second half is delivered to PGRO. Eleven sub-samples of the mixed sample are measured using the PGRO Master Martin tenderometer, and the mean value calculated after discarding the first reading. At the same time, the test tenderometer operator measures the values on the retained batch of peas using the same methodology. Comparisons between the PGRO Master and the test tenderometer are made and the test tenderometer is adjusted if necessary to calibrate with the PGRO Master.

Summary

At a range of maturities over the range TR 90-130 samples of peas were harvested, vined and washed and the maturity measured by both the PGRO Master Martin tenderometer and the Dodman digital tenderometer.

Over an approximate 3 week period, 29 June to 19 July the maturity of 109 samples of vining peas was measured using the PGRO Master Martin tenderometer and the Dodman tenderometer. This comprised 26 different varieties over a tenderometer range of 79 to 158.5 units (as measured by the Martin tenderometer). Five samples were ran through each machine and the average, maximum, minimum and range of the tenderometer readings calculated.

On a weekly basis over about an eight week period, standardisation of the PGRO Master tenderometer was carried out. The tenderometer reading from a commercially obtained sample of vined, washed and size graded peas was measured. The size grades were small, medium and large and these served to give a range of maturity. After cooling, half of the samples were retained by PGRO and half sent to Campden BRI in cooled boxes. The maturity of the samples was also measured using the PGRO Dodman tenderometer and a Dodman tenderometer at Campden BRI.

Eleven sub-samples of the mixed samples were measured using the PGRO Master Martin tenderometer, and the average, maximum, minimum and range of the tenderometer readings calculated after discarding the first reading. At the same time, the Campden BRI Master Martin tenderometer and the PGRO and Campden BRI Dodman tenderometers measured the values using the same methodology.

Previous work by PGRO in 2003 with a Dodman prototype tenderometer indicated a good relationship with the PGRO Mater Martin tenderometer. Several factories and grower groups have now adopted the latest version of the Dodman tenderometer and this project aims to show that a Dodman tenderometer could be used as the standard for the industry.

The data within this project suggests that the Dodman digital tenderometer could be adopted as the industry standard and be used a reference Master tenderometer against which factory and grower group crosschecks are made.

Financial Benefits

There are sometimes issues with the calibration of Martin tenderometers. Accurate and consistent estimation of tenderometer readings at the time of delivery to the factory is important to growers as there are financial penalties for pea loads that fall out of the Grade specification.

For example: if peas grown for A grade are down graded to B grade because of tenderometer inaccuracies the financial penalty can be £25 per tonne of peas. At an average yield of 4.95t/ha this equates to a loss of £124/ha.

Action Points

- PGRO to action the use of the Dodman digital tenderometer as the Master for the industry Cross check and standardization.
- Tenderometers need regular maintenance

SCIENCE SECTION

Introduction

The Martin pea tenderometer has been the mainstay of the industry as a means of determining pea maturity and payment is usually made according to the tenderometer reading (TR). The tenderometer is used to assess the maturity of crops prior to harvesting and to measure the maturity of the vined produce.

The Martin tenderometer has an upper grid which is moved by means of an electric motor, through a second grid mounted on the same shaft. Peas are filled in the space between the grids and once started the grids squash the peas and eventually shear through them. The force required is measured by the displacement of a weighted pendulum attached to the second grid and is indicated by a pointer on a scale reading from 0 to 200. There are several points at which the tenderometer can produce variable readings, including the resistance of the weighted pendulum, resistance of worn bearings, slippage between the attachment of the pointer to the grid and movement of the printed scale which is fixed to the back of the grid housing. Because of these factors, it is necessary to continually adjust the settings on the tenderometer to maintain a standard reading and to avoid drift. PGRO operates a scheme to ensure that Master instruments give accurate results. As a back up, cross checking with the Martin tenderometer at Campden BRI is made several times over the season. Tests are carried out at the start of the vining season, and then routine tests can be made each week. More frequent tests are made if problems are suspected with a particular tenderometer, or if the factory instrument is used for checking other tenderometers.

