The results of the survey given the first quarter in the senior and graduate student course (B) after exposure to international students are shown in Table 4. Of the domestic students, 44% could correctly identify the international students' home countries correctly. Females did a better job at country identification than did males. Only one American student out of 12 could identify correctly all three international students' countries. Domestic male students identified only one third of the possible countries correctly; whereas, females were correct 60% of the time. International students, as would be expected, made a score of 100% on country identification, and the instructional group obtained a score of 83%.

Since only questionaires with the correct country responses were evaluated for the remainder of the survey questions, the potential responses for domestic students were reduced by 56%. The male American students did a better job at identifying capitols (57%) than did the female students (11%). Response on the size of a country was surprisingly low in all categories (0-16%) as was hemisphere identification (33-43% by domestic students) of a country which should have been 50% by chance alone. There is no explanation as to why the international students did so poorly (11%) on this question. Religion responses were also fairly weak in the case of domestic students (33-43%). The domestic male students did a better job (71%) with agricultural crops than did the domestic female students (33%). The students who received the best academic grade in the class could answer none of the survey questions correctly.

Other countries which were identified in addition to the correct answers included Mexico, India, Iran, China, Iraq, Brazil, and Vietnam. Several answers were unexpected and also were interesting, including the fact that students who identified countries such as Iran incorrectly, stated that the size of this country was "to large," the size of Korea was also identified as "too large," while the sizes of Brazil and Vietnam were identified as "too small." It is interesting to speculate if these unexpected answers are related to the students' political evaluation of these countries. Since the three countries represented are also very religiously oriented, it was surprising to find such responses as to the religion(s) of these countries as "communism" and "atheism."

In general, the domestic students did a slightly better job of identifying the home country of international students than they did in identifying the Ohio home town of their domestic classmates. This is as would be expected since the differences are less between Ohio students' hometowns than they are between domestic and international students' home countries. However, in both cases, the success rate was surprisingly low.

To follow up on this survey (B), the same survey was used again the following quarter with another senior-graduate student class (C) containing domestic and international students. Since some of the international and domestic students were involved in the previous survey, they were eliminated from this one. The results of the second survey are shown in Table 5. The results are only slightly different from the previous survey and give added credibility to the previously described results.

Summary

Transfer of international (or domestic) non-class related information seemed to be poor in an agricultural science course in which international subject matter is not stressed. If, however, a better method is not found to transfer international information, it appears that very little will happen simply as a consequence of proximity of domestic and international college students in the same course. It appears that the current methods used are not internationalizing domestic agricultural students. Are we missing an excellent opportunity, and should deliberate effort to be devoted to promote and encourage greater transfer of information between students?

Drawbar Performance Prediction Using a Microcomputer

J. Chaplin, D. Hansen and T. Fan

Introduction

Prediction of tractor performance has been a major focus for many researchers over the last twenty years. Several empirically-based equations have been proposed and accepted by many engineers in the profession. The most noted of these is the Wismer and Luth theory (1974). They used dimensional analysis that resulted in an equation relating tire performance to slip, tire dimensions, tire load and soil strength.

Others have modified the Wismer and Luth equation to incorporate tire deflection in the dimensionless term called "mobility number" (Gee-Clough et al. 1978). This work was similar to Wismer and Luth; however, field conditions were more broadly defined as those found in agricultural situations and the theory does not cover extremely hard or slippery surfaces.

Even though these empirical approaches are well founded, it is not easy to present these concepts so that students learn how design parameters affect tractor-implement performance. Zoz (1972) presented a nomograph which was based on measured performance of tractors under field conditions and included soil condition, tractor speed and hitch geometry. Although this was and still is a valuable teaching tool, students still find it difficult to visualize what is occurring.

Personal computers have added a new dimension to concepts which use an iterative approach for the

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solution of a problem. Kotzabassis (1985) presented a paper that discussed an IBM-PC based tractor performance program. Three approaches were compared, a) using the work done by Zoz, 1972; b) an OECD model based on the mobility number; and c) a model based on Wismer and Luth equations. Kotzabassis showed through comparison that the Wismer and Luth based model was the most flexible for a wide range of conditions and gave a realistic response to changes in soil strength.

