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Key Words

model edge effects spacing carrots competition variation marketable yield size grade root diameter

FINAL REPORT

Row Spacing model to improve uniformity of carrot crops

Project Number

FV 124

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Location of Project: HRI Wellesbourne & East Malling

Relevance to growers and practical application

Application

A model that predicts the seeding rates in each row that eliminate edge effects and maximizes yield in specified diameter grades has been encoded in software called SPACING. SPACING runs a personal computer (PC) and, through a series of menus, allows the user to enter relevant information about his intended production system. The seeding rates in outer and inner rows and the likely financial returns are calculated.

Summary

Edge effects are well known in carrots crops grown on a bed system, and contribute to undesirable root-to-root size variation. Such edge effects can be eliminated by increasing the within-row seeding rate on the outer rows with respect to that in the inner rows. The extent of this differential in seeding rate depends on the row spacing system, duration of growth, overall plant density and target diameter grade. A competition model developed at HRI, Wellesbourne can calculate the weight of roots, taking all these factors into account.

This model was developed as a research tool and was encoded in a computer language not available for Grower's or Advisor's PCs. Software was also developed as a 'game' to illustrate the potential of the model to members of the public. This software converted weights to diameters, allowing the yield of a crop in diameter grades to be calculated. Also, the realistic feature was added that the diameters within each row were variable. However, this 'game' was extremely restricted in durations of growth and row spacing systems it would allow. It also could not be run easily on a PC because it had been written in an inappropriate language.

The objective of this project was to develop software so that the model would be readily available to growers or to advisors, in a form that would be easy to use and interpret. Therefore, the software should run on a PC, with the necessary information being supplied using clear menus. To allow the model to run on a PC, the coding was converted to another language. This entailed much effort investigating numerical procedures, readily available on the HRI computer, but not so available for software intended for applications for inexperienced users. The program was written so that all the information required, such as row spacing system, duration of growth, seed and harvest costs, could be easily entered via menus on the PC's screen. In addition, the results are presented in a clear table, listing all the relevant information the grower requires. This final report can also be printed. The software has been written in a modular form, so that it can be easily upgraded in response to new research findings. In addition, this modular structure allows foreign language versions of the software to be easily produced. This new PC-based software is called SPACING.

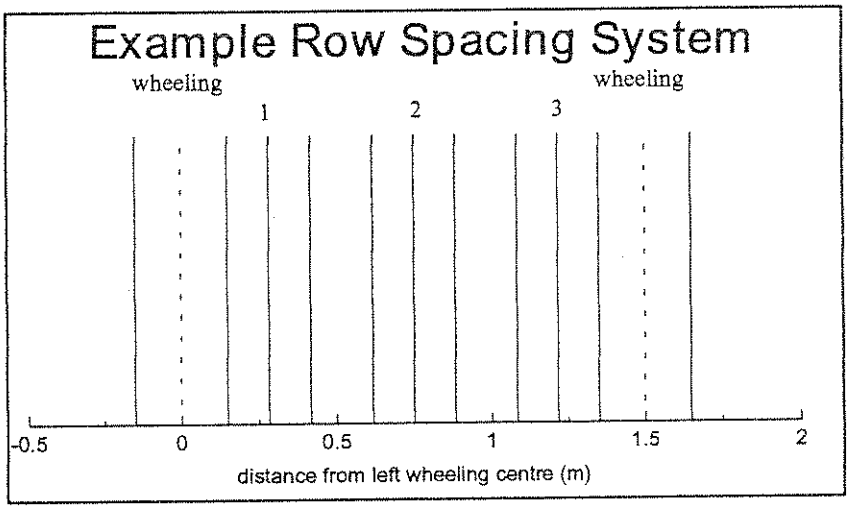
SPACING would be provided to users on a floppy disc, and be accompanied by documentation. This documentation would provide assistance to allow SPACING to be loaded onto the grower's PC, and to provide a succinct explanation of SPACING's features and capabilities. SPACING is written so that it can be run almost immediately without any former learning. For example, the bottom line of the screen briefly explains what is required for the current box highlighted in the menu. Pressing the F1 key will give a display of a fuller explanation of what is required in each part of SPACING's operation. There is also a HELP menu, which provides an introduction, guide and contact names and describes the

features and assumptions of SPACING.

SPACING allows the user to evaluate different row spacing systems, by comparing the expected yields and financial returns for different diameter grades of carrots and durations of growth. For each row spacing system, the seeding rate in inner and outer rows is stipulated to give maximum yield in a target diameter grade. These forecasts are the result of extensive evaluation of the model, whose parameters are based on the results of eleven sets of data from two carrot spacing experiments conducted at Wellesbourne. Furthermore, the model gave a good prediction of the carrot weights in ten other sets of data from four experiments. Five of these sets of data were from two experiments in the USA and one of the sets of data was from an experiment in Poland. The relationships between diameter and weight are based on the results of two experiments conducted at Wellesbourne.

Evaluating different row spacing systems will allow growers to target their within-row spacings more precisely to ensure maximum yield of roots in marketable size grades.

Here is an example row spacing system. The bed is 1.5 m wide (wheeling centre-to-wheeling centre). Within the bed there are three groups of rows. The distance between the groups across a wheeling is 0.3 m, (outer row to outer row). The distance between groups within a bed is 0.2 m. This leaves 0.133 m between rows within each group. Below is the spacing report produced by SPACING for this row system. The crop is to be sown on 1st April and harvested on 15 July and the greatest yield is to be in the 35-40 mm grade. The value of this grade is £0.15/kg, most other grades attract only £0.10/kg.



