



Title	Survey of the Composition of Water Supplies Used in Glasshouses
Authors(s)	Gormley, T. R. (Thomas Ronan), O'Flaherty, T.
Publication date	1970
Publication information	Gormley, T. R. (Thomas Ronan), and T. O'Flaherty. "Survey of the Composition of Water Supplies Used in Glasshouses." An Foras Talúntais, 1970.
Publisher	An Foras Talúntais
Item record/more information	http://hdl.handle.net/10197/6983

Downloaded 2026-05-01 16:17:39

The UCD community has made this article openly available. Please share how this access benefits you. Your story matters! (@ucd_oa)



© Some rights reserved. For more information

SURVEY OF THE COMPOSITION OF WATER SUPPLIES USED IN GLASSHOUSES

T. R. Gormley and T. O'Flaherty

An Foras Talúntais, Kinsealy Research Centre, Kinsealy, Malahide Road, Dublin 5

ABSTRACT

Sample bottles and questionnaires were sent to 240 glasshouse growers in 24 counties. A response of 87% was obtained. The water samples were analysed for pH, Ca, Mg, Na, K, P, Mn, O, specific conductivity (SC) and total hardness. Information was obtained from the questionnaire on water source, storage, treatment, presence or absence of algae, use of a boiler for heating and sterilising, and type of feeding system used.

Calcium and SC readings fluctuated most and, in general, supplies from wells were hard while those caught as 'roof rainwater' were very soft. The linear correlation between Ca contents and SC readings was 0.91, and the hardness of water was correctly predicted for 157 samples out of 197 by making an SC reading and converting it to ppm Ca using the regression line.

Thirty-six percent of samples were obtained from wells, 29.4% from 'mains,' 14.7% from rivers and the remainder from combinations of these or other sources. Supplies which were stored were more likely to contain algae than those which were not. The hose system of feeding was used most frequently.

Forty-five percent of growers used boilers, but of these less than one-fifth treated the water. Of the samples not treated 26.5% were classified as moderately hard, 21.0% as hard and 4.2% as extremely hard.

INTRODUCTION

The size of the glasshouse industry in Ireland has increased from 76.1 ha in 1960 to an estimated 182.3 ha in 1969. In general the unit size is from 0.2 ha upwards. The growing of glasshouse crops is becoming highly automated and feeding is accomplished by diluter systems using sprayline, hose or trickle. Many glasshouses are boiler heated, and steam may be drawn from the boiler for both heating and soil sterilising. Because of the extent of liquid feeding and boiler heating it is important to know the composition of the water being used and the effects of its use.

Water supplies naturally high in salts may cause difficulty by:

- a) producing a high salt concentration in the soil when used for feeding and irrigation,
- b) scaling boilers,
- c) leaving a deposit on glasshouse roofs when used for washing,
- d) leaving a deposit on fruit when used for spraying.

In this survey sample bottles and questionnaires were sent to 240 growers. The composition of each sample was obtained, together with useful information on water source, storage, presence or absence of algae, type of liquid feeding system, and use of a boiler for glasshouse heating.

PROCEDURE

Because of the large number of growers in the Dublin area it was decided to divide the country into two sections—Dublin county and the rest of the country. All growers outside Dublin were included in the survey. The Dublin area was divided into four sections by two lines, *i.e.*, the river Liffey as east-west and Balbriggan-Kippure as north-south. Twenty-five percent of the growers from each section were selected at random and were included in the survey. The total number of growers covered by the survey was 240, 71 of whom were from County Dublin. Because of the great difference in the water supplies between North and South County Dublin, each was considered as a separate county in the overall analysis.

Sample bottles ($2\frac{1}{2}$ l) and questionnaires (see Appendix) were dispatched to each grower who was requested to fill the bottle from his water supply, complete the questionnaire and return both to Kinsealy. Three reminder notes were sent at intervals of 2 weeks.

