

# **MACRONUT:**

**Calculation Software for Custom Mixed  
Nursery Fertilizers**



**Cooperative Extension Service • DS-20  
College of Agriculture and Home Economics**

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# MACRONUT

## Calculation Software for Custom Mixed Nursery Fertilizers

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### INTRODUCTION

The MACRONUT program is designed to help container nurseries and researchers calculate custom-formulated, water-soluble fertilizers. Many nurseries and researchers are custom-formulating fertilizers from raw chemicals rather than using pre-formulated, water-soluble commercial fertilizers. This allows specific ratios of mineral nutrients to be obtained in fertilizers. MACRONUT alleviates the need for the cumbersome calculations necessary to formulate custom fertilizers.

The MACRONUT program uses 17 commonly available compounds traditionally used in fertilizer formulations. MACRONUT allows the user to prioritize different sources of nutrients in the formulation. The MACRONUT program allows you to set ratios in the fertilizer solution for these mineral macronutrients: nitrogen, phosphorus, potassium, magnesium, calcium, sulphur.

MACRONUT will tell you how to mix your concentrated stock solution and the nutrient levels of your applied solution. Due to chemical constraints, a 5% tolerance has been put in the program. Some ratios will not be achievable; however, MACRONUT will calculate a stock solution within 5% of the target ppm, or it will tell you the target ratios you set are unachievable.

MACRONUT does not tell you any information regarding chemical incompatibility. It allows the user to set priorities for the compounds and relies on their knowledge of this information. Chemical incompatibility can be a significant problem when using calcium nitrate in a nutrient solution (see Landis et al. 1989 for further information). Refer to Appendix A for a generalized solubility and incompatibility diagram of the 17 compounds MACRONUT utilizes.

### EQUIPMENT REQUIRED TO RUN MACRONUT

1. IBM®-compatible computer with either a 3.5" 5 1/4" drive.
2. DOS® version 2.1 or greater.
3. The MACRONUT program.

### INFORMATION REQUIRED TO RUN MACRONUT

1. Injection ratio of your injector or siphon.
2. List of available chemicals. Table 1 lists what chemicals MACRONUT will recognize as source chemicals. Use this table as a reference when running MACRONUT.

### HOW TO RUN MACRONUT

#### User Inputs

All user inputs into MACRONUT are either alphabetic (without case sensitivity) or numeric as an integer. There are no decimal inputs or percent sign inputs. The minimum concentration in parts per million (ppm) is one (1). Any corrections to an input can be made by using the <Backspace> key before pressing the <Enter> key.

**Table 1. Sources of mineral macronutrients recognized as nutrient sources by MACRONUT.**

Compound name	Source for					
	N	P	K	Mg	S	Ca
Ammonium nitrate	X					
Ammonium sulfate	X				X	
Calcium nitrate	X					X
Diammonium phosphate	X	X				
Dipotassium phosphate		X	X			
Magnesium sulfate				X	X	
Monoammonium phosphate	X	X				
Monopotassium phosphate		X	X			
Nitric acid						
Phosphoric acid	X					
Potassium carbonate		X				
Potassium chloride		X				
Potassium nitrate	X		X			
Potassium sulfate			X		X	
Sodium nitrate	X					
Sulphuric acid					X	
Urea	X					

### Starting MACRONUT

First, change the directory to the drive in which the MACRONUT program is located. To start MACRONUT simply type <MACRONUT> at the DOS® prompt and press the <Enter> key.

### Running a MACRONUT Calculation

MACRONUT is a prompt-driven program. All you need to do is enter an appropriate response to questions and press the <Enter> key. Answer all the questions on a screen. When you press the <Enter> key after the last question, MACRONUT will advance you to the next screen.

At any time during the program, the user can abort the program either by pressing the <Control> and <Break> keys simultaneously or the <Control> and <c> keys simultaneously.