The report listed below is displayed on the terminal screen when SPACING has competed its calculations. A printed version is available by the menu system, and a file in ASCII format is produced on disc containing the report of the latest run of SPACING. This is useful if one should need to produce a report for recommended seeding rates.

HORTICULTURE RESEARCH INTERNATIONAL

Plant Spacing Report
Spacing Model - Prediction for Carrots

Spatial Aspects

Specified

Sowing Date : April 1, 1994
Harvest Date : July 15, 1994
Bed Width : 1.50
Across wheeling row spacing : 0.30 m
Between group row spacing : 0.20 m
Within group row spacing : 0.13 m
Number of groups in a bed : 3
Number of rows in a group : 3
Diameter Chosen : 35 - 40 mm

Spacing Predicts

Mean Diameter : 28.8 mm
Seeds/Metre of row :
Rows adjacent to wheeling : 46.2
Rows on edge of groups : 35.6
Rows inside a group : 26.5

Financial Details

Specified

% Germination : 90.00%
Field Factor : 0.90
Seed Costs (£/1000000) : £200.00
Fixed area costs : £100.00
Expected yield loss : 10.00%

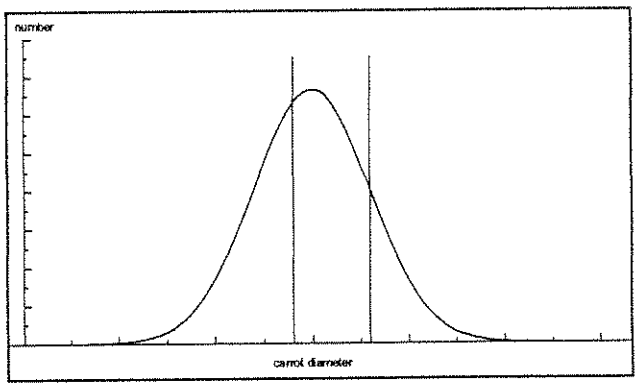
Spacing Predicts

Total seed costs (£/ha) : £419.06

Diameter (mm)	Yield (kg/ha)	Yield (% of total)	Value (£/kg)	Total Value (£)
15 - 20	281	1.97	0.50	140.65
20 - 25	1055	7.40	0.10	105.50
25 - 30	2471	17.34	0.10	247.10
30 - 35	3787	26.58	0.10	378.73
35 - 40	3904	27.39	0.15	585.58
40 - 45	2753	19.32	0.02	55.06

Total nett income for field (£) : 993.56

Note that the mean diameter for the entire crop is below the target diameter. This arises because larger roots make a greater contribution to yield than those having a small diameter. Hence, to obtain the maximum *yield* between the diameter limits shown on this graph, the mean diameter needs to be towards or below the lower diameter limit. The target diameter grade contained only 27% of the yield. This is a consequence of the assumption that there is variability in diameters within each row. The extent of the variability observed within crops implies that much of the yield would be outside the most strict commercial target diameter grades.



To achieve the maximum yield in the target diameter range, the seeding rate in the inner rows in each group should be 26.5 per metre, for the outer rows of the groups, but not next to the wheelings, the seeding rate is 35.6 per metre, and for rows next to the wheeling it should be 46.2 seeds per metre.

The effect of different sowing and harvest dates, price structures and costs can be evaluated by re-running SPACING with these attributes altered. Every item of listed on the above report can be altered in SPACING's menus and SPACING takes only a few seconds to run, depending on the capacity of the PC.

Model development section

Introduction

Edge effects are well known in carrots crops grown on a bed system, and contribute to undesirable root-to-root size variation. Such edge effects can be eliminated by increasing the within-row seeding rate on the outer rows with respect to that in the inner rows. The extent of this differential in seeding rate depends on the row spacing system, duration of growth, overall plant density and target diameter grade.

Sutherland and Benjamin (1987) developed a competition model that can calculate the weight of roots taking the above factors into account. Competition between individual plants is simulated by assuming that each plant draws resources from a circular zone, and that the efficiency of resource capture decreases with distance from the plant. Spacing effects are taken into account by further assuming that the area from which a plant draws resources, is restricted to a rectangle. The size of this rectangle is determined by the location of the immediate neighbours within the row and the midpoint between rows. The amount of resources available to plants and their efficiency of capture depends on time. In this way, the effects of different durations of crop growth are taken into account. Note that the effects of specific environmental factors (for example, light, temperature water, mineral status etc.) have not been taken into account. The parameters of the model were estimated by fitting to a wide range of experimental treatments found in published papers. The second model uses a linear relationship between logarithm of root weight and logarithm of diameter (Benjamin and Sutherland, 1989).

The competition model was developed as a research tool and encoded in FORTRAN to run on the HRI VAX computer. Software was also developed to show the potential of the model to members of the public at an HRI, Wellesbourne Open Day. This software converted the weights of carrots to diameters (Benjamin and Sutherland, 1989), allowing the yield of a crop in diameter grades to be calculated. In addition, variability in individual root diameter within each row was assumed to occur. This component is important if realistic implications are to be drawn from the competition model's predictions of mean weight.

This software still had several weaknesses. For example, the permitted row-spacing systems and durations of growth were highly restricted. Also, the software had been written in FORTRAN, calling some VAX-bound routines, so that the model was not generally available to growers or to their advisors.

The objective of this project was to develop software so that the model would be readily available to growers or their advisors, in a form that would be easy to use and interpret. Therefore, the software needed to run rapidly on a PC, with the necessary information being supplied using clear menus. The user must be allowed to set many variables of interest to him. For example, production costs, target diameter grades, row spacing system. Finally, the predictions made by the software must be clearly presented to the user. The software was called SPACING, and below I list how it was developed, some of its features, and an example of its application.

