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Authors(s)	Gormley, T. R. (Thomas Ronan)
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THE INFLUENCE OF PEAT SOIL ON CROP QUALITY

By T. R. Gormley
(Kinsealy Research Centre, Dublin 5)

34

Introduction

Peat has a good potential for crop growth because of its many excellent physical properties, *e.g.*, uniformity and water holding capacity. Much has been said about the high yields that may be obtained in peat, however, little information is available on quality, especially in comparison with crops grown in mineral soil.

In Ireland peat is being used for the production of vegetables, fruit and flowers both outdoors and under glass and plastic. Experiments on carrot quality from peat and mineral soil began in 1969, and tests on tomatoes and strawberries were carried out in 1971. It is essential that quality should be studied because the time is fast approaching when the quality food product will be fully recognised and will command a premium price. In addition to the fresh market, processors also want top quality because they recognise that a high quality processed product requires top grade raw produce.

Soil type and Carrot quality

Carrots are an important crop in Ireland (more than 3,000 acres in 1971) and over a quarter of the total production is processed. Gormley *et al* (1971) tested samples of cultivars Nantes 1003, Amsterdam 558 and Sweetheart in 1969 and Nantes 1003, Touchon and Sweetheart in 1970. Roots of each cultivar were grown in peat and mineral soil. There were three harvest dates in 1969 and two in 1970. Two weeks separated each harvest date and there were three field replicates. The number of days from sowing to harvesting was the same for each cultivar. Roots (10 per sample) were tested for dry matter content (DM), reducing sugar content—Shaffer Somogyi method (Laboratory Method Sheet, 1967), carotene content—by extraction (Gormley, 1971) and texture—using a shear press (Kramer, 1951, Gormley, 1971).

The results (Table I) show that peat grown carrots had significantly lower levels for DM, carotene, reducing sugar and shear than those grown in mineral soil. All levels, except reducing sugar, increased with successive harvests for roots grown in mineral soil; reducing sugar fell progressively. For peat grown samples only carotene increased with successive harvests while reducing sugar, DM and shear values increased between the first and second harvests, but fell again between the second and third (Table I).

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TABLE I

COMPOSITION AND TEXTURE OF CARROTS GROWN IN PEAT AND MINERAL SOIL (1969) (MEANS OF THREE CULTIVARS AND THREE FIELD REPLICATES AT THREE HARVEST DATES)

	HARVEST 1			HARVEST 2			HARVEST 3		
	Peat	*'t test'*	*Mineral*	*Peat*	*'t test'*	*Mineral*	*Peat*	*'t test'*	*Mineral*
DM (%)	9.70	***	13.76	10.36	***	14.80	9.66	***	15.18
Carotene (mg/100g fresh wt.)	6.82	***	15.46	8.42	***	18.89	10.44	***	20.89
Reducing Sugar (%)	2.67	***	3.63	2.70	***	3.18	2.04	***	2.59
Shear (lb.)	1226	***	1367	1274	***	1388	1262	***	1408

Footnotes: 1. ***, Significant ($p \leqslant 0.001$)

In 1970 peat grown roots had lower levels of DM, carotene and shear than those from mineral soil, but reducing sugar contents were higher (Table II). In contrast to results obtained in 1969, DM levels remained static in peat grown roots, and fell in mineral grown roots in the second harvest; shear values also decreased between the first and second harvests.

TABLE II

COMPOSITION AND TEXTURE OF CARROTS GROWN IN PEAT AND MINERAL SOIL (1970) (MEANS OF THREE CULTIVARS AND THREE FIELD REPLICATES AT TWO HARVEST DATES)

	HARVEST 1			HARVEST 2		
	Peat	*'t test'*	*Mineral*	*Peat*	*'t test'*	*Mineral*
DM (%)	10.30	***	15.30	10.32	*	13.81
Carotene (mg/100g fresh wt.)	7.31	***	16.20	8.90	**	16.80
Reducing Sugar (%)	3.19	NS	2.97	3.05	*	2.62
Shear (lb.)	1333	***	1448	1267	**	1333

Footnotes
1. * , Significant ($p \leqslant 0.05$)
** , Significant ($p \leqslant 0.01$)
*** , Significant ($p \leqslant 0.001$)
NS , Not significant

Data in Tables I and II are means for three cultivars. Figures for each individual cultivar were similar to the means in the tables except for Nantes which had a much lower carotene content in both soil types in 1969 and only carotene increased with successive harvests.