Dissolved oxygen content of the samples was measured when received with a dissolved oxygen meter. Analyses for pH, specific conductivity (SC)¹, total hardness, Ca, Mg, Mn, P, K and Na were carried out in Johnstown Castle using the methods outlined in the 'Methods of Analysis' handbook (1). Hardness was measured by estimating the amount of Ca and Mg in a sample and then calculating both as CaCO₃. The following categories of hardness (ppm CaCO₃) were used:

soft	< 50
moderately soft	50–100
moderately hard	101–200
hard to very hard	201–350
extremely hard	> 350

Theoretical frequencies (TF) based on marginal totals (2) are used extensively in this paper to illustrate results which are different from the overall pattern and thus greatly reduce the size and number of tables presented. In cells where the actual frequency differed from the theoretical frequency by three or more the actual and

$${}^1SC = \frac{\mu \text{ mhos}}{10}$$

theoretical frequencies are listed. The difference of three was taken for convenience irrespective of the number of units involved, *e.g.*, actual frequency for a parameter=1, theoretical=4 or actual frequency=20, theoretical=23; both of these would be quoted as departures from theoretical frequencies even though a departure of 3 from 4 is proportionately greater than 3 from 23.

RESULTS

Water source

A response of 87% was obtained. Water was used from a private well by 36% of growers, from a local reservoir by 29.4% and from a river by 14.7% (Table 1). By referring the numbers of samples tested from each county (Table 2) to the percentage

TABLE 1: Distribution of supplies

Water source	Supplies		Water source	Supplies	
	Actual numbers	%		Actual numbers	%
Mains from reservoir	58	29.4	River	29	14.7
Well	71	36.0	Lake	3	1.5
Catch rainwater	6	3.0	Combination of sources	30	15.4

TABLE 2: Number of samples tested from each county

County	Number of samples	County	Number of samples
Armagh	2	Longford	1
Carlow	3	Louth	9
Cavan	1	Mayo	3
Clare	2	Meath	24
Cork	22	Monaghan	5
Donegal	5	Offaly	5
Dublin (North)	45	Sligo	3
Dublin (South)	11	Tipperary	3
Galway	6	Waterford	2
Kerry	2	Westmeath	3
Kildare	10	Wexford	8
Laois	7	Wicklow	14
Limerick	4		

figures in Table 1 the actual number of supplies from a particular source can be calculated for each county, provided the distribution agrees with the theoretical frequency. For example, 24 supplies from Meath were tested (Table 2) and 36% of all supplies were obtained from wells (Table 1), therefore 8.6 ($TF=24 \times 0.36$) supplies in Meath should come from wells. In fact the actual frequency was 9 which agreed closely with the theoretical one. However, the case in Dublin North was very different, *i.e.*, 45 samples were tested, therefore 16.2 ($TF=45 \times 0.36$) should come from wells; in fact 26 supplies were obtained from wells which showed a marked difference from the theoretical frequency. Distributions for reservoirs and rivers in Dublin North were eight ($TF=13.2$) and three ($TF=6.6$) respectively. Distributions for Dublin South, Kildare and Wicklow did not agree closely with theoretical frequencies. In Dublin South only one supply ($TF=4.0$) was obtained from a private well. In Kildare six ($TF=2.9$) growers received their supply from a reservoir. In Wicklow the distribution for reservoir and private well was seven ($TF=4.0$) and two ($TF=5.0$) respectively.

Storage, algae, boilers and water treatment

The results (Table 3) can be approximated on a 'water source basis' or 'county basis' by referring to the actual numbers in Tables 1 and 2 respectively. Departures from theoretical frequencies are given in the text. More than half the growers stored water and only about one-quarter of the supplies contained algae (Table 3). Forty-five percent of growers had boilers, but of these only 17.8% treated the water. There was no correlation between incidence of treatment and type of water, *i.e.*, the cases where water was treated were not necessarily those with a high level of hardness or with a low pH. This is illustrated by the fact that of the samples used in boilers which were not treated 26.5% were classified as moderately hard, 21.0% as hard to very hard and 4.2% as extremely hard.