Development of SPACING

The coding for the demonstration program for an HRI Open Day was converted from FORTRAN to TURBO PASCAL. This allowed the program to be run on a PC rather than on a VAX. The program called many routines from the Numerical Algorithms Group (NAG) library, which resides on the VAX computer. One such routine did the integration of resource

capture within the rectangle occupied by an individual plant. Another routine did a 'minimization', which calculated the spacing that gave the maximum yield of roots in a specific grade for a given row. The NAG routines were available only on the VAX, and had to be written afresh by referring to numerical recipes (Press *et al.*, 1990).

L and c are parameters of the competition model. L is the amount of resources per area, and increases with time. c is a measure of efficiency of resource capture, and decreases with time. In the demonstration program, the relationship between L and the duration of growth, t, was give by

$$L=-3273+108.4t$$

and the relationship between c and t was given by

$$c=1451-8.458t$$

These relationships could lead to negative parameter values for some values of t, which generated errors. Examination of the original published data revealed better fits of

$$L=4800+48.8t$$

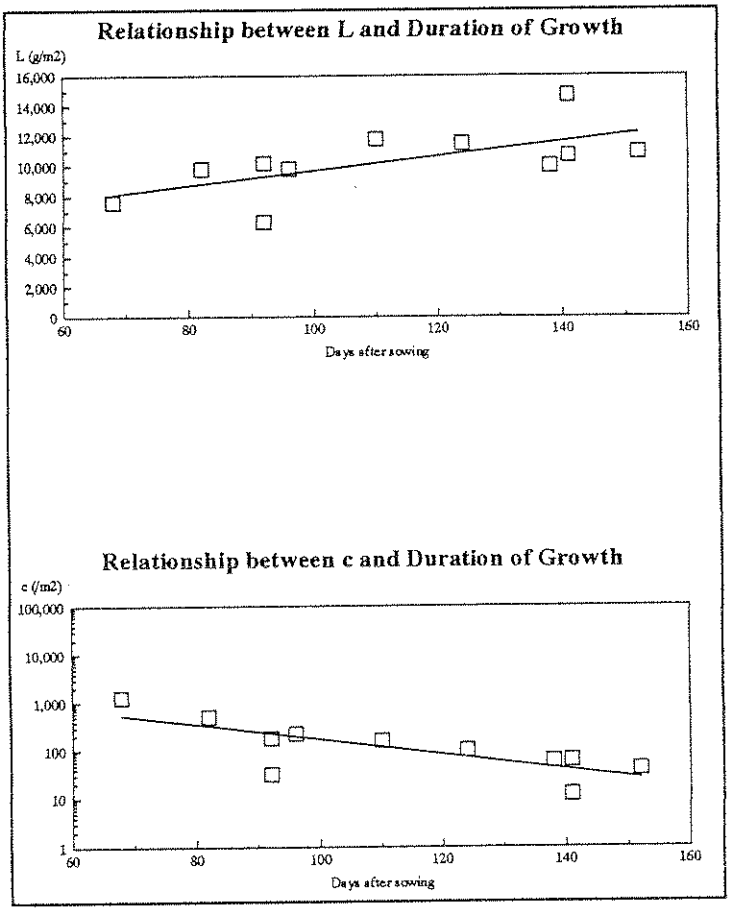
and

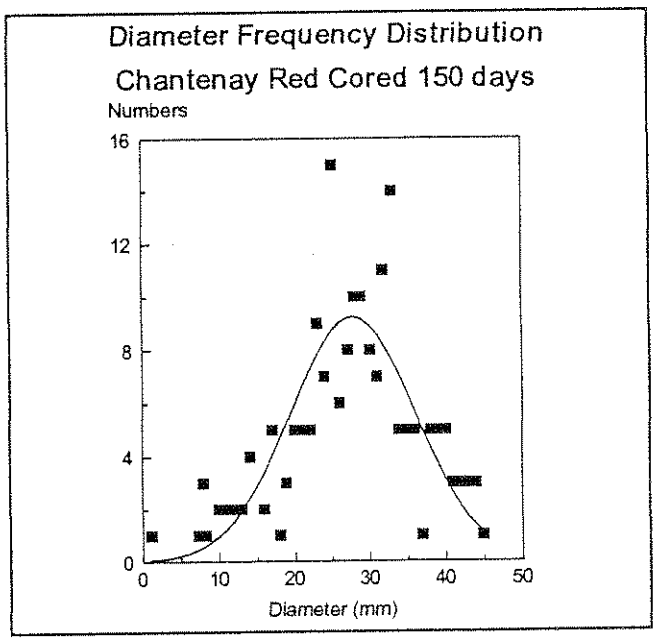
$$\log_e c=8.748-0.03622t$$

The fitted lines shown on the figure are for the revised relationships. The new equations gave a good agreement between fitted and observed values.

To make the predictions of the spacing model realistic in terms of marketable yield, estimates of the plant-to-plant variability within rows had to be made.

Examination of some experimental data revealed that the frequency distributions





of diameters were usually normal with a coefficient of variation of 30%. To illustrate that this a reasonable assumption, such a normal frequency distribution curve has been drawn here, superimposed on some carrot data from HRI, Wellesbourne.