Since DM and reducing sugar contents of carrots from peat soil were lower than those from mineral soil in 1969, taste panels tests were carried out (Gormley, *et al*, 1971) to see if the panel could detect the carrots grown in peat. The results (Table III) indicate that it did and the peat grown roots received the lowest scores. The score of + 0.50 (ideally 0) given to the coded sample of standard was rather high and was due to two members of the panel giving the sample a high rating. Unfortunately, taste panel tests were not carried out on roots from the 1970 experiments. In this season peat grown roots had higher reducing sugar contents but lower DM values and it would have been interesting to know if the panel would not prefer the peat grown roots (highest sugar) rather than mineral grown ones (highest DM content).

TABLE III

RELATIONSHIP BETWEEN PANEL SCORE FOR FLAVOUR ON COOKED[1] CARROTS AND THE SUGAR CONTENT OF THE RAW SAMPLES

Sample		*Panel score for flavour*[2]	*Reducing sugar (%) in raw carrots*
Sweetheart	P[3]	−1.08	2.16
Sweetheart	M	0.00	2.60
Nantes	P	−0.83	2.21
Nantes	M	+0.50	2.45
Amsterdam	M, coded standard	+0.50	3.14

F-test (Panels), NS df = 1, SE = 0.16 Rank correlation coff. = 0.83
F-test (Samples), *** df = 1, SE = 0.25

FOOTNOTES
1. Carrots frozen before cooking.
2. Mean score for 12 estimations; 2 panels × 6 tasters, scoring system; + 1, + 2 = better in flavour than standard; − 1, − 2, = poorer in flavour than standard; zero equal to standard in flavour.
3. P = peat, M = mineral.

These data, however, indicate that carrot composition seems to be inferior on peat soil. The differences found in this experiment may be due to rate of growth in the two soil types. The roots grown in peat were larger and probably had a better supply of water because of the greater water holding capacity of the peat soil.

The lower DM and carotene levels in peat grown carrots could have implications for processing. For example, lower DM content would affect the amount of product obtained after dehydration and lower carotene levels would be important in relation to canning, freezing and drying since carotene gradually breaks down with time. The product, therefore, might have a poor colour which could deteriorate further during storage. On the other hand yield is generally higher on peat and the absence of stones and clods facilitates mechanical harvesting. Also the potential scale of operation could be much larger on peatland. Therefore in economic terms carrots grown in peat could be a better proposition than mineral grown roots despite the lower compositional values. However, further research into new cultivars for growing in peat is necessary in order to obtain compositional values approaching those of mineral grown roots. Tests must also be done on the relationship between yield and quality.

Soil type and Tomato Fruit quality

Spring crop tomatoes (cultivar 'Extase') were grown in three soil types (peat, mineral, 1 : 1 peat/mineral) at five levels of base fertiliser from 0·5 to 2·5 times the standard Kinsealy rate (Woods and Kenny, 1968). Levels of N, P, and K in the base were varied while the trace elements were the same throughout. The plants were grown in trays (61 × 61 cm, two plants in each) and there were four replicates. The plants were fed and watered by the hose system. All treatments received the same amount of water and feed. Soil specific conductivity (SC = $\frac{u \text{ mhos}}{10}$) readings were taken each week (16 weeks) and plant height was measured for the first 10 weeks. Fruit was graded into marketable, remnants and that with blossom-end rot (BER). Analyses for titratable acidity, % soluble solids (% SS), K content in juice (K juice) and specific conductivity of the diluted juice (SC dil. juice) were carried out on fruit from each treatment. Samples were also evaluated for flavour by a taste panel. The effects of different levels of base fertiliser will be discussed in another paper and will not be mentioned here except where an interaction occurred with soil type.

TABLE IV

CHEMICAL COMPOSITION OF TOMATOES GROWN IN DIFFERENT SOIL TYPES (FIGURES AVERAGED OVER FIVE LEVELS OF BASE FERTILISER)

	Peat	*Mineral*	1 : 1 *peat/mineral*	*F-test*	*SE*
% Soluble solids	6.1	6.7	6.5	*	0.14 (df = 40)
Titratable acidity[1]	0.84	0.94	0.94	***	0.02 (df = 40)
SC[2] diluted juice	92	94	97	*	1.33 (df = 40)
K (ppm) juice	3318	3678	3732	***	71 (df = 40)

FOOTNOTES
1. Expressed as milliequivalents acid per 10 ml expressed juice.
2. Conductivity of tomato fruit juice, dilute 1 part juice with 9 parts water.