The Dodman tenderometer has been introduced as an alternative to the Martin and PGRO undertook some comparison trials in 2003 with the prototype digital instrument which indicated its suitability as a substitute. There were many improvements in the new instrument which resulted in a reduction of the number of moving parts, and a replacement of the mechanical resistance mechanism with one which is directly controlled electronically thereby reducing the variability of the TR values between pea samples.

The most recent digital tenderometer (Dodman) has now been introduced by many processing factories and by larger grower groups. Standardisation is still required for the purposes of quality assurance but it is now necessary for the PGRO service to include the digital tenderometer as part of the standardisation service, and after a full validation, replace

the master Martin with the Dodman instrument. It is envisaged that the time taken for the standardisation checking will be greatly reduced and the need for regular adjustment to maintain the standard will be reduced. Because of the reduction of reading drift through the season and the fact that the digital instrument can be re set electronically at the start of each season, there will be no need to carry out cross checking with the Campden Martin tenderometer. Such reductions will result in cost saving by the factory and providing growers with the assurance that the tests are comparable, reproducible and reliable through the harvest season.

The current cross check procedure is carried out on a batch of vined, washed vining peas that have been cooled to 20ºC. One half of the batch is retained by the test tenderometer operator and the second half is delivered to PGRO. Eleven sub-samples of the mixed sample are measured using the PGRO Master Martin tenderometer, and the mean value calculated after discarding the first reading. At the same time, the test tenderometer operator measures the values on the retained batch of peas using the same methodology. Comparisons between the PGRO Master and the test tenderometer are made and the test tenderometer is adjusted if necessary to calibrate with the PGRO Master.

Materials and methods

A range of Vining pea varieties in the PGRO variety trials evaluation were sown and grown according to best and local practice.

At a range of maturities over the range TR 90-130 samples of peas were harvested, vined and washed and the maturity measured by both the PGRO Master Martin tenderometer and the Dodman digital tenderometer.

Over an approximate 3 week period, 29 June to 19 July the maturity of 109 samples of vining peas was measured using the PGRO Master Martin tenderometer and the Dodman tenderometer. This comprised 26 different varieties over a tenderometer range of 79 to 158.5 units (as measured by the Martin tenderometer). Five samples were run through each machine and the average, maximum, minimum and range of the tenderometer readings calculated.

Subsequently the data set was reduced to 99 as the range within each set of 5 readings was >8 TR units.

On a weekly basis over about an eight week period, standardisation of the PGRO Master

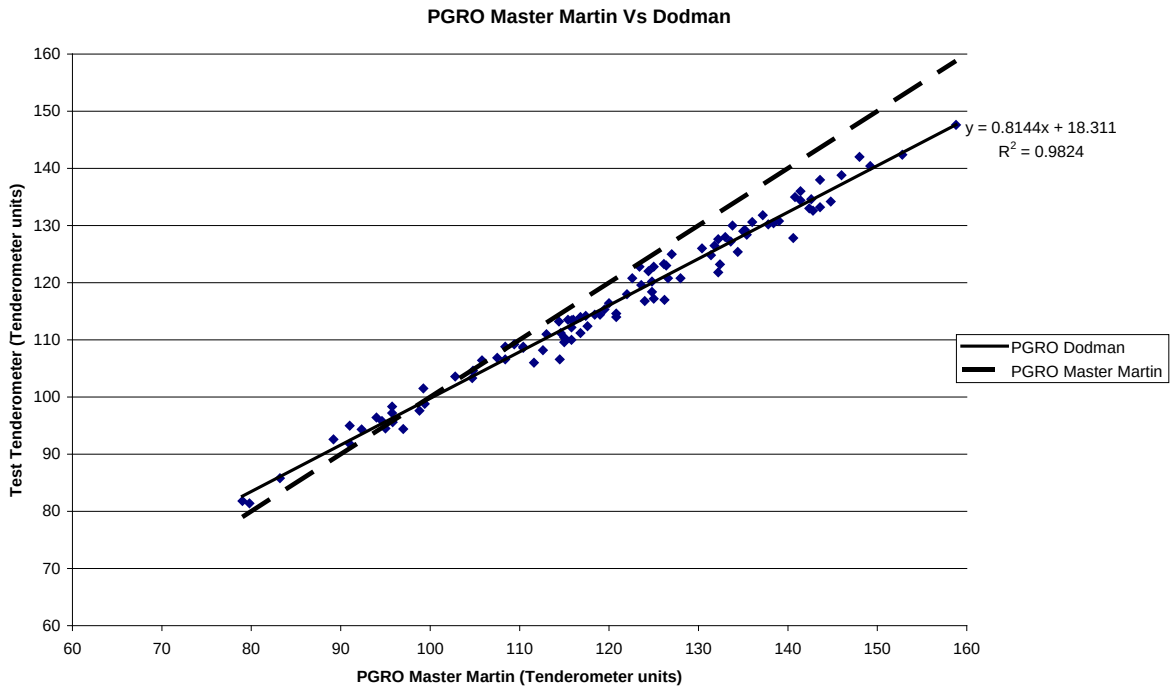
tenderometer was carried out. The tenderometer reading from a commercially obtained sample of vined, washed and size graded peas was measured. The size grades were small, medium and large and these served to give a range of maturity. After cooling, half of the samples were retained by PGRO and half sent to Campden BRI in cooled boxes. The maturity of the samples was also measured using the PGRO Dodman tenderometer and a Dodman tenderometer at Campden BRI.