TABLE 3: Grower response^a (%) to questionnaire

Question ^b	Positive answer ('Yes')	Negative answer ('No')	No answer
Is water stored	51.3	43.1	5.6
Are there algae in the supply	23.5	74.0	2.5
Is a boiler used	45.2	50.3	4.5
Is steam drawn from the boiler ^c :			
a) for heating	33.7	56.2	10.1
b) for sterilising	49.5	41.8	8.7
Is the boiler water treated ^c	17.8	80.0	2.2

^a Appropriate results can be approximated on a 'water source' or 'county basis' by referring to Tables 1 and 2

^b Question asked on questionnaire

^c Only calculated for those having boilers

TABLE 4: Distribution of liquid feeding systems^a

Feeding system	Growers (%)	Feeding system	Growers (%)
Hose	35.0	Hose+sprayline	6.1
Trickle	25.9	Trickle+sprayline	3.0
Sprayline	14.7	Hose+trickle+sprayline	2.0
Hose+trickle	7.1	Floor system	1.0
		No answer	5.2

^a Results can be approximated on a 'water source' or 'county basis' by referring to Tables 1 and 2

Frequencies for water storage and treatment on a county basis agreed closely with theoretical frequencies, except for Louth where eight (TF=4.6) out of nine growers stored water and five (TF=0.7) out of nine supplies were treated. The frequencies for water storage and treatment on a 'water source basis' also agreed closely with theoretical frequencies except for supplies from mains and 'caught rainwater.' Out of 58 supplies obtained from mains, 23 were stored (TF=29.7) while 23 out of 25 rainwater supplies or combinations of rainwater with water from another source were stored. In the case of the two rainwater supplies that were not stored, either the growers filled in the questionnaire erroneously or considered the amount of rainwater stored as trivial when compared to the other supply used directly.

The incidence of algae in supplies was lower than expected in Dublin North (4, TF=10.6). Algae occurred in 26.7% of supplies which were stored and only in 16.4% of supplies which were not.

Frequencies for use of boilers were higher than the theoretical ones in Meath (13, TF=9.9) and Louth (8, TF=4.1) and lower in Dublin North (11, TF=20.3). Growers with boilers were more likely to store water (53, TF=45.6) than those without boilers (30, TF=38.1).

Liquid feeding systems

The hose method of feeding was the most frequently used (Table 4). Frequencies for feeding systems on a county basis agreed with theoretical frequencies except for County Cork where 9 (TF=5.4) growers used trickle systems.

Analyses for SC, Ca, Mg, K, Na and hardness

Tables 5 to 10 show percentage distributions of supplies from all counties and water sources in five categories for SC, Ca, Mg, K, Na and hardness. Distributions for individual counties and water sources which were different from the overall pattern are also included. Figures for other individual counties or water sources can be approximated by referring the percentage figures in Tables 5 to 10 to Tables 1 and 2.

TABLE 5: Distribution of supplies in five SC categories

County or water source	SC categories				
	0-15	16-30	31-60	61-90	91-999
All counties and water sources (%)	21.8	17.9	22.9	26.9	10.5
Cork ^c	6 ^a (4.8) ^b	10 (3.9)	3 (5.0)	2 (5.9)	1 (2.4)
Dublin North	1 (9.9)	5 (8.1)	7 (10.2)	18 (12.1)	14 (4.7)
Dublin South	6 (2.4)	4 (2.0)	1 (2.5)	0 (3.0)	0 (1.1)
Meath	0 (5.3)	3 (4.3)	9 (5.5)	9 (6.4)	3 (2.5)
Wicklow	9 (3.1)	2 (2.5)	1 (3.2)	2 (3.8)	0 (1.4)
Mains supply ^a	26 (12.6)	12 (10.6)	14 (13.2)	6 (15.6)	0 (5.9)
Private well supply	4 (15.5)	8 (13.0)	10 (16.2)	32 (19.1)	17 (7.2)

^a Frequency—actual number^b Theoretical frequency^c Distributions for individual counties and water sources which were different from the overall pattern