The results (Table IV) show that growing in a 1 : 1 peat/mineral mix gave the highest levels of acidity, conductivity and K in the fruit while peat gave the lowest levels. These results suggest that fruit from peat/mineral soil should have the best flavour since they have the highest K content. A taste panel test was carried out on samples from the three soil types grown at standard and twice standard base fertiliser levels. The 10 member panel was asked to rate flavour of the samples from first to sixth. A ranking-range method (Kramer and Twigg, 1966) was used for statistical analyses of the results.

Fruit from plants grown in peat/mineral soil at double the standard base fertiliser level received the highest panel rating ($p \leqslant 0{\cdot}01$) and had the highest K content (Table V). In contrast with this, fruit from the same soil type at the standard level of base fertiliser got the lowest rating even though its K content was only fourth lowest. Fruit grown in mineral soil was rated higher for flavour than that from peat. However, it should be pointed out that the flavour of fruit from peat was still very acceptable. The panel results are in reasonable agreement with the results in Table IV except for the sample grown in peat/mineral soil at the standard base fertiliser level (Table V). These data suggest that, under the conditions of this experiment, a pure peat substrate may not give the best flavour; however, in a mixture with mineral soil the composition and flavour is improved.

A number of theories can be put forward for these compositional differences. Plants grown in peat were significantly taller after five and nine weeks indicating more vigorous growth (Table VI). Total yield was also greater for this treatment (Table VII). This suggests, therefore, that high yielding treatments may adversely affect fruit composition to some extent. This situation could arise when growth is vigorous and yield heavy. When peat and mineral soil are combined the advantages of both seem to be enhanced and a situation is attained where a good yield of high quality fruit is obtained. Peat soil also gave more remnant fruit and a high incidence of BER.

TABLE V

TASTE PANEL FLAVOUR EVALUATION OF TOMATO FRUIT FROM THREE SOIL TYPES GROWN AT NORMAL AND TWICE NORMAL BASE FERTILISER LEVELS

Sample	*Panel Score*	*Panel Preference*	*K (ppm)*
P1	41	4	3850 (6)
M1	28	2	4250 (2.5)
PM1	46	6	4150 (4)
P2	42	5	3950 (5)
M2	35	3	4250 (2.5)
PM2	18	1	4450 (1)

FOOTNOTES
1. P, M, PM denote soil types, and 1 and 2 fertiliser levels.
2. Range for significance at $p \leqslant 0.05$ = 22—48.
   Range for significance at $p \leqslant 0.01$ = 20—50.
3. Correlation co-efficient (rank method) between panel preference and K content = 0.75.

TABLE VI

HEIGHT OF TOMATO PLANTS (CM) GROWN IN THREE SOIL TYPES. (MEASURED AT TIME OF PLANTING AND AFTER FIVE AND NINE WEEKS)

Time	*Peat*	*Mineral*	*Peat/Mineral*	*F-test*	*SE*
At planting	40	41	40	NS	0.57 (df = 42)
At 5 weeks	89	82	87	***	0.99 (df = 42)
At 9 weeks	138	115	131	***	2.23 (df = 42)

TABLE VII

YIELD DATA (KG/TWO PLANTS) FOR TOMATOES GROWN IN THREE SOIL TYPES

Yield	*Peat*	*Mineral*	*Peat/Mineral*	*F-test*	*SE*
Marketable	3.50	2.84	3.57	**	0.16 (df = 42)
Remnants[1]	1.14	0.44	0.53	***	0.07 (df = 42)
BER	0.72	0.04	0.10	***	0.04 (df = 42)
Total	5.36	3.32	4.20	***	0.19 (df = 42)

FOOTNOTE
1. Remnants include all non-marketable fruit other than those with blossom-end rot (BER).