SPACING works by going through the following steps:-

i) For a row with a specified between-row spacing and duration of growth, calculate the mean weight of carrots for a given within-row spacing.

ii) Calculate the weight of carrots in specified diameter grades, given that the frequency distribution of diameters is normal and that logarithm of weight is linearly related to logarithm of diameter.

iii) Repeat steps (i) and (ii) for each row, varying the within-row spacing, until the maximum yield in a target diameter grade has been achieved.

iv) For each grade of carrots, calculate the monetary return, given the yield in the size grades and the value of the roots. The yield is adjusted for expected losses during lifting and packing, and due to forking, splitting and disease.

v) Calculate the net financial return per area, by summing the return for each grade and subtracting seed costs and costs of production. Calculate the monetary value for each grade.

The program was written so that all the information required, such as row spacing system, duration of growth, seed and harvest costs, could be easily entered on the PC's screen. In addition, the results are presented in a clear Table, listing all the relevant information the grower requires. This final report can also be printed. The software has been written in a modular form, so that it can be easily upgraded in response to new research findings. In addition, this modular structure allows foreign language versions of the software to be easily produced. In the next section, the procedure to run SPACING is described and the implications of its output values discussed.

Running SPACING

SPACING is written so that it can be run almost immediately without any former learning. When SPACING is run, initially, the screen displays the HRI logo, and the name of the software. The licence agreement is listed when any key is pressed. To proceed, press the <ESC> key. Pressing this key is taken that you have agreed to be legally bound by the conditions set in the Licence Agreement. The next screen is as follows and describes how the user moves around the menu system of SPACING:-

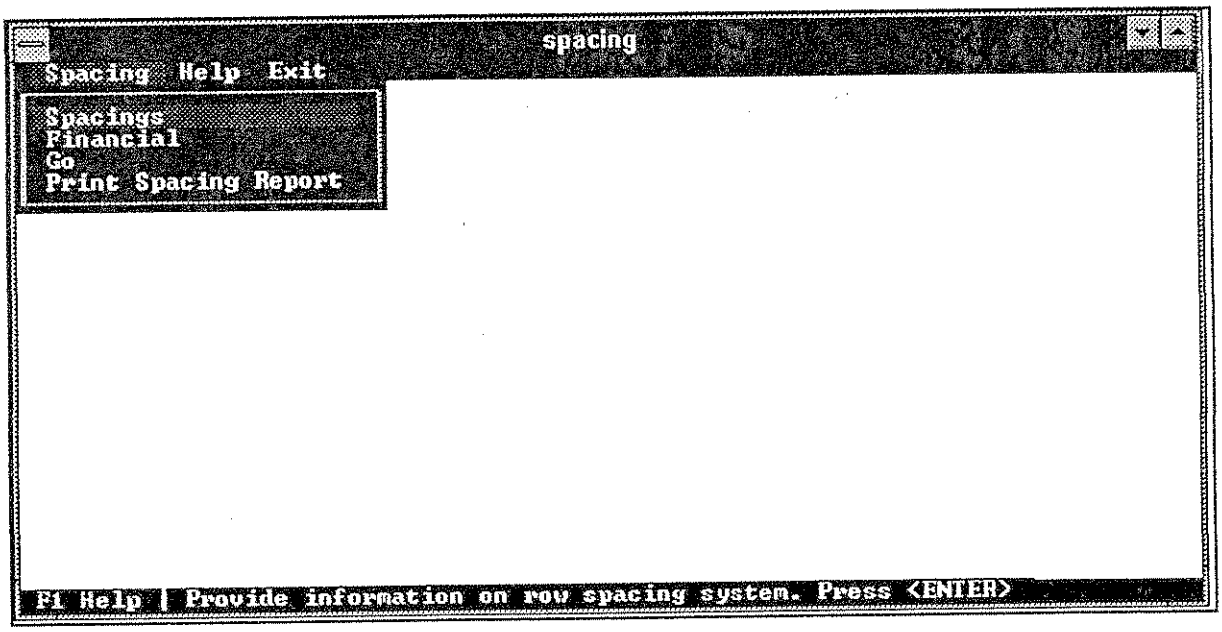
The MAIN MENU items are on the top line of the screen.
The current item is the one highlighted. Eg Spacing
The description of the current item is displayed
on the bottom line.

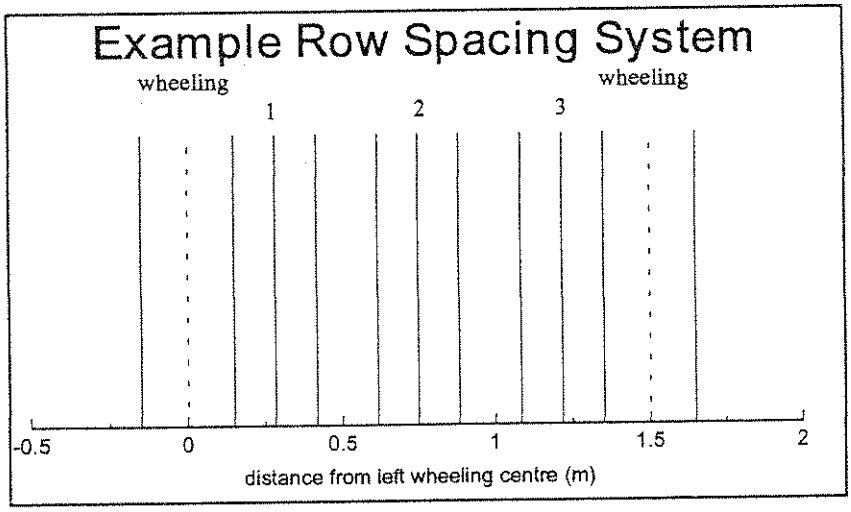
Selecting an item will lead to a SUB-MENU or a form.