Objective

The objective of this article is to describe a tractor performance prediction program for use on an Apple Macintosh™ computer. The program should be interactive and comply with the programming philosophy set forth by Rose et al. (1986). This philosophy advocates software that appeals to non-programmers. The applications should be easy to use and should embody three qualities: responsiveness, permissiveness and consistency. The user should be able to get direct results and be able to "do anything reasonable" in changing input. The environment presented by the application should follow the standard Macintosh guidelines set down by Apple.

Model Strategy

The Wismer and Luth empirical equations are used in the model. This selection was based on Katzabassis's findings as well as the fact that the approach has been widely accepted. In order to maintain complete flexibility a set of commonly used implements was selected from the ASAE standards (ASAE D230.4 1986). An equation giving draft as a function of speed or operating depth is solved simultaneously with the traction equation. This set of equations does not give a full matrix as some implements were not tested, or were not suited to all soil types.

A shell program, Menuing, Event and Windowing System (MEWS) (developed by the Microcomputer Systems Group, University of Minnesota, 1986) was used throughout to handle the windows created by the TRACTOR program. MEWS effectively polls for events such as mouse clicks and distinguishes between them. Use of this program greatly simplified the programming effort required to accomplish the objective.

Turbo Pascal™ was used in developing TRACTOR as it provides very fast error location/correction and compile time. Turbo Pascal also supports the Apple QuickDraw™ routines which are the kernel of the Macintosh user interface.

The user enters information concerning tractor or implement type and computational units via entries on the standard Macintosh menu bar. Currently the tractor type is limited to 2WD, although future plans include expansion to 4WD and tracklaying types. Implement types include moldboard plow, chisel plow, disk, cultivator and rotary hoe. The Units menu allows the user to choose between metric and English units.

After the user selects a tractor type, the program presents a window containing a schematic of a tractor and various buttons and controls which allow the entry of additional information regarding the tractor, including weight, no-load-speed, engine power, soil cone index, tractor wheelbase and tire size. A set of instruction notes is presented in the Appendix and these show diagrams of each of the windows discussed here.

The user selects tires by clicking on the front or rear tire buttons until the appropriate tire size appears on the button. Information from the Tire and Rim Handbook (1986) regarding the selected tire, including dimensions and allowable maximum load, is built into the program.

A vector in the tractor window represents the force between the implement and tractor. This can be manipulated by the user to represent a trailed, semi-mounted or mounted implement. The user can enter the coordinates for the hitch pitch (VHP) and the center of resistance (COR) by typing them in through a window. This allows simulation of a front mounted implement or a loader in addition to the traditional trailed implement.

The tractor weight distribution is adjusted via a "slider bar" type control. For a 2WD tractor this is limited to a maximum of 75% rear and 25% front with infinite variation in between. This approach gives the user a feel for actually moving the weight fore and aft and allows direct feedback.

When the user has finished entering the parameters, the Start button begins the simulation. During model computations, checks are made continuously to ensure that maximum slip does not exceed 50%, that minimum front axle load for steering is limited to 20% of the total tractor weight, that the required drawbar power does not exceed maximum engine power and that the tires are not overloaded. If any of these checks fail, TRACTOR presents a dialog box with a warning message and a suggestion of what changes are required to correct the situation.

When the computations are complete, the tractive efficiency, slip, ground speed and draft are presented along with a plot of tractive efficiency vs. slip. In subsequent runs of the model during the session, curves from previous simulations are displayed along with the current one so that the student may see the effects of changes made to the parameters.

Program Methodology

A flow chart of the program is presented in Figure 1. The first computation determines the front and rear dynamic axle loads based on the position and magnitude of the force vector. The rolling resistance for each wheel is determined followed by the thrust at the initial slip. Initial slip is found from the tractor no-load speed and the expected implement field speed.

A prediction of slip is also obtained using the draft required at the expected field speed. A new speed is computed based on this prediction of slip. The values of slip are compared and the procedure is iterated until