An interaction ($p \leqslant 0.05$) was obtained between soil type and base fertiliser level in the case of fruit with BER. The 1·5 standard base gave the highest incidence of BER for peat and mineral soils, but the second lowest for peat/mineral. However, incidence of BER was high at each base level in peat and this suggests that it may be an effect of the peat rather than the base fertiliser or an effect of bad irrigation practice. Blossom-end rot is often attributed to an irregular water supply but, under low moisture conditions peat should be a better reservoir than mineral soil. However, it is possible that trays containing mineral soil may have been watered more than the trays with peat, especially since the watering was carried out by the hose system. When trays with peat and mineral soil are side by side an operator could tend to concentrate to a greater extent on the trays with mineral soil since they look drier. It is possible that plants grown in peat, therefore, might have been subjected to a water stress on some occasions which could have contributed to the high incidence of BER. This, however, seems unlikely. This experiment will be repeated using a trickle system so that each tray will get the same amount of water and it will be interesting to note if the incidence of BER in pure peat will decrease. It is unlikely, however, that fruit composition will change since more recent experiments at Kinsealy have shown higher K levels in fruit from mineral soil than from peat (Prasad, 1971).

TABLE VIII

SOIL SPECIFIC CONDUCTIVITY (SC) LEVELS IN THREE SOIL TYPES AT TIME OF PLANTING AND AFTER FIVE, TEN AND FIFTEEN WEEKS

Time	*Peat*	*Mineral*	*Peat/Mineral*	*F-test*	*SE*
At planting	120	142	123	**	5.3 (df = 42)
At 5 weeks	102	157	150	***	8.4 (df = 42)
At 10 weeks	142	140	133	NS	8.1 (df = 42)
At 15 weeks	119	93	119	NS	10.8 (df = 42)

Soil SC levels at various stages in the experiment are presented in Table VIII and it is evident that peat had the lowest salt content early in the experiment but the highest or joint highest at the end. However, values are such that they do not explain the high incidence of BER in peat soil. This lends further weight to the theory that plants in peat were not watered sufficiently.

Soil type and Strawberry quality

Fruit quality of cultivars of 'Cambridge Vigour', 'Templar' and 'Elista' from peat and mineral soil was compared in 1971. This was a preliminary experiment and definite conclusions cannot be drawn until it is repeated for at least two more seasons.

Fruit (three replicates) was tested for pH, titratable acid content, per cent soluble solids content, texture and colour of skin, flesh and puree. Colour was measured by reflectance with the Hunter Colour Difference Meter. Samples were frozen in liquid Freon and the amount of drip on thawing was measured. The thawed berries were evaluated by a taste panel.

TABLE IX

CHEMICAL COMPOSITION OF STRAWBERRIES GROWN IN PEAT AND MINERAL SOIL (MEANS FOR THREE CULTIVARS)

	Peat	*Mineral*	*F-test*	*SE*
pH[1]	3.5	3.2	***	0.03 (df = 10)
Titratable acidity[2]	1.42	1.49	NS	0.034 (df = 10)
% Soluble Solids	8.5	8.4	NS	0.10 (df = 10)

FOOTNOTES
1. Measured on puree.
2. Titratable acidity as milliequivalents acid per 10 g puree.

Peat soil gave fruit with a significantly higher pH, but did not affect titratable acid or soluble solids content (Table IX). Studies on the effect of pH on colour stability in strawberries (Sistrunk, 1970) indicated that lower pH values (circa 3·0) seemed to give best colour stability as measured by optical density and Hunter Colour Difference Meter.

'Elista' had a lower acid content (p W 0·001) than the other two cultivars while 'Templar' had a higher per cent soluble solids content ($p \leqslant 0{\cdot}001$). The colour of the three cultivars was significantly different as would be expected. 'Elista' gave lower L values for flesh, skin and puree indicating it was darker and also higher 'a' values showing that it was redder.

Significant interactions were obtained between cultivar and soil type for acidity ($p \leqslant 0{\cdot}05$) and per cent soluble solids ($p \leqslant 0{\cdot}001$). The first interaction was due to the fact that 'Elista' had a much lower acid content in peat soil than in mineral soil. 'Templar' had an equal acid content in both soil types while 'Cambridge Vigour' had a higher acid content in peat. The interaction in the case of soluble solids was caused by a similar effect.