Cursor Keys	
To move between MAIN MENU items use	« »
To move between SUB-MENU items use	↓ ↑
To select a highlighted item use	↵
To cancel current selection use	Esc
To move forward between items within a form	TAB KEY
To move backward between items within a form	SHIFT TAB KEY
To obtain "help" on the highlighted item use	F1

The main items in SPACING are **Spacing**, **Help** and **Exit**.

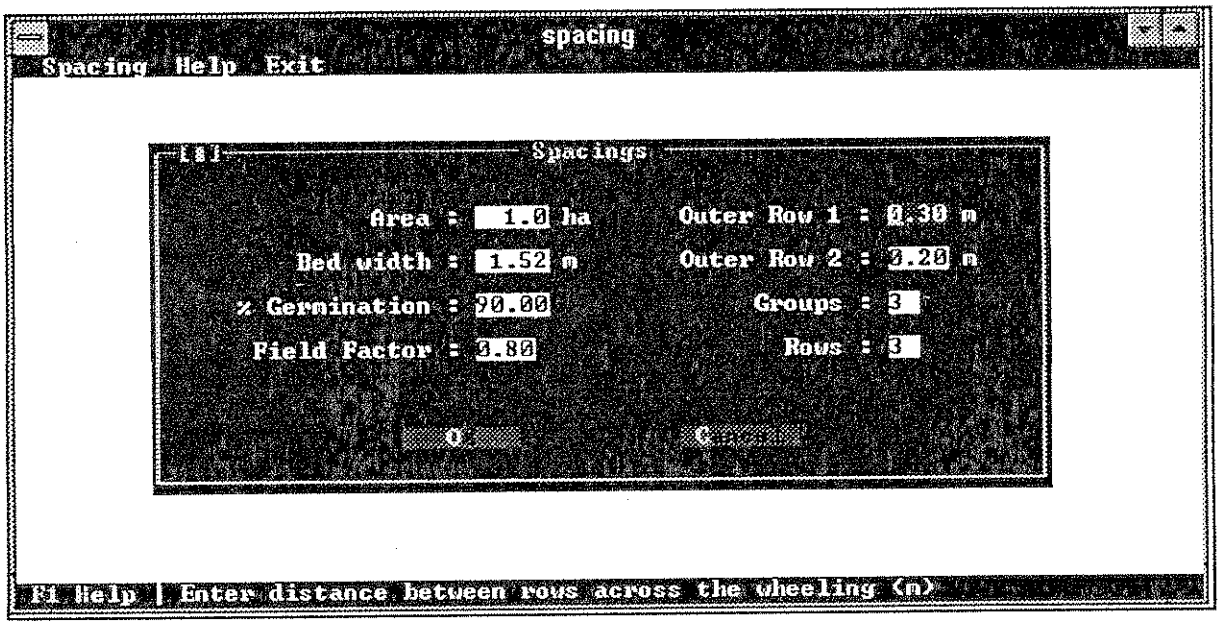
In **Spacing**, there are four sub-menu items, **Spacings**, **Financial**, **Go** and **Print Spacing Report**.





The form produced when selecting the **Spacings** sub-menu item is shown on the next page. This form requests the user to supply details related to the spatial pattern of plants. To illustrate its use, reference is made to an example row spacing system, illustrated here. There are three groups each containing three rows. The distance between groups (outer row to outer row) is 0.2 m. The three groups are in a bed 1.5 m wide with 0.3 m between groups across a wheeling. From a spatial point of view, there are only three types of row in this system. Those rows next to the wheeling (outer row1), those on the edge of the groups, but not next to a wheeling (outer row2) and the inner rows within each group (inner). To save having to type in nine sets of data for each row, SPACING has been designed to take advantage of this spatial simplicity. There is no need within SPACING to enter the distance between rows within a group, as this can be calculated from all the other information supplied.

The Area box simply allows the user to enter the area of the carrot field (ha). This



is used in the final report to calculate the financial return for the field. In our example, the field is taken as one hectare.

The bed width box allows the user to enter the bed width. Note that it is the distance from tractor wheeling centre to centre, and is **not** the width of uncompressed soil between the 'shoulders' of the bed. A six foot bed is used, so a distance of 1.52 m is entered.

The % Germination box allows the user to enter the percentage of seeds that germinated for the intended seed lot in standard laboratory tests. This figure can usually be supplied by the seed firm. I have entered a value of 90%, assuming a good seed lot.

The Field Factor box allows the users to take account of seedling mortality that nearly always occurs during seedling establishment. The value of this depends on the seed bed conditions and soil type. In the final report, the recommended seeding rates have been adjusted by the % germination and field factor values, and do not need to be increased further. I have entered a value of 0.8, which would be typical of reasonable seed bed conditions.

The Outer Row 1 box allows the user to specify the distance between rows across a wheeling, as described above. A value of 0.3 is entered.