TABLE 6: Distribution of supplies in five Ca categories

County or water source	Ca categories (ppm)				
	0-20	21-40	41-80	81-140	141-999
All counties and water sources (%)	31.8	13.9	22.9	23.0	8.4
Cork ^c	13 ^a (7.0) ^b	4 (3.1)	4 (5.0)	0 (5.0)	1 (1.9)
Donegal	5 (1.6)	0 (0.7)	0 (1.1)	0 (1.1)	0 (0.5)
Dublin North	4 (14.3)	3 (6.3)	11 (10.3)	18 (10.3)	9 (3.8)
Laois	0 (2.2)	1 (1.0)	1 (1.6)	5 (1.6)	0 (0.6)
Meath	1 (7.6)	3 (3.3)	9 (5.5)	9 (5.5)	2 (2.1)
Wicklow	10 (4.5)	1 (2.0)	1 (3.2)	2 (3.2)	0 (1.1)
Mains supply ^a	36 (18.5)	4 (8.2)	11 (13.4)	7 (13.5)	0 (4.4)
Private well supply	8 (22.7)	8 (10.1)	20 (16.2)	23 (16.6)	12 (5.4)
Rainwater supply	5 (1.9)	0 (0.9)	0 (1.4)	0 (1.4)	1 (0.4)
River supply	6 (9.3)	6 (4.1)	8 (6.6)	9 (6.8)	0 (2.2)

^a Frequency—actual number^b Theoretical frequency^c Distributions for individual counties and water sources which were different from the overall pattern

Only 10.5% of supplies were in the highest SC category and the remainder were fairly evenly distributed between the other four categories (Table 5). Over 50% of supplies had Ca levels above 41 ppm (Table 6), while for Mg half the samples were in the 3 to 7 ppm category (Table 7). Forty percent of samples were hard to extremely hard and a further 21% were moderately hard (Table 8). Approximately 92% of samples had Na levels above 8 ppm and about 82% had K levels less than 7 ppm (Tables 9 and 10).

The results (Tables 5 to 10) also show that distributions which were different from the overall pattern for SC, Ca, Mg, Na, K and hardness were found in supplies from Cork and Dublin North. In general, mineral contents of samples from Dublin North were much higher than expected while the opposite was the case for Dublin South and

TABLE 7: Distribution of supplies in five Mg categories

County or water source	Mg categories (ppm)				
	0-2	3-7	8-13	14-19	20-999
All counties and water sources (%)	15.9	49.8	19.4	11.4	3.5
Cork ^a	1 ^a (3.5) ^b	18 (10.9)	2 (4.3)	0 (2.5)	1 (0.8)
Dublin North	0 (7.2)	13 (22.3)	14 (8.7)	14 (5.1)	4 (1.7)
Dublin South	5 (1.8)	6 (5.5)	0 (2.1)	0 (1.3)	0 (0.3)
Meath	0 (3.8)	16 (11.9)	5 (4.8)	2 (2.7)	1 (0.8)
Wicklow	6 (2.2)	5 (7.0)	2 (2.7)	0 (1.6)	1 (0.5)
Mains supply ^c	20 (9.4)	32 (28.9)	2 (11.2)	3 (6.5)	1 (2.0)
Private well supply	0 (11.5)	26 (35.3)	23 (13.7)	16 (7.9)	6 (2.6)
River supply	2 (4.8)	19 (14.4)	7 (5.6)	0 (3.2)	0 (1.0)

^a Frequency—actual numbers

^b Theoretical frequency

^c Distributions for individual counties and water sources which were different from the overall pattern

