C-EC-11-Rev

# B-21 INPUT FORM GUIDE BOOK

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## Introduction

To be a competitive crop producer, you must use your limited land, labor, and machinery resources efficiently. Based on the data you provide, B-21 carefully calculates the possible ways that your resources can be used and selects the way that will provide the largest return to your present land, labor, and machinery resources. In allocating your land, labor and machinery resources to the most profitable crop production alternatives, differences in the direct costs of production (fertilizer, seed, chemicals, etc.), differences in yield related to plant-harvest date and differences in amount and timing of machinery and labor needed are recognized. You can describe your farm in B-21 by entering the quantity of land, labor and machinery resources available, and the methods you use to produce crops.

To use the model to explore alternative problem solutions, you will first want to be sure that your current situation is accurately represented. The accuracy of your representation can be tested by providing the requested data and then reviewing the model results. The results you obtain should indicate average yields similar to those you receive. The results should also indicate that planting and harvesting are completed at the times you are typically finished. The results will not match any specific year, but should represent the typical case. If the model results differ from those you experience in real life, you will need to change one or more input entries.

After you have developed a realistic representation of your current situation, you can use B-21 to assess many alternatives:

1. How might changing your crop mix affect your farm business?

2. How might reducing some of your tillage operations or a shift to a reduced tillage production system affect your farm business?

3. How might working additional hours or hiring part-time labor during the spring and fall affect your farm situation?

4. How would purchasing a larger planter or combine affect your farm situation?

5. How would adding more land through rental or purchase affect your crop mix and machinery resource requirements?

6. How would purchasing a drill and planting corn and soybeans at the same time affect your farm situation?

7. How would adding auto-steer technology affect timeliness?

For each situation you choose to investigate, B-21 will select the combination of crops and the acreage of those crops that provides the maximum return to your land, labor and machinery resources.

**Estimating the Value of Scarce Resources**

In B-21, the crop year has been divided into 20 time periods. Most of these time periods are one, two, or three weeks in length. Because lower yields are expected when crops are not planted and harvested in the best time periods, the resources available in the best time periods will be used first. At least one of these resources is likely to be used completely. Why? Because you don't have enough labor or machinery capacity to complete planting and harvesting your most profitable crop at the most profitable time. We say the labor or machinery resources are scarce, when all that is available in a period is used.

If a resource is scarce, it will have an economic value. The marginal value or shadow price contained in your solution report is an estimate of the value of a scarce resource for your farm situation. Shadow prices for scarce resources represent the increase in return to your land, labor and machinery resources achieved by using the last unit (acre of land, hour of labor, hour of planter time, etc.) If the last unit of a scarce resource were not used, returns would be reduced by the amount of the marginal value or shadow price. If a resource is not completely utilized, the return for the last unit (its shadow price) will be zero. Several of your resources will have a zero shadow price, indicating there is more available than needed (an excess quantity).

You can calculate a planter time shadow price yourself. If you were to unexpectedly miss an hour of planting on May 1st, when would you make it up? Is your answer the next good field day? Well, when you decided your farm size, your crop mix, and your planter size, you likely committed the next day as a part of your planting schedule. Therefore, you can make up for the missed hour only at the end of your planting season when expected yields are lower.

Suppose you grow only corn and begin planting it in late April and finish about May 20. Suppose your expected May 1 yield is 160 bushels per acre and your other yields are similar to the yield adjustment set for corn on page 43 of the B-21 Input Form.

Refer to the corn yield adjustment set for the October 11-31 harvest period. Note that May 1 planting yield is 98 percent and May 20 yield is 84 percent. With a best yield at 160,

| | | |
|---|---|---|
| the May 1-October 11-31 yield is .98 X 160 = | | 157 |
| the May 20-October 11-31 yield is .84 X 160 = | | 134 |
| the difference is | | 23 bushels |
| with a six row planter, you can plant approximately | X | 6 acres/hr |
| and your yield difference per hour is | | 138 bushels |
| at $2.50 corn price | X | $2.50 |
| and your May 1 shadow price | = | $345 per hour |

As you will discover, if B-21 uses all your acres, acres become scarce and your solution will have a shadow price for acres. The acres shadow price indicates the return (revenue minus variable costs) for growing the *last* (least profitable) acre of a crop grown with your labor and machinery time. Since this is linear programming, the land shadow price may also indicate your returns to resources for the *next* acre you add.

Figure 1 is Table A-1 of your B-21 solution.

Total Contribution Margin is $261,223. This is the return to your resources for growing your crops in the best way possible for your solution.

Profit from Operation is also $261,223. Since this amount is the same as the total contribution margin, no land, labor, or machinery charges were entered on Input Form page 49.

Acres not used is “0". Great! All acres you entered in Input Form page 5 were used. When this amount is not “0", find the reason and correct the problem before doing any other analysis.

Total Additional Acres rented is “0", when this amount is not “0", but less than acres available to rent that you entered on page 49, you know that the solver couldn’t profitably rent all the available extra rented acres.

Table A-1: Production Summary

| | | |
|---|---|---|
| Total Contribution Margin (Return to Resource) | | $ 261223 |
| Profit from Operation | | $ 261223 |
| Total Acres Not Used | | 0.0 |
| Total Additional Acres Rented | | 0.0 |
| Crop Production | | |
| CCorn | (acres) | 100.0 |
| CCorn (nd) | (acres) | 0.0 |
| BCorn | (acres) | 850.0 |
| BCorn (nd) | (acres) | 0.0 |
| WCorn | (acres) | 100.0 |
| BCorn – s | (acres) | 0.0 |
| Wheat | (acres) | 100.0 |
| Wheat (nd) | (acres) | 0.0 |
| CBeans (wr) | (acres) | 0.0 |
| CBeans (nr) | (acres) | 850.0 |
| BBeans | (acres) | 0.0 |
| DWBeans | (acres) | 100.0 |
| BPop | (acres) | 0.0 |
| Set-aside | (acres) | 0.0 |
| Other Crop #1 | (acres) | 0.0 |
| Other Crop #2 | (acres) | 0.0 |
| Other Crop #3 | (acres) | 0.0 |

**Figure 1. Production Summary**

Figure 2 is Table B-1. It summarizes the labor and machinery resources that were completely used. If a resource is not completely used it will not be listed in this table. Since “labor” does not appear in the table, labor was never completely used in any period in this solution. The corn planter was completely used in three periods, and the drill was completely used in a fourth period. Likely, this farm is “timely”, i.e., does not have too much or too little planting equipment. Harvester time is completely used in only two periods. If the working rate was right, the combine may be too big, a problem of excess harvesting capacity.