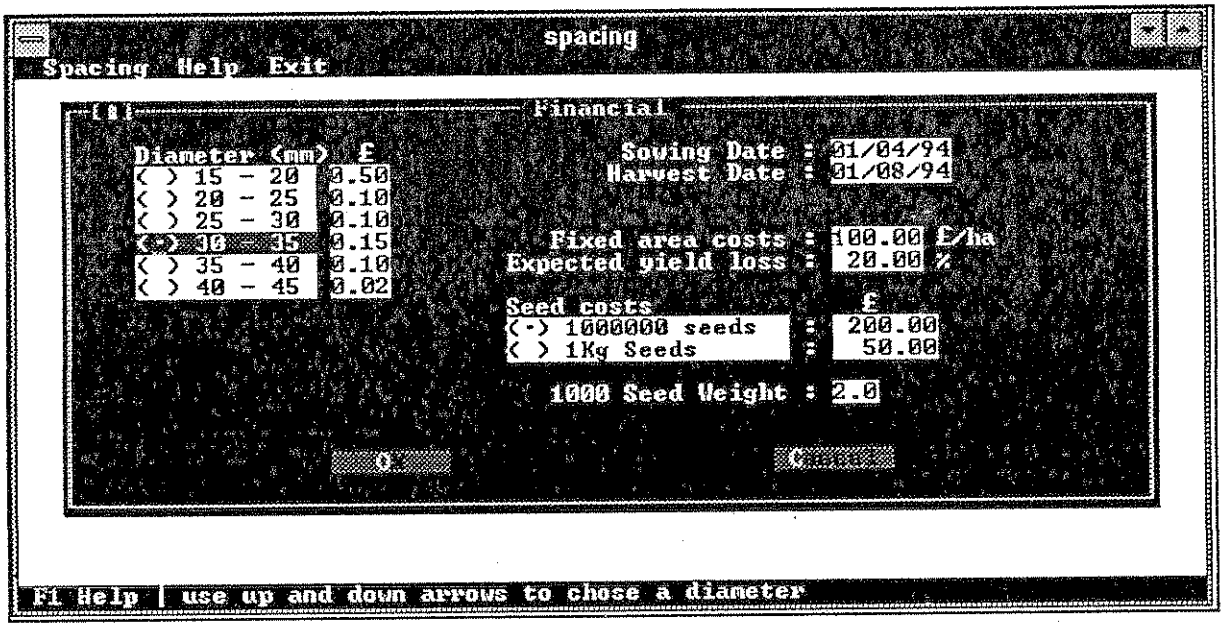
The Outer Row 2 box allows the user to specify the distance between groups within a bed. Note that this distance is from outer row to outer row and so a value of 0.2 is entered. Where there is no grouping of rows within the bed, then a 0 should be entered.

The Groups box allows the user to specify the number of groups within a bed. In this example, a three is entered. If there is no grouping of rows within the bed, then one is entered. If one is entered here, then Outer Row 2 must be set to zero. If it is not zero, then a value of one cannot be entered for Groups. In these circumstances, a value of two can be entered for Groups. One can then use <SHIFT><TAB> to go back to Outer Row 2. Now enter zero, and then used <TAB> to return to Groups and the value one can now be entered.

The Rows box allows the user to specify the number of rows in each group. For the example, I have entered the value three.

If all the values entered are acceptable, then use <TAB> to move to the OK box and press <ENTER> to move back to the main menu.

Now the Financial Form can be selected. Its appearance is illustrated below.



The box headed Diameter (mm) lists six alternative diameters that can be chosen by the user to be the target diameter grade. This is done by using the up and down arrow keys until the dot on the left-hand side is within the brackets of the desired grade. When this has occurred, then press <TAB> to move on to the box headed with a £ sign. This allows the user to enter the expected gross income (that is value) for each kilogram of root of this diameter grade. The values of all six grades can be entered, but it is rather awkward. One must use the <SHIFT><TAB> keys to move back to the Diameter box, then use the up or down keys to select a grade, use the <TAB> key to move to the £ box, where the value can be entered. Up and down keys cannot be used within the £ box! In this example, I have chosen 30-35 mm diameter carrots as the grade whose yield I wish to maximise. This grade I anticipate will have a value of £0.15/kg, all the others have a value of £0.10/kg, but with two exceptions. The large roots (40-45 mm diameter) have a very low value of £0.02/kg, but the smallest grade (15-20 mm diameter) is very valuable, being £0.50/kg. Note that SPACING will maximise the yield in the 30-35mm grade, irrespective of the values in the different grades.

The Sowing Date and Harvest Date boxes allow the user to specify the duration of growth. The number of days is calculated and is used as t in the above equations to calculate the values of L and c. Note, meteorological conditions have not yet been taken into account in this version of the competition model.

The Fixed area costs box allows the user to provide an estimate of those costs of productions that are determined on a per unit area basis. Here a single figure is entered to include the total cost of land rental, fertilizer and spreading, chemicals and application, irrigation water and application, land preparation, drilling, lifting and grading. I have estimated a cost of £100/ha. The income from each grade, and the total income from the field will have these fixed area costs deducted.

The estimated yield loss box allows the user to enter the percentage of the yield lost during lifting and packhouse operations. Also, the user should include the estimated percentage losses due to forking, splitting and disease. I have estimated that these losses to be 20%. The yield of each grade will be deducted by this percentage, and the financial return will take this yield loss into account.

The Seed Costs box allows the user to select whether seeds are purchased by number, or by weight. The choice between the two is made by using the up and down arrow keys until the dot on the left-hand side is within the brackets of correct method of payment. When this has occurred, then use the <TAB> key to move onto the box headed with a £, where the price per million or per kilogram can be added. I have chosen to pay by number and have entered £200 per million seeds. If the method of payment is by weight, then the seed weight box must have an accurate figure entered. This number should be the weight (g) of a thousand seeds. If the method of payment is by number, then the value in the seed weight box is ignored by SPACING.

If all the values entered are acceptable, then use <TAB> to move to the OK box and press <ENTER> to move back to the main menu.