### Screen 1

The first screen you will see after starting MACRONUT is an introduction screen. Press the <Enter> key to continue the program. Press the <Esc> to exit the program.

### Screen 2

The second screen requests the user to input target fertilizer properties.

The first question asks the user to set the nitrogen level in ppm.

The second question asks the user to set the percentage of nitrogen to be derived from NO<sub>3</sub> compounds.

Questions 3 through 6 ask the user to set the target levels of phosphorus, potassium, magnesium, and sulphur in ppm.

After setting all these levels, press the <Enter> key to continue.

### Screen 3

The third screen has a list of 17 commonly used compounds used in making fertilizers. These are the only compounds MACRONUT will recognize as sources for fertilizers. After each line, either press <y> if the compound is available or press <n> if it is not available. If you just press the <Enter> key without responding <y> or <n>, the program will interpret this as a "no" response.

MACRONUT has two error traps which will be invoked if either one of these errors occurs:

The first error trap involves setting a target magnesium level but not listing magnesium sulfate as an available compound. MACRONUT allows the user to correct this problem one of two ways. The user can set the desired magnesium level to 0 or make magnesium sulfate available. A third option is to restart the program. Example number 2 in Appendix B provides an example of this type of error.

The second error trap involves the ratio of magnesium to sulphur in the desired fertilizer. If you set a sulphur level too low relative to magnesium it will be impossible to achieve the desired ratio because the only

way to add magnesium is by adding sulphur as well. The user can correct this problem two ways: 1) reset the magnesium level to "0," or 2) reset the sulphur target level to the minimum. The computer has already calculated this value for you. The last option is to restart the program. Example number 3 in Appendix B provides an example of this type of error.

#### Screens 4 - 7

Screens 4 through 7 ask the user to rank the compounds they have selected for each mineral nutrient. A ranking of "1" indicates this is the preferred compound for the source of this element. A ranking of "2" indicates this compound is the user's second preferred source of this compound, and so on.

Several compounds, such as potassium nitrate, contain more than one of the mineral nutrients. If selected, potassium nitrate will appear in both the nitrogen priority screen and the potassium priority screen.

As you can see from the list of compounds which MACRONUT recognizes, there is only one source for magnesium. Therefore, MACRONUT defaults and prioritizes magnesium sulfate as "1."

#### Screen 8

The eighth screen will give you the following message: "Please be patient: calculating optimum formulation....." MACRONUT is in the process of calculating your fertilizer formulation.

#### Screen 9

Provided MACRONUT can formulate a solution with your inputs, the ninth screen asks for your injector ratio or siphon rate. Enter the number of parts of water in which 1 part of fertilizer is added. For example, if your injector is set at 1:100, you need to enter <100>, as this represents the amount of water to which 1 unit of fertilizer is added.

If you are not using an injector, simply set the injection ratio to "1" and this will give you the applied solution formulation.

#### Error Screen

If MACRONUT cannot formulate a solution with your inputs, it will respond "No solution is possible with current criteria." MACRONUT will generate the closest formulation possible using the inputs the user provided. Example number 4 in Appendix B provides an example of this type of error.

#### Screen 10

The tenth screen provides the calculated applied solution for your desired fertilizer. The top half of the screen lists the ppm for each mineral nutrient, with nitrogen being further broken down into its ammonium and nitrate levels in the applied solution. This screen also lists the target levels the user assigned to each of the mineral nutrients in the applied solution.

Using the information from the top half of Screen 10 and the set injection ratio, MACRONUT calculates the number of grams per liter or grams per gallon required for each compound to formulate the concentrated stock solution. This information appears on the lower half of this screen.

The tenth screen also offers the option of being printed.

#### HINTS AND TIPS

If you are new to custom fertilizer applications, try listing all compounds as available and ranking them according to price to see which compounds the computer uses to develop the correct formulation.