Hunter L, 'a' and 'b' values on puree of fruit grown in the two soil types were not significantly different showing that soil type did not affect puree colour. Hunter 'a' values were different ($p \leqslant 0{\cdot}01$) for skin colour, in this case peat soil ($a = +34{\cdot}4$) gave fruit with redder skin than mineral soil ($a = +31{\cdot}5$). Colour readings on the flesh gave different ($p \leqslant 0{\cdot}05$) Hunter 'b' values showing that peat grown samples ($b = +18{\cdot}7$) were less yellow than mineral grown ones ($b = +19{\cdot}2$). Even though some of these values were significantly different, in practical terms colour differences were small.

TEXTURE, DRIP LOSS AND FLAVOUR EVALUATION

Peat grown fruit was softer ($p \leqslant 0{\cdot}001$) (42 lb. force) than that from mineral soil (49 lb. force) as indicated by shear press reading. Of the three cultivars, 'Templar' was softest ($p \leqslant 0{\cdot}01$). A significant interaction for texture ($p \leqslant 0{\cdot}001$) was obtained between soil type and cultivar. This was due to the fact that 'Cambridge Vigour' and 'Elista' were firmer on mineral soil while 'Templar' was firmer on peat.

Freon frozen samples were placed in funnels and were allowed to thaw for four hours. The drip was collected in beakers and was weighed. Mineral grown fruit (14·4 per cent) gave less drip ($p \leqslant 0{\cdot}001$: SE = 0·73) than that from peat (34·0 per cent) indicating that cell damage during freezing was much less in the former. Differences in drip were so large that it is possible that pectin content and cell structure may be different in fruit from the two soil types. Further studies will be required on this topic in future seasons.

In the case of the individual cultivars, 'Elista' gave less ($p \leqslant 0{\cdot}001$) drip (16·9 per cent) than 'Templar' (26·8 per cent) or 'Cambridge Vigour' (28·9 per cent). These differences are important since it is likely that the amount of strawberries frozen in Ireland will increase and it will be essential to have cultivars with good freezing characteristics.

Thawed fruit from the drip experiment was evaluated for flavour by a 10-member taste panel. The panel was asked to rate flavour of samples from 1st to 6th. The results (Table X) show that fruit from mineral soil was rated highest except for the cultivar 'Elista' which was downgraded on both soil types. The low flavour score for 'Elista' is unfortunate since this cultivar gave least drip. It should be emphasised that the panel was carried out on frozen fruit and the poor texture of the samples from peat may have contributed to the low flavour rating even though the panel was asked not to allow texture to influence its decision.

TABLE X

TASTE PANEL FLAVOUR EVALUATION OF THREE STRAWBERRY CULTIVARS GROWN IN PEAT AND MINERAL SOIL

Sample		*Panel Score*	*Panel Preference*
Templar	(P)	40	4.5
Elista	(P)	44	6
C. Vigour	(P)	37	3
Templar	(M)	25	2
Elista	(M)	40	4.5
C. Vigour	(M)	24	1

FOOTNOTES
1. P = peat, M = mineral.
2. Range for significance at $p \leqslant 0.05$ = 22—48.
   Range for significance at $p \leqslant 0.01$ = 20—50.

Conclusions

The main conclusion of these experiments is that, in general compositional values for carrots, tomatoes and strawberries were lower in peat than in mineral soil. The lower values for tomatoes grown in peat were accompanied by a higher yield; it was not possible to establish if this was also the case for carrots and strawberries since the plots were not yielded. It is likely that a balance exists between rate of growth, yield and composition and further studies should be carried out on this topic. Nutrition of crops in peat must also be more carefully assessed.

It is likely that cultivars will differ widely in their response to different soil types, so the testing of existing and new cultivars for their suitability for growing in peat must be continued and intensified.

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References

GORMLEY, T. R., O'RIORDAIN, F. and PRENDIVILLE, M. (1971). *J. Food Technol.*, **6**, (4), 393.

KRAMER, A. (1951). *Food Technol.*, **5**, 265-269.

KRAMER, A. and TWIGG, B. A. (1966). Fundamentals of Quality Control for the Food Industry, 2nd Ed., 252. Avi., Westport Conn.

Laboratory Method Sheet, No. 19 (1967). Dept. of Horticulture, The University of Maryland, U.S.A.

PRASAD, M. (1971). Personal Communication.

SISTRUNK, W. A. and CASH, J. N. (1970). *Food Technol.*, **24**, 169.

WOODS, M. J. and KENNY, T. (1968). Proc. VIth Colloq. International Potash Institute, Italy, 342.