TABLE 8: Distribution of supplies in five hardness categories

County or water source	Hardness categories ^a				
	Soft	Moderately soft	Moderately hard	Hard to very hard	Extremely hard
All counties and water sources (%)	22.9	15.0	21.4	25.4	15.3
Cork ^d	7 ^b (5.0) ^c	8 (3.3)	4 (4.7)	2 (5.6)	1 (3.4)
Dublin North	2 (10.3)	2 (6.7)	9 (9.6)	15 (11.5)	17 (6.9)
Louth	5 (2.1)	0 (1.3)	3 (1.9)	1 (2.3)	0 (1.4)
Meath	1 (5.5)	3 (3.6)	4 (5.1)	13 (6.1)	3 (3.7)
Wicklow	9 (3.2)	2 (2.1)	1 (3.0)	2 (3.6)	0 (2.1)
Mains supply ^d	27 (13.2)	9 (8.8)	13 (12.4)	9 (15.0)	0 (8.6)
Private well supply	4 (16.2)	7 (10.8)	10 (15.1)	25 (18.4)	25 (10.5)
Rainwater supply	4 (1.4)	1 (0.9)	0 (1.3)	0 (1.6)	1 (0.8)
River supply	4 (6.6)	6 (4.4)	8 (6.2)	11 (7.5)	0 (4.3)

^a See procedure

^b Frequency—actual numbers

^c Theoretical frequency

^d Distributions for individual counties and water sources which were different from the overall pattern

TABLE 9: Distribution of supplies in five K categories

County or water source	K categories (ppm)				
	0-2	3-6	7-10	11-31	32-999
All counties and water sources (%)	57.9	24.9	4.1	9.1	4.0
Cork ^a	16 ^a (12.7) ^b	4 (5.5)	0 (0.8)	2 (2.0)	0 (1.0)
Dublin North	19 (26.0)	11 (11.2)	0 (1.8)	10 (4.0)	5 (2.0)
Dublin South	10 (6.3)	0 (2.7)	1 (0.4)	0 (1.0)	0 (0.6)
Louth	3 (5.2)	6 (2.2)	0 (0.4)	0 (0.8)	0 (0.4)
Wexford	2 (4.6)	5 (2.0)	1 (0.3)	0 (0.7)	0 (0.4)
Wicklow	12 (8.1)	1 (3.5)	1 (0.6)	0 (1.3)	0 (0.5)
Mains supply ^c	48 (33.6)	9 (14.4)	1 (2.4)	0 (5.3)	0 (2.3)
Private well supply	29 (41.1)	17 (17.7)	3 (2.9)	15 (6.5)	7 (2.8)
River supply	16 (16.8)	12 (7.2)	1 (1.2)	0 (2.6)	0 (1.2)

^a Frequency—actual numbers^b Theoretical frequency^c Distributions for individual counties and water sources which were different from the overall pattern

TABLE 10: Distribution of supplies in five Na categories

County or water source	Na categories (ppm)				
	0-7	8-15	16-25	26-70	71-999
All counties and water sources (%)	8.0	39.5	26.5	22.5	3.5
Cork ^a	1 ^a (1.8) ^b	10 (8.7)	9 (5.8)	2 (5.0)	0 (0.7)
Dublin North	0 (3.6)	6 (17.8)	7 (11.9)	27 (10.1)	5 (1.6)
Kildare	4 (0.8)	3 (4.0)	2 (2.7)	1 (2.2)	0 (0.3)
Laois	0 (0.6)	6 (2.8)	1 (1.9)	0 (1.5)	0 (0.2)
Mains supply ^c	7 (4.7)	35 (22.8)	13 (15.4)	3 (13.0)	0 (2.1)
Private well supply	2 (5.8)	11 (27.9)	21 (18.8)	31 (15.9)	6 (2.6)
River supply	1 (2.4)	17 (11.4)	9 (7.7)	2 (6.5)	0 (1.0)

^a Frequency—actual numbers^b Theoretical frequency^c Distributions for individual counties and water sources which were different from the overall pattern

Cork. Water supplies from Wicklow were similar to those from Dublin South and had low levels of Ca, Mg, K, hardness and also SC, while those from Meath generally had high levels of these parameters. The number of soft supplies in Louth was greater than expected and K values were unusually low. Samples from Laois had Ca levels above and Na levels below average.

Distributions which were different from the overall pattern for SC, Ca, Mg, Na, K and hardness were found in supplies obtained from 'mains supply' and private well supplies (Tables 5 to 10). In general, supplies from mains were low in mineral content while samples from private wells were high. Rainwater supplies had practically no mineral content, while samples from rivers were reasonably high in Ca and hardness and low in K.