If you keep getting a "no solution possible" screen, try adjusting the target levels within the following pairs:

Magnesium - Sulphur  
Potassium - Phosphorus  
Ammonium - Nitrate

#### TECHNICAL SUPPORT

For program technical support in English, contact the New Mexico State University, Mora Research Center, Tel. (505) 387-2319 or FAX (505) 387-9012. For technical support in Spanish please send a facsimile stating your name, the problem, and your FAX number and we will do our best to solve the problem.

#### LITERATURE CITED

Landis, T.D., Tinus, R.W., McDonald, S.E., Barnett, J.P. 1989. *Seedling Nutrition and Irrigation, Vol. 4. The Container Tree Nursery Manual*. Agric. Handbk. 674. Washington, DC. U.S. Department of Agriculture. Forest Service. 119 p.

## APPENDIX A

	Urea	Ammonium nitrate	Ammonium sulfate	Potassium nitrate	Potassium chloride	Potassium sulfate	Ammonium phosphate	Magnesium sulfate	Phosphoric acid	Sulfuric acid	Nitric acid	Calcium Nitrate
Urea												
Ammonium nitrate												
Ammonium sulfate												
Potassium nitrate												
Potassium chloride												
Potassium sulfate												
Ammonium phosphate												
Magnesium sulfate												
Phosphoric acid												
Sulfuric acid												
Nitric acid												
Calcium Nitrate												

	Fully compatible
	Reduced solubility
	Incompatible

**Figure 1.** Incompatibility chart for common chemicals used to formulate custom fertilizer mixes (modified from The Container Tree Nursery Manual, Vol. 4. Seedling Nutrition and Irrigation).

## APPENDIX B

### A successful example:

At the DOS prompt type <MACRONUT> and press the <Enter> key.

#### Screen 1.

This program determines the amounts of available preferred compounds to mix per liter or per gallon that supply the macro-nutrients (N,P,K,Mg,S,Ca) to develop customized fertilizer solutions.

Press enter to continue escape to exit...? <Enter>

Now enter the target levels of mineral nutrients in the applied solution.

#### Screen 2.

What is the ppm target level of total Nitrogen in the applied solution? 150  
<Enter>

What is the percentage of total Nitrogen derived from NO3 compounds? 50 <Enter>

What is the ppm target level of Phosphorus in the applied solution? 75 <Enter>

What is the ppm target level of Potassium in the applied solution? 75 <Enter>

What is the ppm target level of Magnesium in the applied solution? 38 <Enter>

What is the ppm target level of Sulphur in the applied solution? 49 <Enter>

What is the ppm target level of Calcium in the applied solution? 0 <Enter>

Because several of the compounds may supply more than one of the macro-nutrients, deriving a formulation that exactly meets the ppm target levels may not be possible. Therefore a 5% tolerance is incorporated to allow for formulation using specified criteria.

Press enter to continue...? <Enter>

Now enter the compounds which are available.

### Screen 3.

All of the questions on this screen can be answered with a y/n.  
The default (just pressing <Enter>) is NO.

Is Ammonium Nitrate available as a component of the stock solution? y <Enter>  
Is Ammonium Sulfate available as a component of the stock solution? n <Enter>  
Is Diammonium Phosphate available as a component of the stock solution? n <Enter>  
Is Dipotassium Phosphate available as a component of the stock solution? n  
<Enter>  
Is Magnesium Sulfate available as a component of the stock solution? y <Enter>  
Is Monoammonium Phosphate available as a component of the stock solution? y  
<Enter>  
Is Monopotassium Phosphate available as a component of the stock solution? n  
<Enter>  
Is Nitric Acid available as a component of the stock solution? n <Enter>  
Is Phosphoric Acid available as a component of the stock solution? y <Enter>  
Is Potassium Carbonate available as a component of the stock solution? y <Enter>  
Is Potassium Chloride available as a component of the stock solution? y <Enter>  
Is Potassium Nitrate available as a component of the stock solution? n <Enter>  
Is Potassium Sulfate available as a component of the stock solution? n <Enter>  
Is Sodium Nitrate available as a component of the stock solution? n <Enter>  
Is Sulphuric Acid available as a component of the stock solution? y <Enter>  
Is Urea available as a component of the stock solution? n <Enter>  
Is Calcium Nitrate available for the stock solution? n <Enter>

Now rank the compounds for the nutrients in order of priority (Screens 4 - 7).