Figure 1. Flowchart for Tractor.
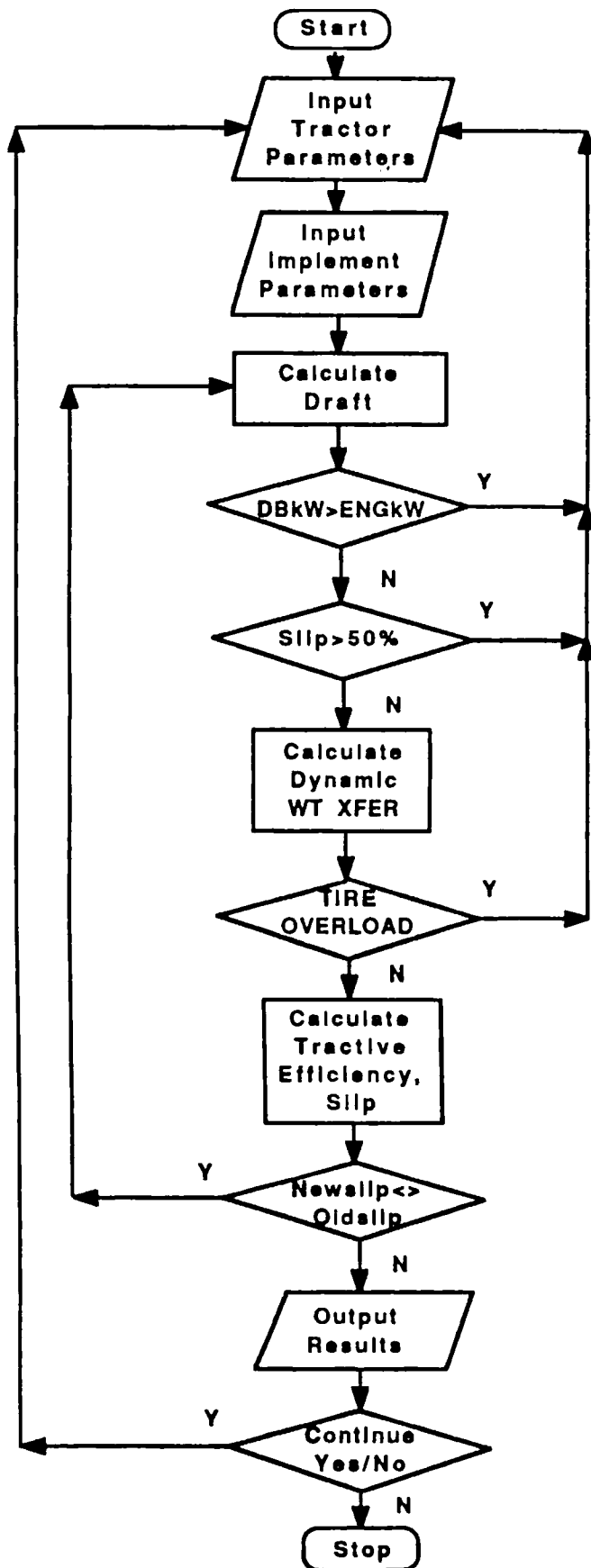
slip and tractive efficiency stabilize. This solution worked well for those implements which have draft related to forward speed, such as a moldboard plow. For other implements tractive efficiency is calculated at uniform slip.

The "safe" condition tractor tests mentioned previously are checked on each loop through the program. Any infringement on the preset conditions causes a halt in the simulation, and a dialog box alerts the user as to the corrections that need to be made.

Auto-incrementing the ballast and tire size were considered; however, this removes the user from the reality of the problem. The concept of the program was to have the user discover what happens when a parameter is changed, rather than have the program produce an unquestioned solution.

Model Testing

The model was tested using data from the Nebraska Tractor Test for a White 2-105 2WD tractor operating with several implements. For tractor parameters see Table 1. These results were then

Table 1. Tractor Parameters

Tractor	White 2-110 2WD
Mass	5368 kg
Power	79 kW
Vno-load	9.0 kmph
Wheelbase	2.78 m

compared to hand calculations and to results obtained from the Zoz chart. The tractive conditions considered were poor (350 kPa), average (700 kPa) and good (1050 kPa). Based on a limited tests of the program it appears that the results fall between those found using either the Zoz nomograph or the Wismer and Luth approach. Tables 2-4 show the results for moldboard plowing, chisel plowing and rotary hoeing when compared to hand calculations and the Zoz nomograph.