Table B-1: Summary of Limiting Labor and Machinery Resources

If a resource is listed in this table, the available quantity is completely utilized. If you could obtain one more unit of this resource, your revenues would increase by the amount of the marginal value.

| Item or Resource | | | | Marginal Value |
|---|---|---|---|---|
| Planters: | | | | |
| Planter | | | | ($/hour) |
| April | 22- | April | 25 | 70.77 |
| April | 26- | May | 2 | 187.75 |
| May | 3- | May | 9 | 149.37 |
| Drill | | | | ($/hour) |
| May | 10- | May | 16 | 3.13 |
| Harvesters: | | | | |
| Combine | | | | ($/hour) |
| Sep | 27- | Oct | 10 | 66.85 |
| Oct | 11- | Oct | 31 | 34.28 |

**Figure 2. Summary of Limiting Labor and Machinery Resources**

Figure 3 is a summary of limiting land resources. Here, the next acre of land, provides a return before the payment of rent of $47.21 per acre. Therefore, at the prices, costs, working rates, and present acreage, a person couldn’t pay much rent for extra acres. (Remember, however, there is no entry for government payments in B-21.)

Table C-1: Summary of Limiting Land and Facility Resources

If a resource is listed in this table, the available quantity is completely utilized. If you could obtain one more unit of this resource, your revenues would increase by the amount of the marginal value.

| Item or Resource | | Marginal Value |
|---|---|---|
| Land: | | ($/hour) |
| Whole farm | -owned/cash | 47.21 |

**Figure 3. Summary of Limiting Land Resource**

Remember, *shadow prices are reported for those resources that are completely used. In the computer at least, the last unit of this resource increased returns by the value indicated. If you could somehow get another unit of the scarce resource it is likely that returns would increase by a similar value.* Compare the estimated value of the resource with the cost of acquiring additional quantities. You will also want to explore how many units to which the shadow price applies.

*Learn to interpret* the computer solution, especially *the shadow prices and use the shadow price signals to guide the development of alternatives for solving the resource problems identified*. The most important use of shadow prices is for you to see which resources limit your returns and to think about the most cost effective alternative, including making no change. On each solution, you may be either untimely or too timely. Many corn-soybean farmers have found they can afford to complete planting in about 10 days and harvesting in about 27-30 good field days. Otherwise, their solutions show a so-called Type I or Type II problem.

**Type I Problem. Untimely Field Work**

Causes of the Problem:
- Too many acres
- Too small machinery
- Too short working days

Symptoms of the Problem:
- Some acres not farmed
- Some acres planted to single crop wheat
- No more Sept. 27-Nov.14 harvest capacity (three shadow prices)[1]
- No more April 26-May 23 planting capacity (four shadow prices)[1]
- Low or non-existent shadow price for land

Alternative Solutions to the Problem:
- Rent out or sell some land
- Work longer hours
- Get bigger machinery
- Grow wheat
- Hope the weather is better next year

**Type II Problem. Excess Machinery/Labor Capacity**

Causes of the Problem:
- Too few acres
- Too large machinery

Symptoms of the Problem:
- Two or less shadow prices in planting periods
- One or less shadow prices in harvest periods
- No land planted to single crop wheat
- High shadow prices for an additional acre of land

Alternative Solutions to the Problem:
- Rent or buy more acres
- Perform custom work for others
- Add more livestock or non-farm job
- Get smaller machinery

[1] These period shadow prices may be any combination of permanent labor hours, tractor hours, combine hours, planter hours, or other machinery hours. The *number* of periods with shadow prices in planting and harvesting is generally more significant than the *amount* of *these* shadow price values. When counting the number of periods, ignore periods where the shadow price on permanent labor equals your part-time hired labor wage rate. In these ignored periods you are hiring some temporary labor but still have extra temporary labor available.

## Visualizing the Linear Programming Process

B-21 finds the best way to use your land, labor, and machinery resources by use of linear programming. You might think of the process this way. Create a big table of information such as outlined in Table 1. This table includes three sections. The resource section will be listed down the left side. The production alternative section will be on the right side. The reward section will be along the bottom of each production alternative column.

### Available Resources

First, make one long column listing of your land, labor, and machinery. Under each resource, make 20 rows, to represent 20 different time periods during the year. Now you have a row in the resource column for each resource for each of the 20 time periods in B-21.

Now make a second column to the right of the first one and label it "Resource Availability". Note that you now have a cell at the intersection of this column with each of the resource rows you made previously. For each resource in the first column, enter the amount of the resource that is available to be used in each of the 20 time periods. Place the amount in the box or cell on the appropriate row.

Now you have completed the part of your table or matrix listing the quantity of each resource available to be used in each time period.

The resources you describe as available for use in crop production in B-21 are:

1. The amount of land available for row crops and small grains.

2. The availability of yourself, other permanent labor, and part-time labor based on the:
   a. number of people available to work,
   b. number of hours per day devoted to work in the field, and
   c. number of days suitable for fieldwork in each of 20 periods.

3. The availability of your machinery based on the:
   a. number of machines of each type available for use in crop production,
   b. number of hours per day that the machine is available for use in crop production, and
   c. working rates in acres per hour for each crop production task.