### Screen 4.

The following list is of available compounds that provide Ammonium for the stock solution. You will be asked to rank these compounds in order of preference for usage.

What rank is assigned to Ammonium Nitrate? 1 <Enter>  
What rank is assigned to Monoammonium Phosphate? 3 <Enter>  
What rank is assigned to Urea? 2 <Enter>

### Screen 5.

The following list is of available compounds that provide Phosphorus for the stock solution. You will be asked to rank these compounds in order of preference for usage.

What rank is assigned to Monoammonium Phosphate? 2 <Enter>  
What rank is assigned to Phosphoric Acid? 1 <Enter>



### Screen 6.

The following list is of available compounds that provide Potassium for the stock solution. You will be asked to rank these compounds in order of preference for usage.

What rank is assigned to Potassium Carbonate? 1 <Enter>

What rank is assigned to Potassium Chloride? 2 <Enter>

### Screen 7.

The following list is of available compounds that provide Sulphur for the stock solution. You will be asked to rank these compounds in order of preference for usage.

What rank is assigned to Magnesium Sulfate? 1 <Enter>

What rank is assigned to Sulphuric Acid? 2 <Enter>

Now the MACRONUT program computes the optimal formulation.

### Screen 8.

Please be patient calculating optimum formulation.....

Now input the injector or siphon ratio.

### Screen 9.

What is the injector ratio or siphon rate 1:###? 100 <Enter>

Now the computer will generate the optimal fertilizer recipe given these inputs.

Screen 10.

Nutrient	ppm in Applied Solution	Target ppm
Magnesium	38	38
Sulphur	49	49
Potassium	75	75
Phosphorus	75	75
Ammonium	75	75
Nitrate	75	75
Nitrogen	150	150

The following table lists the compounds and amounts to use to develop the stock solution to achieve the desired concentration in the applied solution.

Source	Grams/Liter	Grams/Gallon
Magnesium Sulfate	38.00	143.84
Potassium Carbonate	13.39	50.70
Phosphoric Acid	23.44	88.72
Ammonium Nitrate	44.12	167.00

Would you like a printed copy      y/n?

**Error Scenario Number 1. - Not including magnesium sulfate as a source compound.**

At the DOS prompt type <MACRONUT> and press the <Enter> key.

**Screen 1.**

This program determines the amounts of available preferred compounds to mix per liter or per gallon that supply the macro-nutrients (N,P,K,Mg,S) to develop customized fertilizer solutions.

Press enter to continue escape to exit...? <Enter>

Now enter the target levels of mineral nutrients in the applied solution.

**Screen 2.**

What is the ppm target level of total Nitrogen in the applied solution? 150  
<Enter>

What is the percentage of total Nitrogen derived from NO3 compounds? 50 <Enter>

What is the ppm target level of Phosphorus in the applied solution? 75 <Enter>

What is the ppm target level of Potassium in the applied solution? 75 <Enter>

What is the ppm target level of Magnesium in the applied solution? 38 <Enter>

What is the ppm target level of Sulphur in the applied solution? 49 <Enter>

Because several of the compounds may supply more than one of the macro-nutrients, deriving a formulation that exactly meets the ppm target levels may not be possible. Therefore a 5% tolerance is incorporated to allow for formulation using specified criteria.

Press enter to continue...? <Enter>

Now enter the compounds which are available.

### Screen 3.

All of the questions on this screen can be answered with a y/n.  
The default (just pressing enter) is NO.