Eleven sub-samples of the mixed samples were measured using the PGRO Master Martin tenderometer, and the average, maximum, minimum and range of the tenderometer readings calculated after discarding the first reading. At the same time, the Campden BRI Master Martin tenderometer and the PGRO and Campden BRI Dodman tenderometers measured the values using the same methodology.

Results

Graph 1 below shows the tenderometer values from 99 samples of vining peas, through both the PGRO Master Martin tenderometer and the Dodman tenderometer. The solid line is the PGRO Master Martin plotted against the PGRO Master Martin to give a 1:1 relationship and equation of the line is $y = x$.

The solid line is the PGRO Dodman tenderometer plotted against the PGRO Master Martin, here the equation of the straight line $y=0.844x + 18.311$.



Graph 1: PGRO Master Martin Tenderometer vs Dodman digital tenderometer

Table 1 below shows that at lower tenderometer units (TR 80-90) the Dodman reads a little high by 3.5 and 1.5 units respectively compared to the PGRO Martin. At around TR 100 the two machined are aligned. But, as the Tenderometer readings increase, the Dodman reads progressively lower than the PGRO master.

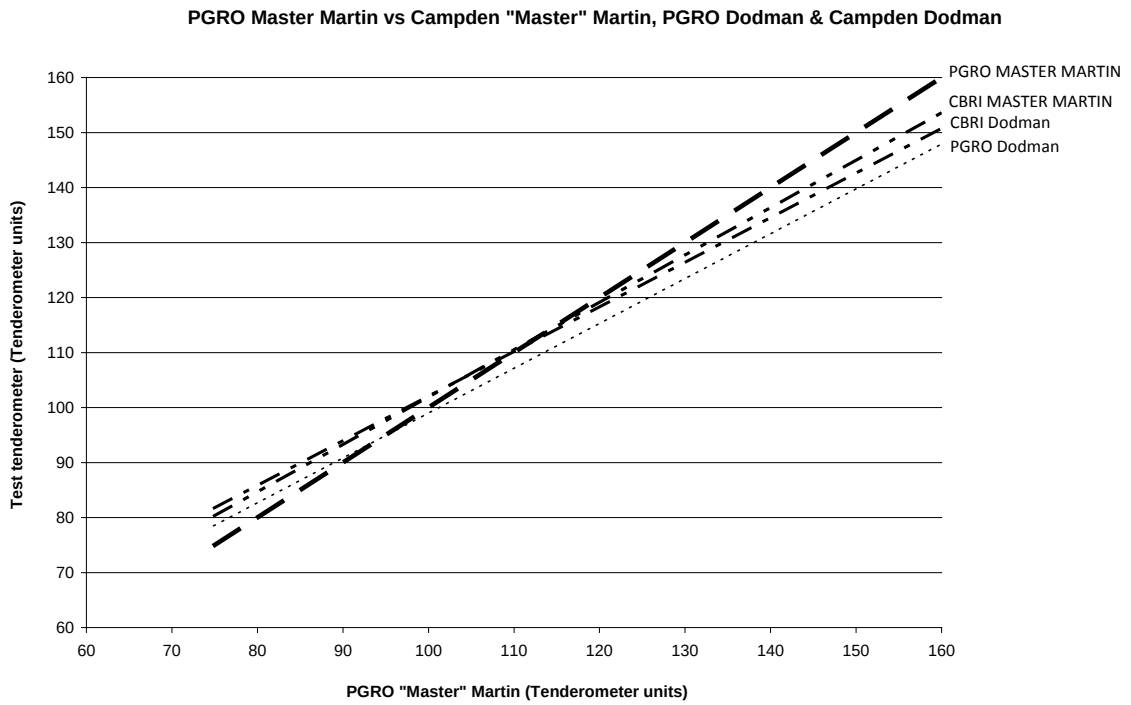
Table 1. Fitted values for the Dodman (y = 0.8144x + 18.311) vs the PGRO Master and the difference Y = 0.8144x + 18.311

X (PGRO master)	Y (Dodman)	Difference
Tenderometer units		
80	83.5	3.5
90	91.6	1.6
100	99.8	-0.2
110	107.9	-2.1
120	116.0	-4.0
130	124.2	-5.8
140	132.3	-7.7
150	140.5	-9.5
160	148.6	-11.4

Graph 2 below shows the tenderometer values from 29 samples of vining peas, through the PGRO Master Martin tenderometer, PGRO Dodman tenderometer, Campden BRI Master Martin Tenderometer and Campden BRI Dodman Tenderometer.

The PGRO Dodman tenderometer, Campden BRI Master Martin tenderometer and Campden BRI Dodman tenderometer show alignment with each other. The fitted lines run parallel to each other and with slight adjustment of the two Dodman machines could fully be aligned.