When you complete the land and labor resource sections of page 5, the days suitable for field work on page 7, and machinery resources on page 9 of the Input Form, you indicate your available resources.

**Table 1. Table Of Available Resources And Alternative Ways Of Using Resources**

| Column 1 | Column 2 | Production Alternatives | | |
|---|---|---|---|---|
| My Resources | Resource Availability | Recipe 1 | Recipe 2 | Etc. |
| Acres<br>Time period 1<br>Time period 2<br>.<br>.<br>Time period 20 | | | | |
| My time + Full-time employee time<br>Time period 1<br>.<br>. | | | | |
| My tractor time<br>Time period 1<br>.<br>. | | | | |
| My field cultivator time<br>Time period 1<br>.<br>. | | | | |
| My planter time<br>Time period 1<br>.<br>. | | | | |
| My combine time<br>Time period 1<br>.<br>. | | | | |
| My storage<br>Time period 1<br>.<br>. | | | | |
| My Reward<br>Per acre revenue (yield x price)<br>Minus variable costs equals<br>Per acre contribution margin | | | | |
| Total contribution margin<br>(Per acre margin X acres produced)<br>Return to farm resources | = | + XXX | + XXX | + XXX |

**Crop Recipes and Resource Usage**

The model is programmed to consider many different ways or recipes to use your resources. Each crop recipe represents a way of growing a crop which is different in at lease one ingredient. Ingredients include level of fertilization, seeding rate, herbicide used, time of planting, and many other factors. Each way is described using one column of Table 1. How might you do this?

First, for each resource row, enter the amount of that resource used if you make one unit (say, an acre) of the alternative. As an example, you would enter "1" at the intersection of your recipe column and your land resource row. This indicates that if you use this recipe to grow an acre of say, continuous corn, you will actually need one acre to do it.

Each alternative recipe is quite specific in terms of the inputs used to produce a crop, the expected yield, and the period that resources are used. Each crop can be grown by planting and harvesting in several different time periods. For example, **CCorn** (corn following corn) can be planted in each of seven planting periods and harvested in each of five harvesting periods. Therefore, there are 7 x 5 or 35 different **CCorn** columns or recipes.

Actually, each crop can be sold at harvest or out of storage and dried either on the farm or off the farm. Also, spring tillage before planting can be done in many different time periods. In B-21, you enter information for all these recipes. How do you do that? The answer is — you enter information for each of the crops defined on page 14 of your Input Form. Then, the model creates the information needed for the crop recipes. You provide estimates of sales prices, the machinery operations required to produce a crop, estimated yields, yield adjustments for planting and harvest periods and cost of purchased inputs.

## Describing Your Crop Alternatives in B-21

In the earlier section of the Input Form, pages 5, 7, and 9, you described the land, labor and machinery resources available on your farm. The alternative ways that these resources can be used to produce crops (your crop recipes) are described by completing a crop production sheet such as Table 2. This sheet for corn following corn is page 17 of the Input Form. On it, indicate the tillage practices by machine ID number, when they can occur, the rate of operation, yield, and production costs for each crop.

**Machinery Working Rates**

For each crop, you are asked to indicate your machinery working rates in acres per hour for each tillage, planting, and harvesting job performed. By this process you do two things.

First, you indicate the amount of labor, tractor, harvester, and other machine *time resources you use* if you grow an acre of a crop.

Table 2. An Example Crop Production Recipe

**CCorn** - Corn Following corn

| | Machinery Type ID No. | Machinery Operations: Beginning Period | Machinery Operations: Ending Period | Working Rate Acres Per Hour | Labor Hours Per Machine Hour |
|---|---|---|---|---|---|
| **Land Preparation** | 1 | 17 | 20 | 21.8 | 1 |
| | 3 | 17 | 20 | 10.5 | 1 |
| | 6 | 1 | 8 | 15.7 | 1 |
| | 4 | 1 | 8 | 10.7 | 1.25 |
| | 6 | 2 | 8 | 16.5 | 1 |
| | | | | | |
| **Planting[1]** | | Yield adjustment set | 1 | | |
| | 1 | | | 8.4 | 1.25 |
| **Post-Plant** | | Job can begin weeks after plant | Weeks to complete | | |
| | 9 | 4 | 2 | 38.3 | 1 |
| | | | | | |
| | | | | | |
| | | | | | |
| **Harvest** | | Expected Yield | | | |
| | 1 | (155) | 160 | 4 | 2 |

What is your per acre cost for seed, fertilizer, lime, & chemicals? (144) $200

What is your per acre cost for tractor and harvester fuel and repairs? (19) $25

[1]Yield adjustment set 1 allows corn to be planted form April 22 to June 6 and harvested from September 20 to December 5. The "1" in the machine type ID No. column indicates the corn planter is used.

Second, the machinery working rate implies the *size of* each *machinery resource you have* available.

Suppose you use a chisel plow and can do that job at the rate of six acres an hour with your big tractor. Your recipe would have numbers placed in the resource cells for chisel plow time , tractor time, and my time of Table 1 to reflect the various types of time charges.

At first, you might think you would put a "6" in each of these cells. *After all, that's what you would put in your B-21 Input Form for **CCorn** in the LAND PREPARATION section*. However, if you can chisel plow six acres per hour, you really use only 1/6 of an hour of each of these resources to get the plowing done on one acre. Therefore, when you input a "6" on page 17, of the Input Form, the model converts it to 0.17 before placing the value in the model. Since all labor and machinery constraints in B-21 are measured in hours, the model converts the values you place in the other cells on this page and similar pages to hours per acre for each crop.

Refer to Appendix Tables A-C for help in developing your working rates and then transfer these rates to the appropriate page for each crop. Note that example farm rates for **CCorn**, **BCorn**, and **CBeans(wr)** have been calculated on the Machinery Working Rate Worksheet (Table 3). Use worksheet Table 4 to calculate your rates. Then, transfer your rates to the appropriate crop Input Form page. The example farm rates for **CCorn** in Table 3 have been transferred to Table 2.