The draft prediction equations for implements operating on soils of different types are incomplete and may not be representative of the draft of newer,

Table 2. Moldboard Plow

Furrows	5
Width	46 cm
Depth	20 cm
vhp	x=0.91 m y=0.53 m
cor	x=3.80 m y=0.14 m

		Tractor Program	Wismer & Luth	Zoz
CI=350 kPa	TE	47	52	*%
	Slip	35	30	*%
	Speed	5.8	6.3	* kmph
	Draft	16.9	17.4	* kN
CI=700 kPa	TE	69	70	58%
	Slip	13	15	22%
	Speed	7.8	7.7	6.9 kmph
	Draft	19.4	19.2	20.6 kN
CI=1050 kPa	TE	75	77	72%
	Slip	11	10	17%
	Speed	8.0	8.1	7.2 kmph
	Draft	19.7	19.9	25.0 kN

Table 3. Chisel Plow.

Tines	5			
Depth	20 cm			
vhp	x=0.91 m y=0.53 m			
cor	x=3.80 m y=0.14 m			

		Tractor Program	Wismer & Luth	Zoz
CI=350 kPa	TE	50	55	•%
	Slip	29	21	•%
	Speed	6.3	7.0	• kmph
	Draft	13.7	14.3	• kN
CI=700 kPa	TE	69	71	58%
	Slip	12	10	22%
	Speed	7.9	8.1	6.9 kmph
	Draft	15.0	15.1	20.6 kN
CI=1050 kPa	TE	75	76	72%
	Slip	7	7	17%
	Speed	8.3	8.4	7.2 kmph
	Draft	15.3	15.4	25.0 kN

presumably better designed implements. The algorithm developed is based on these equations and the Wismer and Luth theory for traction and is limited to the original assumptions and constraints imposed. From the limited testing that has been carried out using the TRACTOR program it appears to underestimate the results of the Zoz chart. This could be due to the limited range of tire size over which the chart is applicable.

Results show that the tractive efficiency is underestimated by the TRACTOR program under poor traction conditions. This error is approximately 6% of the hand calculated value for the tractive efficiency. The Zoz chart indicated infinite slip under such field conditions.

Conclusions

A program that predicts the performance of a tractor-implement system has been developed for use on the Apple Macintosh computer. The program can be used as a direct replacement for the Zoz chart.

TRACTOR V1.0 has been made available on a limited basis. For a copy of the program and instruction

Table 4. Rotary Hoe.

Width	5 m			
vhp	x=0.91 m y=0.53 m			
cor	x=3.80 m y=0.14 m			

		Tractor Program	Wismer & Luth	Zoz
CI=350 kPa	TE	32	3	1•%
	Slip	7	7	•%
	Speed	8.3	8.3	• kmph
	Draft	3.1	3.1	• kN
CI=700 kPa	TE	42	42	58%
	Slip	3	3	22%
	Speed	8.8	8.8	6.9 kmph
	Draft	3.2	3.2	20.6 kN
CI=1050 kPa	TE	47	47	72%
	Slip	2	2	17%
	Speed	8.9	8.9	7.2 kmph
	Draft	3.2	3.2	25.0 kN

notes send $10 to cover disk cost and postage to: Jonathan Chaplin, Agricultural Engineering, University of Minnesota, 1390 Eckles Avenue, St. Paul, MN 55108.

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Appendix

Tractor - A Performance Prediction Program

The Tractor program begins with a blank screen containing only a menu bar across the top. The bar contains three special menus which apply to the Tractor program:

o Tractor - select the tractor type for simulation. Tractor types include 2WD, 4WD, and track layer.

o Implement - choose an implement type for simulation. Implement types include Moldboard Plow, Disk Harrow, Chisel, Cultivator, Rotary Hoe, and Subsoiler.

o Units - select English or Metric units.

o Units - select English or Metric units.

The File menu allows you to print data from the program, or quit the program.

When you have selected a tractor type, the following window appears.
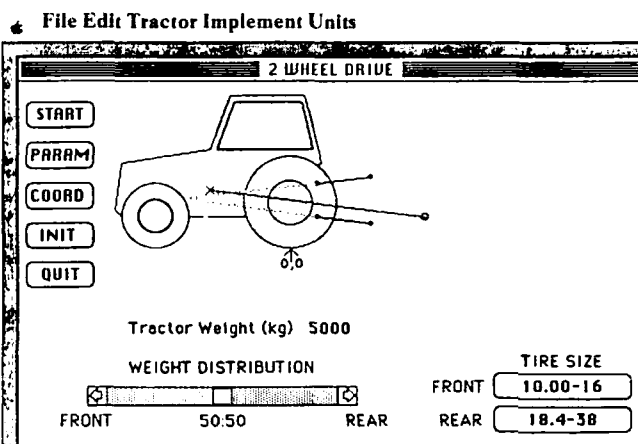
Main Tractor Window

After you have selected a tractor, choose an implement type from the Implement menu. Each implement requires certain parameters to be input to the program. When you click the chosen implement, a dialog box containing the current values for that implement appears.