Analyses for pH, Mn, P and O

Frequencies for pH, Mn, P and O on an 'all county' and 'all water source' basis are given in Table 11. Results for individual water sources and counties can be approximated by referring the percentages in Table 11 to Tables 1 and 2. About 80% of the pH values were between 7.4 and 8.1 (Table 11) and most samples contained only traces of P and Mn. Dissolved oxygen values varied considerably and 61% of samples were in the 7 to 10 ppm category, only 4% in the 11 to 14 ppm category, while 19.7% were in the 19 to 25 ppm category (Table 11).

TABLE 11: Distribution of supplies from all counties and water sources (%) in five categories for pH, Mn, P and O

	pH categories				
	5.0-7.3	7.4-7.7	7.8-8.1	8.2-8.5	8.6-12.0
All counties and water sources	8.1	39.5	40.0	10.8	1.6

	Mn categories (ppm)				
	0.000-0.025	0.026-0.050	0.051-0.100	0.101-0.500	0.501-0.999
All counties and water sources	82.0	11.0	2.0	4.5	0.5

	P categories (ppm)				
	0.000-0.007	0.008-0.010	0.011-0.020	0.021-0.060	0.061-0.999
All counties and water sources	90.0	4.0	1.5	3.0	1.5

	O categories (ppm)				
	0-6	7-10	11-14	15-18	19-25
All counties and water sources	5.1	61.0	4.0	10.2	19.7

Numbers of supplies in the 7.8 to 8.1 pH category for Cork (5, TF=8.8), Dublin North (26, TF=18.1) and Dublin South (0, TF=4.4) differed from theoretical frequencies. Numbers of supplies from mains (15, TF=23.2) and private wells (34, TF=28.0) in the 7.8 to 8.1 pH category were also different as were supplies from mains (11, TF=6.2) in the 8.2 to 8.5 pH category and from rivers (7, TF=11.4) in the 7.4 to 7.7 category.

Distributions for Mn in the 0.000 to 0.025 ppm and 0.026 to 0.050 categories for Cork (14, TF=18.0; 7, TF=2.4) and the 0.000 to 0.025 ppm category for Dublin North (29, TF=36.1) did not agree closely with theoretical frequencies. The number of supplies from private wells in the 0.000 to 0.025 ppm category was less than expected (53, TF=57.5) and in the 0.101 to 0.500 ppm category greater than expected. Twenty-seven supplies (TF=23.8) from rivers were in the 0.000 to 0.025 ppm category.

The number of supplies in the 0.000 to 0.007 ppm category for P in Dublin North was less than expected (36, TF=39.5) while the number of supplies from mains and private wells in this category was 57 (TF=52.3) and 57 (TF=62.2) respectively.

In Cork nine supplies were in the 19 to 25 ppm category for dissolved oxygen (TF=5.7) and in Dublin North 21 (TF=26.4) and 7 (TF=2.3) supplies were in the 7 to 10 ppm and 11 to 14 ppm categories respectively. Unexpected distributions for dissolved oxygen in supplies from mains were found in the 0 to 6 ppm (0, TF=3.3) and 19 to 25 ppm (19, TF=15.1) categories, while those obtained from wells were different from the overall pattern in the 11 to 14 ppm (0, TF=3.2) and 15 to 18 ppm (8, TF=3.2) categories.

Regression analysis

Table 12 shows the results for regressions of SC \times Ca, SC \times Mg, SC \times K and SC \times Ca \times K \times Mg. The relationship between SC and the Ca content of the water was high (Table 12, Fig. 1), while correlations between SC and Mg or K were smaller. Since hardness of water is caused largely by dissolved Ca salts a reasonable estimate of the hardness can be obtained from the SC reading. Parts per million Ca equivalent to the CaCO₃ figures for the different hardness categories (see procedure) were calculated and converted to SC readings using the regression line in Fig. 1 (Table 13).