The PGRO Master Martin again did not align well with the other three test machines and indicates a potential miss-alignment of the PGRO Master Martin.



Graph 2: PGRO Master Martin Tenderometer vs PGRO Dodman tenderometer, Campden BRI Master Martin tenderometer and Campden BRI Dodman tenderometer.

Discussion

Previous work by PGRO in 2003 with a Dodman prototype tenderometer indicated a good relationship with the PGRO Mater Martin tenderometer. Several factories and grower groups have now adopted the latest version of the Dodman tenderometer and this project aims to show that a Dodman tenderometer could be used as the standard for the industry.

Graph 1 indicates that the relationship found in 2003 between the 2 types of tenderometer was no longer present. The difference between the two machines was most apparent at high values.

Graph 2, however, shows that the PGRO Dodman tenderometer, Campden BRI Master Martin tenderometer and Campden BRI Dodman tenderometer show alignment with each other. The fitted lines run parallel to each other and with slight adjustment of the two Dodman machines could be fully aligned. These three tenderometers did not align well with the PGRO Master Martin tenderometer, particularly at higher tenderometer values.

Both Dodman (Campden and PGRO) machines do align well with the Campden BRI Master Martin and with only minor adjustments could be made to fully align over the whole tenderometer unit range.

Conclusions

The data suggests that the Dodman digital tenderometer could be adopted as the industry standard and be used a reference Master tenderometer against which factory and grower group crosschecks are made.

Knowledge and Technology Transfer

A meeting of industry representatives met in October 2012 to discuss canned reference samples that are used to calibrate tenderometers. Based on non-published data and early provisional data from this project, it was agreed the PGRO Master Martin tenderometer be replaced with a Dodman digital tenderometer for the 2013 season.

References

PGRO, (May 2012). Technical Update 141: Tenderometer Standardisation and Maintenance.