After studying your first B-21 solution, you may want to test the effect of a different size machine, such as an 8-row planter instead of your present 6-row planter. Obtain a new Input Form, and replace the 6-row planter rate on each appropriate crop page, such as Input Form page 17 for CCorn. If you then run a new solution, you will see how the use of your other resources is affected and you will obtain a new total contribution margin or return to resources.

If you have entered the extra annual average cost for the larger planter on page 49 of the Input Form, you will learn whether your profit from operations increased. Refer to "Economic Budgets" section later in this publication for more help on how to consider these costs.

**Table 3. Machinery Working Rate[1] Worksheet For Purdue Example Farm**

| Job | Equipment | Width (ft.) | x | Speed (MPH) | x | % Field Efficiency | ÷ | Conversion Factor | = | Rate A/Hr | Amount[2] | CCorn | BCorn | CBean (wr) | Beginning Period | Ending Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Prep | Spread P&K | 60 | x | 6 | x | 50 | ÷ | 8.25 | = | 21.8 | X 1 | 21.8 | 21.8 | | 17 | 20 |
| | Chisel Corn Stalks | 18 | x | 6 | x | 80 | ÷ | 8.25 | = | 10.5 | X 1 | 10.5 | | 10.5 | 17 | 20 |
| | Chisel Bean Stubble | 18 | x | 6 | x | 80 | ÷ | 8.25 | = | 10.5 | X 1 | | 10.5 | | 17 | 20 |
| | Field Cultivator & Herbicide | 28 | x | 6 | x | 77 | ÷ | 8.25 | = | 15.7 | X 1 | 15.7 | 15.7 | 15.7 | 1 | 8 |
| | NH | 20 | x | 5.5 | x | 80 | ÷ | 8.25 | = | 10.7 | X 1 | 10.7 | 10.7 | | 1 | 8 |
| Plant | Field Cultivator | 28 | x | 6 | x | 81 | ÷ | 8.25 | = | 16.5 | X 1 | 16.5 | 16.5 | 16.5 | 2 | 8 |
| | Plant 8-30 | 20 | x | 5 | x | 69 | ÷ | 8.25 | = | 8.4 | X 1 | 8.4 | 8.4 | 8.4 | 2 | 8 |
| Plant | Cultivate | 20 | x | 4 | x | 78 | ÷ | 8.25 | = | 7.6 | X 5[3] | 38[3] | 38[3] | 7.6 | 5 | 11 |
| Harvest | Combine Corn 8-30 | 20 | x | 3 | x | 55 | ÷ | 8.25 | = | 4.0 | X 1 | 4.0 | 4.0 | | 16 | 20 |
| | Combine Small Grain | 25 | x | 3.5 | x | 65 | ÷ | 8.25 | = | 6.9 | X 0.7[4] | | | 4.8[4] | 16 | 20 |

4

5

[1] For all operations indicate the rate for one unit. If you use more than one unit, indicate the *average rate* per unit.
[2] This column is used to make adjustments for the percentage of your acreage that will actually receive this.
[3] Since only 20% of the corn will be cultivated, the rate is multiplied by 5 (5 x 7.6 =38).
[4] Since beans or wheat can be harvested only 70% as many hours per day as corn, the rate is reduced to 70% of the calculated rate (0.70 x 6.9 = 4.8).

**Table 4. Machinery Working Rate Worksheet For Your Farm**

| Job | Crop | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Equipment | Width (ft.) | x | Speed (MPH) | x | % Field Efficiency | ÷ | Conversion Factor | = | Rate A/Hr | Amount | **CCorn** | **BCorn** | **CBean (wr)** | Beginning Period | Ending Period |
| Prep | | | | | | | | | | | | | | | | |
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| Post | | | | | | | | | | | | | | | | |
| Plant | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | |
| Harvest | | | | | | | | | | | | | | | | |
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### The Rewards and Maximizing Them

Now look at the reward section at the bottom of the **My Resources** column in Table 1. Note a row is labeled "Per acre revenue" which is further described as yield times price. Next is a row labeled "Minus variable costs". Variable costs include the seed, fertilizer, chemicals, and also fuel and repairs for the way of growing the crop. Revenue minus variable costs equals per acre contribution margin. The bottom row is "Total contribution margin or returns to resources". You might visualize this as one cell in the large matrix. This cell is the total return from the whole farm, the sum of the per acre contribution margin times the total acres of each crop produced. *The model is programmed to find the one combination of crop production alternatives that makes the "Total Contribution Margin" bigger than any other use of your machinery, labor, and land resources*.

Note that in this section there is no place to enter charges such as the "fixed" land, machinery or labor costs for your resources. That's because, your resources are currently available for use in crop production. They do not vary by the crops produced. If they are not used to produce crops, they will go unused. In this situation "fixed costs" *don't count*.

In real life, "fixed" costs for the land and machinery resources you own and your family labor and the labor of your permanent employees are recognized in the form of debt payment, employee salaries, family living expenses, real estate taxes, personal property taxes, insurance premiums, etc. When you use B-21, you can have the computer subtract the costs you want to recognize for your permanent labor, your land and your machinery by entering these costs on page 49 of the Input Form. Refer to later sections in this guide book for help in considering resource charges.

Suppose you wanted to find the best way to use your resources and define best as being the way that produces the largest total contribution margin (return to your resources). You will want to grow some acreage of some alternative recipes and no acreage of other recipes. How would you find the best acreage of each?

One way would be to make plans using various combinations of each recipe. Given the number of alternatives and the number of resources, you might work with a pencil for many years before you could expect to find the one combination of alternatives that provides the best return to resources.