TABLE 12: Correlation coefficients and coefficients of determination for regressions of SC on Ca, K and Mg

Regression	Coefficient of determination (R^2)	Correlation coefficient (r)
SC \times Ca	0.820	0.905
SC \times Mg	0.588	0.767
SC \times K	0.277	0.527
SC \times Ca \times Mg \times K	0.910	—

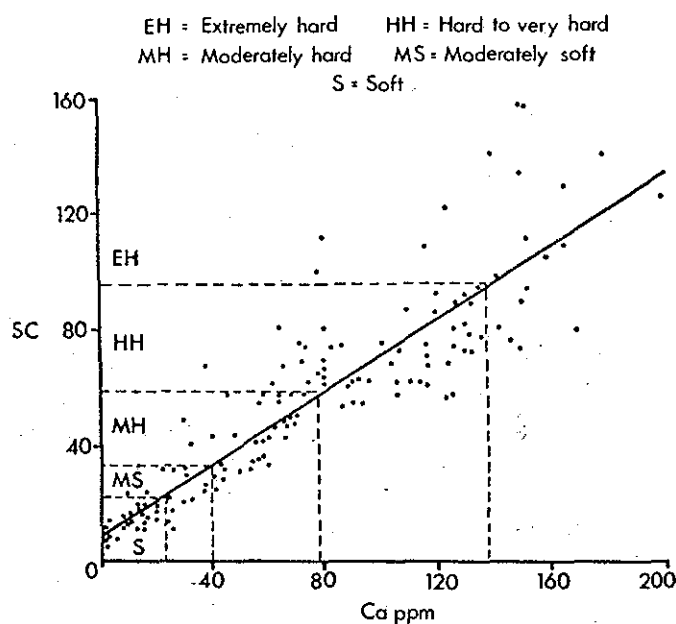


Fig. 1: Regression of SC on Ca

Results of chemical measurements on 197 samples were compared with those obtained by approximation from the SC readings. The SC method correctly predicted the hardness of 157 samples. It should be noted, however, that a range of ± 3 SC units was allowed when making the prediction, *i.e.*, if the chemical method gave a sample as moderately hard an SC reading between 31 and 62 (rather than 34 and 59) would be accepted and the SC method credited with a correct prediction. Of the 40 predictions which were incorrect, 38 were in the hardness category immediately below the one found by the chemical method, *e.g.*, soft (SC method) versus moderately soft (chemical method). The remaining two incorrect predictions were above the hardness categories found by the chemical method and this was caused by very high Na levels which gave abnormally high SC values.

DISCUSSION

It is important to note that about one-third of the growers in the survey used well water for feeding, heating and irrigating since over 50% of the well water samples tested were in the hard to extremely hard category. This stresses the need for treatment,

TABLE 13: Approximate SC levels for different hardness categories

Hardness category	CaCO ₃ (ppm)	Ca (ppm)	SC ^a
Soft	0-50	0-20	0-22
Moderately soft	50-100	20-40	22-34
Moderately hard	100-200	40-80	34-59
Hard to very hard	200-350	80-140	59-96
Extremely hard	> 350	> 140	> 96

^a Calculated from Fig. 1

especially for boiler use. Some form of water treatment is almost always desirable with a boiler, but its importance is greatly increased where steam is taken from the boiler because new water is being continually added to the system when steam is taken off.

The composition figures in Tables 5 to 11 show that supplies from Counties Dublin (North and South), Cork, Meath, Wicklow and, to a lesser extent, Laois and Wexford were unusual in that numbers of supplies in various compositional categories were either higher or lower than expected. This can be partly explained by the ratio of supplies from a 'well' source to supplies from other sources. When this ratio is large for a county most of the supplies fall into the higher compositional categories; with a low ratio most supplies will be in the lower categories. 'Well to other source' ratios of 0.58 and 0.41 were obtained for Dublin North and Meath while figures of 0.16, 0.22 and 0.09 were obtained for Wicklow, Louth and Dublin South. Thus, supplies from Dublin North and Meath contained more dissolved salts than expected while those from Wicklow, Louth and Dublin South contained less. The vast difference in supplies in Dublin North and Dublin South is noteworthy. Supplies from the north of the county were nearly all from wells and were hard while those from the south mostly came from reservoirs fed by streams in the Dublin mountains and were very soft.