Is Ammonium Nitrate available as a component of the stock solution? y <Enter>  
Is Ammonium Sulfate available as a component of the stock solution? n <Enter>  
Is Diammonium Phosphate available as a component of the stock solution? n  
<Enter>  
Is Dipotassium Phosphate available as a component of the stock solution? n  
<Enter>  
Is Magnesium Sulfate available as a component of the stock solution? <Enter>  
Is Monoammonium Phosphate available as a component of the stock solution? y  
<Enter>  
Is Monopotassium Phosphate available as a component of the stock solution? n  
<Enter>  
Is Nitric Acid available as a component of the stock solution? n <Enter>  
Is Phosphoric Acid available as a component of the stock solution? y <Enter>  
Is Potassium Carbonate available as a component of the stock solution? y <Enter>  
Is Potassium Chloride available as a component of the stock solution? y <Enter>  
Is Potassium Nitrate available as a component of the stock solution? n <Enter>  
Is Potassium Sulfate available as a component of the stock solution? n <Enter>  
Is Sodium Nitrate available as a component of the stock solution? n <Enter>  
Is Sulphuric Acid available as a component of the stock solution? y <Enter>  
Is Urea available as a component of the stock solution? n <Enter>

### Error Screen.

You have specified a Magnesium target level of 38 ppm but you do not have an available source of Magnesium. Do you want to 1) Reset the target to 0, 2) Claim Magnesium Sulfate is available, or 3) Start over. 1/2/3?

Select one of the 3 options by entering a <1>, <2>, or <3> and press <Enter>.

## Error Scenario Number 2. - Setting an unachievable magnesium-sulphur ratio.

At the DOS prompt type <MACRONUT> and press the <Enter> key.

### Screen 1.

This program determines the amounts of available preferred compounds to mix per liter or per gallon that supply the macro-nutrients (N,P,K,Mg,S) to develop customized fertilizer solutions.

Press enter to continue escape to exit...? <Enter>

Now enter the target levels of mineral nutrients in the applied solution.

### Screen 2.

What is the ppm target level of total Nitrogen in the applied solution? 150  
<Enter>

What is the percentage of total Nitrogen derived from NO3 compounds? 50 <Enter>

What is the ppm target level of Phosphorus in the applied solution? 75 <Enter>

What is the ppm target level of Potassium in the applied solution? 75 <Enter>

What is the ppm target level of Magnesium in the applied solution? 38 <Enter>

What is the ppm target level of Sulphur in the applied solution? 40 <Enter>

Because several of the compounds may supply more than one of the macro-nutrients, deriving a formulation that exactly meets the ppm target levels may not be possible. Therefore a 5% tolerance is incorporated to allow for formulation using specified criteria.

Press enter to continue...? <Enter>

Now enter the compounds which are available.

### Screen 3.

All of the questions on this screen can be answered with a y/n.  
The default (just pressing enter) is NO.

Is Ammonium Nitrate available as a component of the stock solution? y <Enter>  
Is Ammonium Sulfate available as a component of the stock solution? n <Enter>  
Is Diammonium Phosphate available as a component of the stock solution? n <Enter>  
Is Dipotassium Phosphate available as a component of the stock solution? n  
<Enter>  
Is Magnesium Sulfate available as a component of the stock solution? y <Enter>  
Is Monoammonium Phosphate available as a component of the stock solution? y  
<Enter>  
Is Monopotassium Phosphate available as a component of the stock solution? n  
<Enter>  
Is Nitric Acid available as a component of the stock solution? n <Enter>  
Is Phosphoric Acid available as a component of the stock solution? y <Enter>  
Is Potassium Carbonate available as a component of the stock solution? y <Enter>  
Is Potassium Chloride available as a component of the stock solution? y <Enter>  
Is Potassium Nitrate available as a component of the stock solution? n <Enter>  
Is Potassium Sulfate available as a component of the stock solution? n <Enter>  
Is Sodium Nitrate available as a component of the stock solution? n <Enter>  
Is Sulphuric Acid available as a component of the stock solution? y <Enter>  
Is Urea available as a component of the stock solution? n <Enter>

### Error Screen.

You have specified a Magnesium target level of 38 ppm, and a Sulphur target level of 40 ppm. If Magnesium is a required nutrient then the minimum Sulphur target level is 49 ppm for 38 ppm of Magnesium. 1) Do you want to reset the Magnesium target level to 0, 2) Reset the Sulphur target level to the minimum, or 3) Restart the program.1/2/3?