Another maximizing process would be to use the procedures used in linear programming. This procedure follows a set of rules in deciding what crop alternatives to produce and how much to produce. The optimizer looks at all the available alternatives and picks the one alternative that provides the greatest income. This is the alternative that will be selected first. Next, the procedure determines how much to grow. Since this alternative provides the largest return, you would want to raise as much as possible. How much would this be? It is the amount that completely uses one of your resources. As soon as one of your resources is completely used, such as planting time during the first part of May, it is not possible to produce any additional acreage of this alternative.

All of one resource has been used, but you have several other resources that could be used with other crop production alternatives. The solution procedure next asks if there are other alternatives that will make the return to resources larger. If there are alternatives that will allow an increase in the return to resources, again the solution procedure will grow the maximum acreage of this particular alternative allowed by the available resources.

As more and more alternatives are grown, they will begin to compete for the same resources. In these situations, the quantity of each crop grown will be adjusted in a way that provides the greatest return to resources. *The quantity of the competing crops to raise will depend on the expected return and the quantity of the resource required by the competing alternatives.*

As long as the optimization routine can find an alternative that will improve the returns to resources, it will add the alternative to the list of crops to be grown. Eventually, the possible ways to increase your return to resources will be exhausted and the "best" combination of crop acreage to produce will be determined. For some crops, the acreage grown will be zero.

There are two reasons why you might not grow a crop alternative. First, variable costs might be more than revenue for that alternative recipe. B-21 has perfect knowledge about the crop season you describe. Therefore, if revenue is less than variable costs for a recipe, none of it will be grown. If that situation exists for each and every one of your recipes, nothing will be grown. No work of any kind will be done with your resources and your returns to resources will be "$0.00".

A second reason causes many of your alternative recipes not to be used. The reason is this. Even though a recipe shows a positive dollar return to resources, your total resource returns would be less if you used some of your resources here instead of in other production alternatives. Wheat may show a positive, but lower, return than corn. Strawberries may show a very high per acre return, but may require so much labor per acre that more total resource returns would be realized if the labor were used to grow corn on many acres.

**An Illustration Using Linear Programming Solution Rules**

Let's illustrate the above rules with a simple example that contains two crops (corn and soybeans), and two resources (land and labor). Our objective is to determine the combination of corn and soybeans that will maximize the returns to our land and labor resources. We estimate that corn will provide a return to our land and labor (a contribution margin) of $140 per acre. The estimated return to land and labor from soybean production is $125 per acre. Corn production requires 3.0 hours of labor per acre and soybean production requires 2.1 hours of labor per acre. There is a total of 700 acres of cropland and 1800 hours of labor that can be used to produce these two crops. What combination of corn and soybeans will provide the greatest return, the greatest total contribution margin?

**The Linear Programming Model**

To use the linear programming rules discussed above, the first step is to develop a set of equations that represent our situation. There are two parts to every linear programming model: an objective function and constraints.

The objective function provides an estimate of how much income we will receive (the reward) for the combination of corn and soybeans raised. If we let CORN represent the acres of corn raised and BEANS represent the acres of soybeans raised, then our total returns can be represented by the equation:

$Z = 140 * CORN + 125 * BEANS$
where Z = Total contribution margin or returns to resources

Each acre of corn contributes $140 and each acre of soybeans contributes $125 to the land and labor resources that are available to produce these crops. Multiplying the per acre return by the acres of each crop produced and then adding them together provides the total contribution margin or total returns to resources.

The constraints represent the use and availability of resources. We can represent our resource constraints in our linear programming model by using two inequalities. One of these will represent our land resource and the other our labor resource. For the land resource, we can use the inequality:

$1 * CORN + 1 * BEANS \leq 700$

This constraint states that each acre of corn and soybeans will require an acre of land and that we can raise any combination of these crops as long as total acres used does not exceed 700 acres.

The availability and usage of labor can be represented in the same way. The labor constraint is represented by the inequality:

$3 * CORN + 2.1 * BEANS \leq 1800$

Each acre of corn requires 3 hours of labor per acre and each acre of soybeans requires 2.1 hours of labor per acre. The total labor used cannot exceed the 1,800 hours that are available. Again, this limit says we can raise any combination of corn and soybeans as long as not more than 1,800 hours are used.

If we graph these two constraints, we obtain Figure 4. The acres of corn are on the vertical axis and the acres of soybeans are on the horizontal axis. The constraints divide the graph into two regions. All those combinations that use 700 acres or less of land and 1,800 hours or less of labor, are considered feasible. They use only those resources available, the feasible combinations.

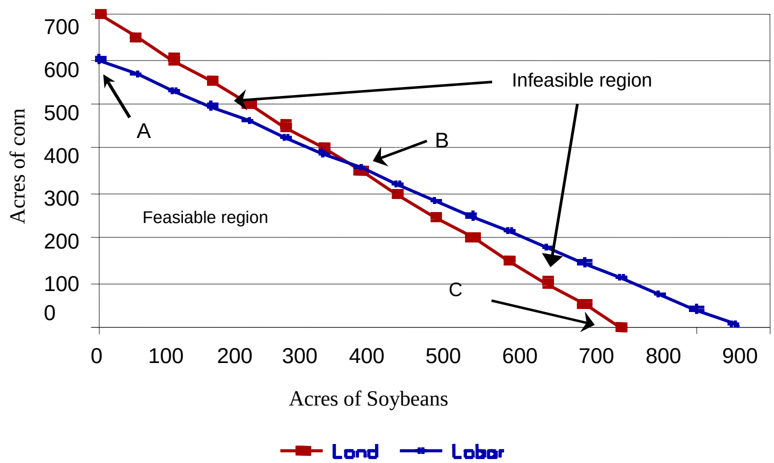


**Figure 4. Production alternatives when considering land and labor resources**

The second region of the graph is the infeasible region. This region represents those combinations of corn and soybeans that require more land, more labor, or both more land and labor than we have available.