Appendices

Appendix 1. Average tenderometer value and range, from 99 samples of vining peas for the PGRO Master Martin and Dodman tenderometers.

sample	Machine	Value	Range	Machine	Value	Range
1	**Master**	107.5	4	**Dodman**	106.9	4
2	**Master**	104.7	3	**Dodman**	103.3	4
3	**Master**	108.4	5	**Dodman**	106.6	4
4	**Master**	126.4	6	**Dodman**	123.0	5
5	**Master**	126.1	5	**Dodman**	123.3	7
6	**Master**	95.0	2	**Dodman**	94.5	2
7	**Master**	113.0	4	**Dodman**	111.0	5
8	**Master**	119.5	2	**Dodman**	115.3	4
9	**Master**	136.0	5	**Dodman**	130.6	4
10	**Master**	132.2	4	**Dodman**	127.6	5
11	**Master**	137.2	6	**Dodman**	131.8	8
12	**Master**	95.8	3	**Dodman**	95.6	1
13	**Master**	104.8	5	**Dodman**	104.6	6
14	**Master**	112.6	4	**Dodman**	108.2	4
15	**Master**	124.8	2	**Dodman**	118.4	4
16	**Master**	117.6	6	**Dodman**	112.4	5
17	**Master**	120.8	3	**Dodman**	114.0	5
18	**Master**	133.6	6	**Dodman**	127.2	5
19	**Master**	133.0	5	**Dodman**	128.0	3
20	**Master**	122.0	7	**Dodman**	118.0	2
21	**Master**	124.0	6	**Dodman**	116.8	4
22	**Master**	139.0	7	**Dodman**	130.8	3
23	**Master**	143.6	4	**Dodman**	138.0	7
24	**Master**	91.0	2	**Dodman**	95.0	2
25	**Master**	89.2	2	**Dodman**	92.6	1
26	**Master**	102.8	2	**Dodman**	103.6	3
27	**Master**	94.0	5	**Dodman**	96.4	3
28	**Master**	83.2	4	**Dodman**	85.8	3
29	**Master**	127.0	8	**Dodman**	125.0	5
30	**Master**	124.4	4	**Dodman**	122.0	2
31	**Master**	108.4	7	**Dodman**	108.8	4
32	**Master**	110.4	5	**Dodman**	108.8	6
33	**Master**	123.4	5	**Dodman**	122.8	4
34	**Master**	122.6	3	**Dodman**	120.8	3

35	**Master**	105.8	4	**Dodman**	106.4	4
36	**Master**	141.4	3	**Dodman**	136.0	5
37	**Master**	146.0	3	**Dodman**	138.8	3
38	**Master**	91.0	4	**Dodman**	91.8	2
39	**Master**	142.4	6	**Dodman**	133.0	6
40	**Master**	149.2	8	**Dodman**	140.4	8
41	**Master**	140.8	4	**Dodman**	135.0	2
42	**Master**	133.8	4	**Dodman**	130.0	2
43	**Master**	148.0	2	**Dodman**	142.0	4
44	**Master**	142.6	7	**Dodman**	134.6	5
45	**Master**	158.8	5	**Dodman**	147.6	3
46	**Master**	141.4	3	**Dodman**	134.4	4
47	**Master**	125.0	5	**Dodman**	122.8	5
48	**Master**	117.4	5	**Dodman**	114.2	5
49	**Master**	116.8	3	**Dodman**	111.2	6
50	**Master**	111.6	5	**Dodman**	106.0	3
51	**Master**	99.3	2	**Dodman**	101.5	5
52	**Master**	94.6	4	**Dodman**	95.8	5
53	**Master**	92.3	6	**Dodman**	94.3	1
54	**Master**	79.0	2	**Dodman**	81.8	2
55	**Master**	79.8	3	**Dodman**	81.4	3
56	**Master**	114.5	6	**Dodman**	106.6	6
57	**Master**	115.0	7	**Dodman**	110.4	2
58	**Master**	95.8	3	**Dodman**	97.2	7
59	**Master**	95.8	1	**Dodman**	98.3	3
60	**Master**	99.4	6	**Dodman**	98.8	4
61	**Master**	120.8	5	**Dodman**	114.6	2
62	**Master**	116.8	8	**Dodman**	114.0	9
63	**Master**	109.4	3	**Dodman**	109.2	4
64	**Master**	118.4	6	**Dodman**	114.4	4
65	**Master**	115.8	6	**Dodman**	112.2	3
66	**Master**	131.4	8	**Dodman**	124.8	5
67	**Master**	132.2	5	**Dodman**	121.8	3
68	**Master**	120.0	6	**Dodman**	116.4	4
69	**Master**	126.6	5	**Dodman**	120.8	5
70	**Master**	125.0	3	**Dodman**	117.2	3
71	**Master**	124.8	5	**Dodman**	120.2	4
72	**Master**	152.8	7	**Dodman**	142.4	9
73	**Master**	140.6	5	**Dodman**	127.8	7
74	**Master**	132.4	3	**Dodman**	123.2	7