To make a prediction, using SPACING, simply select Go in the main menu and a report file will be generated on the screen. Even on some now old XT PCs, SPACING takes only about a minute to run. On the more standard 486 PCs, SPACING completes its calculations in less than a second. A report file in ASCII format, called SPACING.REP, is generated on disc containing the above information. This can be printed off, or more simply, the above report can be printed using the menu system within SPACING. The contents of this file are shown below.

HORTICULTURE RESEARCH INTERNATIONAL

Plant Spacing Report
Spacing Model - Prediction for Carrots

Spatial Aspects

Specified

Sowing Date : April 1, 1994
Harvest Date : August 1, 1994
Bed Width : 1.52
Across wheeling row spacing : 0.30m
Between group row spacing : 0.20m
Within group row spacing : 0.14m
Number of groups in a bed : 3
Number of rows in a group : 3
Diameter Chosen : 30 - 35mm

Spacing Predicts

Mean Diameter : 25.17mm
Seeds/Metre of row :
Rows adjacent to wheeling : 136.87

Rows on edge of groups : 90.73
Rows inside a group : 58.29

Financial Details

Specified

% Germination : 90.00%
Field Factor : 0.80
Seed Costs (£/1000000) : £200.00
Fixed area costs : £100.00
Expected yield loss : 20.00%

Spacing Predicts

Total seed costs (£/ha) : £1067.85

Diameter (mm)	Yield (kg/ha)	Yield (% of total)	Value (£/kg)	Total Value (£)
15 - 20	781	4	0.50	390.37
20 - 25	2546	14	0.10	254.58
25 - 30	4715	26	0.10	471.48
30 - 35	5194	29	0.10	779.15
35 - 40	3497	19	0.15	349.65
40 - 45	1462	8	0.02	29.24

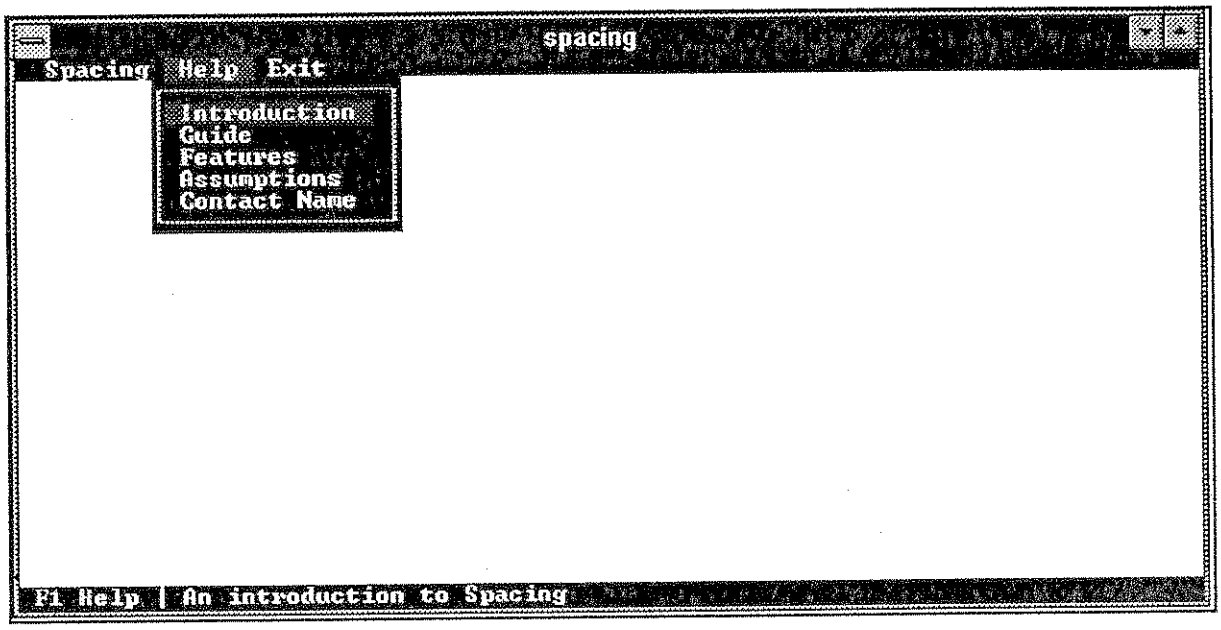
Total nett income for field (£) : 1106.62

This output from SPACING lists the items specified by the user. It then stipulates the seeding rate in each row that would produce the greatest yield in the target diameter grade. In our example, this is 137 seeds per metre for rows next to wheeling, 91 seeds per metre for rows on edge of groups, and 58 seeds per metre for rows inside a group. These seeding rates take into account the percentage germination and field factors. The use of these seeding rates should eliminate edge effects and maximize yield in the target diameter grade.

The table of yields in the different grades at the bottom of the report reveals that the greatest yield is predicted to be in the 30-35 mm diameter range. Note that only 29% of total yield is predicted to be in this grade. This low percentage is entirely a consequence of the

assumptions of variability in root diameters within each row. It would have been entirely unrealistic to assume that elimination of the edge effect results in all the roots being in the target grade. The yields listed on the table are after subtracting the 20 percent assumed to be lost during field and packhouse operations.

The mean root diameter for the entire field is 25 mm, whereas the maximum yield is in the 30-35 mm grade. This is because the diameters are assumed to be normally distributed around the mean and the wider roots have greater weight. Hence, the mean diameter for the entire population must be towards the bottom or below the lower diameter limit of the grade whose *yield* is to be maximized.



When running SPACING, further help and background information is available via the help menu. The user can select an Introduction, Guide to SPACING, a description of the Features and Assumptions of the software, and there is also a contact name at HRI.