**Selecting the Most Profitable Combination**

While considering only feasible alternatives reduces the number of corn and soybean acreage combinations that we must consider, there are still several. However, by using the rules of a linear programming optimizer, we can quickly find the most profitable combination.

What alternative provides the most income?
  Corn -- $140 per acre compared to only $125 for soybeans
What is the maximum that we can produce?
  600 acres (Point A) -- because at that point we have used all the available labor and can't produce any more corn
What is our reward?
  600 acres x 140 = $84,000

Can we find a combination that would provide more income? We have used all the labor, but there is land that is not planted. Soybeans take less labor than corn. If soybeans were added to the crop mix, we could farm more acres with the same amount of labor. And, soybeans provide a positive return to land and labor, just not as much as corn.

Moving from Point A to B changes the mix of corn and soybeans. Starting at Point A and moving toward Point B, the acres of corn produced must be reduced in order to obtain the labor needed for producing soybeans. Since each acre of soybeans produced requires less labor than corn, an acre of soybeans can be added without reducing corn by a full acre. To obtain the labor needed for one acre of soybeans (2.1 hours), corn production must be reduced by 0.7 acres (2.1 hours/acre ÷ 3 hours/acre = 0.7 acres). As we substitute soybeans for corn (move from Point A to Point B), the amount of unused land decreases. Does this substitution increase our return? We are giving up the return from 0.7 acres of corn (0.7 x $140 = $98). We are gaining the return from one acre of soybeans ($125). This substitution will increase our reward.

The mathematical solution of the system of equations indicates that at Point B, we are producing 366.7 acres of corn and 333.3 acres of soybeans, and both land and labor are completely used. Our return has now increased to $93,000.50 (366.7 x $140 + 333.3 x $125).

If we continue to add soybeans, move from Point B to Point C, to our crop mix, the land resource will now determine how we must substitute soybeans for corn. This constraint requires that for each acre of soybeans added, corn must be reduced by one acre. We gain $125 for the additional acre of soybeans, but must give up $140 in reduced corn production. Since this will cause returns to decline, this substitution should not be made. The combination of corn and soybeans that maximizes returns would be at Point B, 366.7 acres of corn and 333.3 acres of soybeans. This combination of crops provides a total return of $93,000.50.

**Value of Limiting Resources**

Production of 366.7 acres of corn and 333.3 acres of soybeans exhausts the available land and labor resources. Since the land and labor resources are completely utilized, they are said to limit production. Estimating the economic value (the shadow price) of these resources can help us decide if we should try to obtain more of these limiting resources. If the estimated value is more than the expected cost, this indicates that additional resources could help increase profits.

To illustrate how the shadow price for a resource can be estimated, assume that the amount of available land is increased 50 acres (a "small" change). How much would our income increase? How should we adjust the crop mix in order to maximize returns in this new situation? Should both corn and soybean production be increased? Or should only corn production be increased, since it is the most profitable of the two crops?

Figure 5 can help with this analysis. With the increase in land, the land constraint will shift to the right (the "More land" line in the graph). For this new situation, the combination of corn and soybeans that maximizes returns will shift from Point B to Point D. We should decrease corn production but increase soybean production. With 50 more acres of land, the combination of corn and soybeans providing the largest return is 250 acres of corn and 500 acres of soybeans. The total return for this combination of crops is $97,500.

Returns have increased $4,499.50 ($97,500 - $93,000.50) with the addition of 50 acres. The added return per acre would be $89.99 ($4,499.50 ÷ 50). If land can be rented for less than this amount, profits can be increased by renting additional land. However this return will be obtained only if the crop mix is changed. By referring back to Figure 5, we can see that adding additional land will result in more soybean acres and fewer corn acres because of the limited quantity of labor. If the quantity of available labor is also changed, then some other combination of corn and soybean acreage would maximize returns.

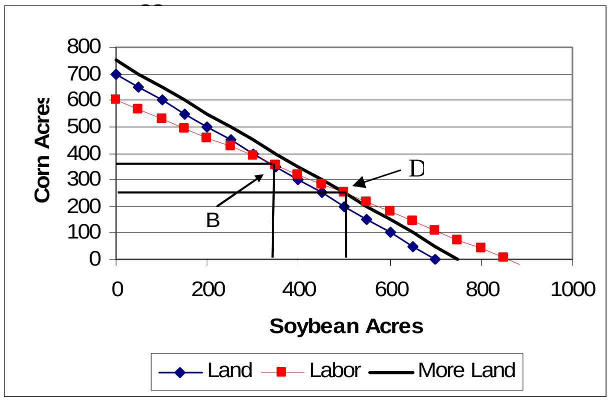


**Figure 5. Production possibilities with 50 additional acres**

As you review the shadow prices that are contained in your results, remember that these numbers are generated by making small changes in resources, only one resource is changed, and to achieve this return it is likely that there will need to be changes in production levels. What might happen if more than one change is made in the quantity of resources? The linear programming solution process does not provide any direct information about multiple changes. To assess the impact of making more than one change at a time, it will be necessary to make the changes incrementally in your original problem and obtain a new solution for each proposed change.

## Additional B-21 Features and Considerations

The remaining sections of this publication provide information about the additional features of the B-21 model. It also contains information that will help you complete the Input Form and get the most from your use of the model.

**Crop Yields**

Note the crop yield is placed in the reward section of Table 1. Now look at page 17 of your Input Form. Find the cell for “Expected Yield” of the **CCorn** crop. This cell is asking, "What is your average yield in your best plant-harvest period in bushels per acre at 15% moisture for **CCorn**?"

You enter a yield for only one of the 35 ways that **CCorn** can be raised. It is for the April 26-May 2 plant and September 27-October 10 harvest date. Likely, you will think your best yield normally occurs when your corn is planted in early May and harvested in early October. That's the way the model is programmed to use your answer to this question. Yields for other plant/harvest periods are reduced by the yield adjustments contained in the program.