The implement contains a default set of data when the program begins. However you may change the parameters to see their effect on the model. You may also select a different soil type by clicking the check-box next to the appropriate soil. Following is a table of the inputs necessary for each implement.

Moldboard Plow Dialog Box

	Plow	Disk	Chisel	Cultivator	Rotary	Hoe	Subsoiler
Speed	x	x	x	x	x		x
Mass		x					
Furrows	x						
Width	x						
Depth	x		x	x	x		x
Tines			x	x			x

The speed that you enter for the moldboard plow, the chisel and the rotary hoe are initial guesses at the actual implement speed based on the other implement and tractor parameters. When the tractor-implement combination is analyzed, the speed for these implements will be updated to the actual computed value.

The tractor window contains several other buttons and controls which allow you to make changes to the system before running it. Following is a description of these controls:

Force Vector: The vector on the tractor schematic represents the force exerted on the tractor by the attached implement. The vector has an x at one end (the virtual hitch point, or VHP) and an 'o' at the other end (the center of resistance, or COR). Use the mouse to drag either end of the vector to the desired position. Click the **COORD** button on the picture to see the actual coordinates of each end of the vector. While the window presented by the COORD button is on the screen, you may type in coordinate values for the vector ends. The vector is updated on the screen when you close the Coordinates window.

PARAM: The PARAM button presents a window in which you may enter values for other important tractor attributes, including weight, power, no load speed and wheelbase for the tractor, and cone index for the soil.

WEIGHT DISTRIBUTION: The sliding weight distribution bar allows you to select the percentage of weight distributed to the front and rear of the tractor. The maximum distribution to either end is 75%.

TIRE SIZES: Click the front and rear tire buttons to select the desired tire sizes. The tire sizes are presented in standard sizes, regardless of the type of units chosen.

INIT: INIT redraws the picture and resets the vector to its original position. The tractor parameters will also be reset to the default program values; implement values will not change.

START: Click the START button to analyze the tractor-implement combination. If the calculations run satisfactorily, TRACTOR displays a results window containing a graph of the Tractor Efficiency vs. the percentage of Slip. If there is a problem with the calculations, the program stops and displays a warning dialog stating the problem and a hint for correcting it.

After you have entered all parameters for your run, you may send a hard copy of the data to the printer by selecting PRINT in the File menu.

The results window contains the computed tractive efficiency, slip, implement speed, and draft. If the initial speed guess has been changed in the calculations, it will also be displayed in the implement menu.

If you make changes to parameters in the tractor window and then click Start, the new curve will be displayed on the same graph as the previous one. Up to 5 curves are displayed simultaneously. The crosshairs on the graph show the position of the tractive efficiency and slip displayed above.
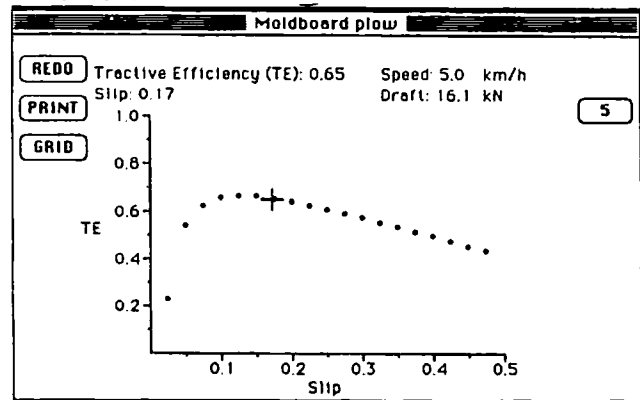
Moldboard Plow Results Window

REDO: Redo allows you to return to the tractor window, change data values, and re-calculate.

GRID: Click Grid to overlay a grid on the graph. Click Grid again to remove the grid.

PRINT: Click PRINT to print the graph on the printer.

 # CURVES: Click the # CURVES button to select the number of curves to be displayed on the plot. Up to 5 curves may be displayed at once.