Select one of the 3 options by entering a <1>, <2>, or <3> and press <Enter>.

### Error Scenario Number 3. - Setting an unachievable ratio for the compounds listed as available.

At the DOS prompt type <MACRONUT> and press the <Enter> key.

#### Screen 1.

This program determines the amounts of available preferred compounds to mix per liter or per gallon that supply the macro-nutrients (N,P,K,Mg,S) to develop customized fertilizer solutions.

Press enter to continue escape to exit...? <Enter>

Now enter the target levels of mineral nutrients in the applied solution.

#### Screen 2.

What is the ppm target level of total Nitrogen in the applied solution? 100  
<Enter>  
What is the percentage of total Nitrogen derived from NO3 compounds? 50 <Enter>  
What is the ppm target level of Phosphorus in the applied solution? 75 <Enter>  
What is the ppm target level of Potassium in the applied solution? 75 <Enter>  
What is the ppm target level of Magnesium in the applied solution? 50 <Enter>  
What is the ppm target level of Sulphur in the applied solution? 100 <Enter>

Because several of the compounds may supply more than one of the macro-nutrients, deriving a formulation that exactly meets the ppm target levels may not be possible. Therefore a 5% tolerance is incorporated to allow for formulation using specified criteria.

Press enter to continue...? <Enter>

Now enter the compounds which are available.

### Screen 3.

All of the questions on this screen can be answered with a y/n.  
The default (just pressing enter) is NO.

Is Ammonium Nitrate available as a component of the stock solution? y <Enter>  
Is Ammonium Sulfate available as a component of the stock solution? <Enter>  
Is Diammonium Phosphate available as a component of the stock solution? y <Enter>  
Is Dipotassium Phosphate available as a component of the stock solution? y  
<Enter>  
Is Magnesium Sulfate available as a component of the stock solution? y <Enter>  
Is Monoammonium Phosphate available as a component of the stock solution? y  
<Enter>  
Is Monopotassium Phosphate available as a component of the stock solution? y  
<Enter>  
Is Nitric Acid available as a component of the stock solution? y <Enter>  
Is Phosphoric Acid available as a component of the stock solution? y <Enter>  
Is Potassium Carbonate available as a component of the stock solution? y <Enter>  
Is Potassium Chloride available as a component of the stock solution? y <Enter>  
Is Potassium Nitrate available as a component of the stock solution? y <Enter>  
Is Potassium Sulfate available as a component of the stock solution? n <Enter>  
Is Sodium Nitrate available as a component of the stock solution? y <Enter>  
Is Sulphuric Acid available as a component of the stock solution? n <Enter>  
Is Urea available as a component of the stock solution? y <Enter>



### No Solution Screen.

No solution is possible with current criteria. The closest approximation is shown in the table below with the list of compounds used to develop the approximation to the desired concentrations in the applied solution.

Nutrient ppm in Applied Solution	Target ppm
Magnesium	50
Sulphur	79
Potassium	75
Phosphorus	75
Ammonium	50
Nitrate	50
Nitrogen	100

Source

Magnesium Sulfate  
Dipotassium Phosphate  
Ammonium Nitrate

Do you want a printed copy y/n?

Note: Here MACRONUT was not able to achieve 100 ppm of sulphur in the applied solution. By default MACRONUT will not calculate mixing rates for a stock solution.