What are the yield adjustments made for each plant/harvest possibility? Note the corn yield adjustment set information on page 43 of the Input Form. For each of the 35 plant/harvest periods, the model is programmed to multiply the yield you input on page 17 by the appropriate percentage coefficient shown in this table. The model places each calculated yield in the appropriate cell of each continuous corn recipe.

You may wish to change these percentages to better reflect your farm situation. If so, create a new yield adjustment set on page 47 of the Input Form.

Crop yield coefficients for soybeans are on Input Form pages 44 and 45. Wheat is on page 44; barley and canola are on page 45. Note the coefficients for wheat, barley, and canola show almost no yield variation by date. Is this true for your situation?

An example yield is shown adjacent to the yield cell on page 17, etc. The following yield relationships between crops are intended:

Rotation corn yield = 1.00 x your yield in your best plant/harvest period.
Continuous corn yield = 0.93 x rotation corn yield
Wide row bean yield = 0.302 x rotation corn yield
Narrow row or solid seed beans = 0.335 (for medium season) x rotation corn yield
Wheat yield = 0.45 to 0.55 x rotation corn yield (0.45 for Brookston soil, 0.50 for Crosby soil, 0.55 for Miami soil)
Barley yield = 0.6 to 0.7 x rotation corn yield
Double crop bean yield = 0.19 x rotation corn yield

These yield relationships are reported in Purdue Publication ID-152 as being representative relationships for Indiana conditions for a typical year. Be careful about using a different relationship. You create your own yield relationships when you enter yields on each of the crop pages. Use a variation only after you are convinced your situation is different.

**Crop Price Relationships**

Crop prices are entered on page 11 of the Input Form. When deciding on the crop prices to use, remember the budget is usually developed to represent a period of 3-5 years in length. Unless you are using this budget for a specific year, or unless you know relationships are likely to be fixed for a period of years because of government programs, you will likely want to use average price relationships between crops. For Indiana, these are approximately the following:

Bean price = 2.3 - 2.4 x corn price
Wheat price = 1.3 - 1.4 x corn price
Barley price = 0.8 x corn price

Be careful in using a different relationship. Price relationships prior to planting are the same at harvest *only about half the time*. Therefore, if you switch your planted acreage to a new crop because of a pre-plant price relationship, you may want to consider somehow contracting for that price.

**Crop Rotations**

When Table 1 was presented, it appeared that each crop production alternative or recipe was for one crop grown in a specific plant-harvest period. However, in B-21, it is assumed that crops will be grown in specified combinations called rotations. The B-21 version was created to include up to 20 crop rotations as discussed on page 14 of the Input Form. On page 15, enter any acreage limits that you want to specify for each rotation. The model is programmed to consider your crop rotation acreages in a typical year. This means you will have the same acres of each crop *in that rotation*. For example, 100 acres of **BCorn-CBeans(wr)** is 50 acres of each crop in any one year. A 100 acres of the three-year **BCorn**, **CCorn**, **CBeans(wr)** rotation would have 33.3 acres of each crop in any one year. To investigate the very best use of your resources, enter a large number such as 9999 to remove any limits you have specified.

**Machinery Adjustments for Multiple Machines and Other Special Situations**

The machinery working rates in Table 2 are for one machine. Labor requirements in Table 2 are the labor requirements for each hour the machine is operating in the field.

What do you enter if you have, say, two plows? The answer is, you enter "2" in the cell headed "No. of machines" on page 9 of the B-21 Input Form. Then, you still give the machine working rate for one plow on each appropriate crop page such as Input Form page 17 if you plow for **CCorn**. Therefore, if the plows are different sizes, you must decide what sort of weighted average machine rate to use. Now, the model can plow with one or both plows depending on availability of tractors and drivers and the competition for completing other jobs.

What do you enter if you, say, chisel plow half your continuous corn stalks and disk half the acreage? The answer for page 17 is you can enter the chisel plow on one line at twice its actual rate and you can enter the disk on another line at twice its actual rate.

How can you compare, say, conventional tillage with no-till? Make two crop pages. Use page 37, Other Crop, for one of these crops. Remember to include rotations for both of these crops on page 15.

**Crop Yields By Tillage System**

Corn and soybean yields are thought to vary by type of tillage. Yield relationships for different soils, different tillage, and different rotations are reported in Table 5. Of course, your experience may indicate different yield relationships between systems.

Suppose you decide to make an alternative budget with a different tillage system. You may decide to adjust yields from your present system by the percent indicated in Table 5.

**Crop Moisture**

Drying cost is calculated based on the expected harvest moisture by date, desired storage moisture content, and the fuel and repair rate per point of moisture removed. Crop moisture by harvest date is shown with the yield adjustment sets on pages 43-45 of the Input Form. You can change these in the same way you change yields.

**Variable Costs by Tillage System**

Remember, in each column, the reward section includes a cell for variable costs. What's included in this cell?

Seed, fertilizer, lime, chemical, hauling, interest, misc. entered on each crop page;
plus machinery fuel and repairs entered for each crop;

plus calculated drying fuel;

plus additional temporary hired labor;

plus additional land rented in.

Refer to the information in APPENDIX Table D for estimates of variable cost quantities for continuous corn, rotation corn, rotation beans, and wheat, using a conventional tillage system.

In the example budgets, fertilizer applications are based on maintaining present fertility levels and are based on yield. Nitrogen quantities are also based on organic matter and previous crop. In the tables, soybeans are charged for fertilizer even though this fertilizer may be applied with the fertilizer for rotation corn. For B-21 to correctly select the combination of crops that maximizes the return to your resources, be sure that your fertilizer costs for corn and soybeans are correctly allocated to each crop.

Fuel is $3.25 per gallon. It is based on coefficients in APPENDIX Table E. Machinery repairs are based on annual hours used coefficients from APPENDIX Table F derived using the Purdue Machinery Cost Calculator (PMC). Repair costs are for a seven year trading policy for planters and combines and a ten year policy for other machinery.