75	**Master**	119.0	7	**Dodman**	114.4	6
76	**Master**	110.4	3	**Dodman**	108.6	3
77	**Master**	115.8	3	**Dodman**	110.0	5
78	**Master**	135.2	4	**Dodman**	129.2	5
79	**Master**	128.0	6	**Dodman**	120.8	7
80	**Master**	142.8	3	**Dodman**	132.6	5
81	**Master**	135.4	6	**Dodman**	128.4	8
82	**Master**	97.0	6	**Dodman**	94.4	3
83	**Master**	98.8	4	**Dodman**	97.6	5
84	**Master**	130.4	5	**Dodman**	126.0	4
85	**Master**	114.6	5	**Dodman**	111.2	7
86	**Master**	114.4	4	**Dodman**	113.2	4
87	**Master**	134.4	4	**Dodman**	125.4	6
88	**Master**	115.8	6	**Dodman**	113.4	7
89	**Master**	115.0	6	**Dodman**	109.6	1
90	**Master**	135.0	2	**Dodman**	129.0	4
91	**Master**	123.6	3	**Dodman**	119.6	7
92	**Master**	144.8	5	**Dodman**	134.2	8
93	**Master**	143.6	2	**Dodman**	133.2	5
94	**Master**	138.4	5	**Dodman**	130.4	3
95	**Master**	137.8	6	**Dodman**	130.2	6
96	**Master**	116.0	4	**Dodman**	113.5	1
97	**Master**	115.4	3	**Dodman**	113.5	1
98	**Master**	131.8	4	**Dodman**	126.5	3
99	**Master**	126.2	6	**Dodman**	117.0	2

Appendix 2. Average tenderometer value, from 25 samples of vining peas for the PGRO & CBRI Master Martin and PGRO & CBRI Dodman tenderometers.

Sample	PGRO Master	PGRO Dodman	CBRI Master	CBRI Dodman
		Tenderometer value		
1	74.8		78.7	81.1
2	79.8		84.3	86.6
3	91.6	91.0	92.7	93.7
4	91.9		91.7	
5	92.8		90.5	
6	98.0		100.9	
7	101.3	100.3	106.4	104.9
8	103.1		103.1	103.7
9	107.7	108.6	114.9	108.1
10	111.7		110.6	109.0
11	112.6		114.8	116.0
12	118.4		117.4	115.1
13	120.3	113.6	126.2	
14	122.1		121.9	119.7
15	125.3	119.5	127.5	124.9
16	131.2	123.9	127.9	127.3
17	132.6		134.1	133.2
18	132.8	124.5	126.1	126.5
19	134.9	129.4	131.6	131.4
20	138.8		134.1	129.0
21	143.1	134.1	138.7	138.5
22	143.7	132.4	136.8	135.2
23	146.2	137.1	141.0	141.5
24	150.3		146.9	
25	162.9	151.4	152.1	152.8

Appendix 3. Photographs of the two tenderometer types (top, Martin and bottom Dodman)