Future improvements in SPACING are anticipated. New research should reveal more accurate estimates of changes in variability in response to crop density and duration of growth. This would tackle the major cause of low yield in target diameter grades. The relationships between light and temperature and growth are being investigated, and could be incorporated in upgraded versions of SPACING. SPACING could also be applied to other row crops. These changes, along with production of versions in foreign languages could be done easily due to the modular construction of the software.

Conclusion

SPACING should allow growers to adjust the seeding rates in each row so that edge effects are eliminated and the maximum yield in target diameter grades is produced. The ease of use of SPACING and the speed of its execution allows the user to investigate many different spatial patterns As such, SPACING will act a useful aid to the management decisions that the grower needs to make The more effective deployment of seeds in different rows will increase the profitability of the carrot crops.

References

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Contract between HRI (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

PROPOSAL

1. TITLE OF PROJECT **Contract No: FV/124**

ROW SPACING MODEL TO IMPROVE UNIFORMITY OF CARROT AND PARSNIP CROPS

2. BACKGROUND AND COMMERCIAL OBJECTIVE

Roots in edge rows can be between 10 and 100 percent larger than those from inner rows, resulting in a reduction in the proportion of produce in marketable size grades. Experiments at Wellesbourne have demonstrated that these edge effects account for about 10% of the size variability in carrot crops and that these edge effects can be eliminated by increasing the seeding rate in the outer rows. The economic advantage of eliminating these edge effects is recognised by growers and currently seeding rates in edge rows are increased usually by one and a half or two fold with respect to inner rows in carrot crops. This practice is by 'rule-of-thumb' and is unlikely to effectively eliminate edge effects as the extent of the increase in seeding rate needed to eliminate the edge effect varies with row spacing, density, duration of growth and with many other factors. In addition, it is impossible to estimate by how much the seeding rate should be increased by experimentation since each grower's circumstances differ. The only sensible approach is to simulate these effects with a computer model which can then be 'run' to evaluate a number of different situations and estimate optimum within-row spacings for each row.

Such a model has been developed by Sutherland & Benjamin (1987) *Annals of Botany* **59**, 399-411 and recently it has been shown to give excellent predictions of red beet and carrot weight for individual rows in contrasting row spacing systems at a wide range of densities in experimental plots at Wellesbourne. The model predicts weights of roots, but the relationships between weight, diameter and length found by Benjamin & Sutherland (1989). *Journal of Agricultural Science, Cambridge* **113**, 73-80 can be used to predict yield in diameter and/or length grades. Currently, the model is encoded in FORTRAN on a VAX minicomputer and has performed numerical integration by calling on standard NAG routines. This was appropriate for the development of the model, but is not feasible for its practical application as a tool to be used on personal computers (PC). The model on a PC could be used to calculate the seeding rate in each row that will give the greatest net profit. Proper commercial development of this software should be accompanied by a demonstration of the financial benefits of the model in commercial conditions.

The software as a practical tool would be made available by

HRI to growers through HDC.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

Economic production dictates that many root crops should be within specific diameter grades, and their length can be important too. The use of the software will allow growers to increase the proportion of their crops in marketable size grades by stipulating, on a scientific basis, the best deployment of seeds in different rows to reduce edge effects. Varying the within-row seeding rate between rows does not incur any cost to the grower, provided a constant overall density is maintained, so the increase in the yield of marketable-sized produce increases grower's profit. It is difficult to quantify the monetary effect of increases in the marketable proportion of a crop because the main monetary benefits accrue from reductions in the cost of harvesting, grading and packaging and from increases in the speed of these processes. In addition, there would be a reduction in the amount of waste from the crop, and hence a reduction in the costs of its disposal. These costs are major concerns to growers, so the potential economic benefit of the use of the model is considerable.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

The objective of this work is to:-

i) develop 'user-friendly' software that can be used on a grower's personal computer;
ii) demonstrate the extent to which the use of the model increases the monetary value of carrot crops by increasing the proportion of these crops in marketable size grades.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

MAFF are currently funding work at Wellesbourne to study the mechanism of competition between plants and to develop mathematical models to simulate these competitive interactions. This research might indicate modifications that would improve the performance of the model. Such modifications could be exploited as upgraded versions of the software.

Kevin Stone at HRI has also successfully developed Ventem, a software package for use on PCs, which is a practical tool for apple scab control. Ventem is based on models developed at HRI by Dennis Butt and Xiangming Xu.

6. DESCRIPTION OF THE WORK

Kevin Stone at HRI, EM will convert the programme from FORTRAN to TURBO PASCAL, which will run on a PC, and develop graphical subroutines to make it easy for inexperienced computer users to put in the information the

model requires to make a prediction. The software will be developed for carrots, and will require the user to specify the seed costs, the row spacing system, the duration of crop growth, the costs of harvesting a unit length of row and the market value of each diameter and/or length grade. To be 'user-friendly' the layout of the questions on the terminal screen must be clear, making use of the most recent developments in computer graphics.

The programme will be demonstrated to carrot growers to evaluate its usability by inexperienced computer users and to engage growers in practical evaluations of the software. Demonstrations could be at HRI grower meetings and by contact with growers through HDC.

7. COMMENCEMENT DATE AND DURATION

Start date 1.4.92; duration one year. It is likely that the project will be extended for a second year so that the model can be evaluated commercially.

8. STAFF RESPONSIBILITIES

Project Leader: L R Benjamin
Other staff: Software development by Kevin Stone and Richard Owen.

9. LOCATION

Work will be co-ordinated from Wellesbourne, and the software will be developed primarily at East Malling.

10. COSTS

Development of software

Coordination between software development and growers and HDC