The contrast between supplies obtained from wells and those obtained from mains is noteworthy. Samples from wells had much higher levels of salts than supplies from mains. This suggests that most of the mains water must be 'run-off' and not water from underground streams, otherwise a much higher number of supplies from mains would have high SC values. Alternatively, some of the salts in the mains water may have been removed by treatment. Supplies from 'caught rainwater' had very low levels of salts and are therefore most suitable for use on their own or for 'diluting' supplies containing large amounts of salts.

Frequencies for use of boilers were highest in areas where new glass had been erected, *i.e.*, Louth, Meath and Donegal, and lowest in areas which have had a lot of glass for a number of years, *i.e.*, North Dublin. No explanation can be given for the

above-normal incidence of algae in supplies in Kildare and Offaly and the below-normal incidence in North Dublin, since algae occurred in water supplies with widely different composition and from different sources.

The traditional hose feeding method is still widely used, but the sprayline system gives a more even spray, reduces labour and is becoming quite popular. Fifty percent of growers with algae in their supply used a trickle or sprayline feeding system. This could cause clogging of nozzles and capillaries. No definite information is yet available on the effects of feeding and irrigating tomatoes with water supplies naturally high in salts or of possible interactions between feeding system and water supply used. However, an experiment is in progress on this topic and results will be available shortly.

The regression line for SC and Ca content can predict Ca levels of less than 100 ppm from SC readings reasonably well. For values above 100 ppm the points were more scattered (Fig. 1) and prediction was not as good. Level of hardness can be predicted much more accurately because each hardness category involves a spread of at least 20 ppm Ca. Predicting the hardness from the SC reading is a useful practice since it is rapid and involves no calculations other than reading the results from a graph.

CONCLUSIONS

1. Over 40% of the samples tested were hard to extremely hard which stresses the need for water treatment.
2. There is a lack of awareness about the necessity for water treatment, especially for boiler use.
3. Water from wells was in general much harder than that from other sources and so should be avoided if an alternative source is available.
4. Rainwater supplies caught from glasshouse roofs were very soft and could be used very effectively to dilute hard water.
5. Measurement of SC gave a fairly good prediction of hardness of water samples.

ACKNOWLEDGMENTS

We acknowledge Mr. P. Walshe and Mr. L. O'Sullivan of the Horticultural Chemistry Department at Kinsealy for help in organising the survey, Mr. E. Byrne and Mr. T. Power, Johnstown Castle, for carrying out the analyses, and Mr. D. Conniffe and Mr. T. Hegarty for help in preparing the statistical data. We also thank the Glasshouse Crops and Mushroom Department, Kinsealy, for their advice and cooperation.

REFERENCES

1. Byrne, E.—editor, 'Methods of analysis Handbook,' An Foras Talúntais, Johnstown Castle, 110 p., 1968.
2. Steel, R. G. D. and Torrie, J. H., 'Principles and procedures of statistics,' McGraw Hill, New York, 481 p., 1960.

Received June 24, 1970

APPENDIX

Survey of water supplies used by horticultural growers in their glasshouses and boilers

Grower's name and address.....

Date.....

1. Source of water supply for use in your glasshouse or boiler:

mains from local reservoir	private well	public well	catch rainwater	river	lake
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. Do you store water from any of the above sources in your own reservoir: Yes No

3. Are algae or slimes present in the supply: Yes No

4. What type of liquid feeding system do you use:

Hose	Trickle	Sprayline
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. Do you use a boiler for glasshouse heating: Yes No

6. Is steam drawn from the boiler:

a) for heating	(a) <input type="checkbox"/> Yes	<input type="checkbox"/> No
b) for sterilising	(b) <input type="checkbox"/> Yes	<input type="checkbox"/> No

7. Is the water for the boiler treated: Yes No

8. Description of treatment.....

.....

.....