**Table 5. Corn and Soybean Yield Coefficients for Tillage Systems[1], Indiana Soils**

| | Soil Tillage-Management Group[2] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Example Soils | Brookston | Clermont | Maumee | Mucks | Blunt | Crosby | Morley | Miami | Sloping |
| Rotation Corn | | | | | | | | | |
| Fall Plow | 1.00 | **1.00** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Fall Chisel | 1.00 | 1.00 | 1.03 | 1.03 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Spring Plow | 0 .96 | 1.00 | 1.00 | 1.05 | 0 .98 | 0 .98 | 1.00 | 1.00 | 1.03 |
| Spring Disk or Field Cultivate | 1.00 | 1.00 | 1.03 | 1.05 | 1.00 | 1.00 | 1.03 | 1.03 | 1.03 |
| Ridge | | 1.00 | 1.06 | 1.03 | 0 .98 | 1.00 | 1.03 | 1.06 | 1.03 |
| No-Till | 0.97 | 1.06 | 1.06 | 0.98 | 0.96 | 0.98 | 1.06 | 1.10 | 1.10 |
| Continuous Corn | | | | | | | | | |
| Fall Plow | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| Fall Chisel | 0.91 | 0.93 | 0.98 | 0.96 | 0.93 | 0.93 | 0.96 | 0.98 | 0.98 |
| Spring Plow | 0.87 | 0.93 | 0.93 | 0.98 | 0.91 | 0.91 | 0.95 | 0.95 | 0.95 |
| Spring Disk or Field Cultivate | 0.89 | 0.93 | 0.98 | 0.98 | 0.91 | 0.93 | 0.96 | 0.98 | 0.98 |
| Ridge | 0.91 | 0.91 | 0.98 | 0.98 | 0.89 | 0.93 | 0.96 | 1.00 | 1.00 |
| No-Till | 0.84 | 0.95 | 0.92 | 0.90 | 0.87 | 091 | 1.00 | 1.03 | 1.05 |
| Rotation Beans | | | | | | | | | |
| Fall Plow | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Fall Chisel | 0.96 | 1.00 | 1.05 | 1.03 | 1.00 | 1.00 | 1.03 | 1.05 | 1.05 |
| Spring Plow | 0.96 | 1.00 | 1.00 | 1.05 | 1.00 | 1.00 | 1.00 | 1.00 | 1.02 |
| Spring Disk or Field Cultivate | 0.96 | 1.05 | 1.05 | 1.05 | 1.00 | 1.00 | 1.03 | 1.05 | 1.05 |
| Ridge | 0.96 | 1.03 | 1.05 | 1.05 | 0.98 | 1.00 | 1.03 | 1.05 | 1.05 |
| No-Till | 0.90 | 1.07 | 0.99 | 0.96 | 0.97 | 0.98 | 1.05 | 1.10 | 1.12 |

[1]Tillage system descriptions include: Fall plow -- fall moldboard plowing, 1 to 3 spring passes to prepare seedbed. Fall chisel -- same as fall plow, except a chisel plow is substituted for the moldboard plow. An offset or heavy tandem disk system would have similar yield coefficients. Spring plow -- same as fall plow, except moldboard plowing is done in the spring. Spring disk or field cultivate, 1 to 3 spring passes with a disk or field cultivator to prepare seedbed. Ridge till -- planting into wide tilled strips on pre-formed ridge tops; no other tillage operation at planting. No-till -- planting into very narrow tilled strips through old-crop residue; no other tillage operation.

[2]Soil group descriptions:

1 Dark, poorly drained silty clay loams to clays, 0-2% slope. Examples: Brookston, Chalmers, Pewamo.

2. Light (very low organic matter), somewhat poorly and poorly drained silt loams, nearly level to gently sloping, overlying very slowly permeable fragipan or fragipan-like pans that restrict plant rooting and water movement. Examples: Clermont, Avonburg, Iva, Vigo.

3. Dark, poorly drained, "high water table," loamy sands and sandy loams 0-2% slope. Because of moderately coarse and coarse surface textures, these soils are subject to severe wind erosion and damage to young plants by blowing sand. Examples: Maumee, Lyles, Granby.

4. Muck, dark soils with greater than 30% organic matter, poorly drained, nearly level subject to severe wind erosion if left unprotected. Examples: Adrian, Carlisle, Edwards, Haughton.

5. Light (low organic matter), somewhat poorly drained silt loams to silty clay loams with high clay subsoil, nearly level to 6% slopes. Examples: Blount, Nappanee.

6. Same as Group 5, but without high clay subsoil. Examples: Crosby, Fincastle, Iva, Haskins.

7. Light (low organic matter), well and moderately well drained upland soils with silt loam to sandy loam surface texture and high clay subsoil on slopes of 2 to 6% (subject to moderate water erosion). Example: Morley, Glynwood, Markland.

8. Same as Group 7, but without high clay subsoil. Also coarse textured terrace soils subject to moderate wind erosion and/or drought. Examples: Miami, Fox.

9. Light (low organic matter), well drained soils on slopes greater than 6% that are subject to very severe water or wind erosion. Examples: Miami, Russell, Alford. In addition, sands. Example: Plainfield, Oshtemo.

[3]Fall-plow tillage system with early-May planting, early October harvesting is used as a reference yield (yield = 1.00) for each soil group, but actual yield potential may be different between soil groups. As planting is delayed, the spring disk and no-till systems compare more favorably with the plow system. With earlier planting (April) in soil groups with poor drainage, these no-plow systems compare less favorably than shown. Also, these surface residue systems may compare more favorably than the coefficients indicate with the longer growing seasons of southern Indiana, but less favorably with the shorter growing seasons of northern Indiana.

[4]Second-year beans (after beans) are expected to yield 5 percent less than first year beans, third-year beans (after beans) are expected to yield 10 percent less. These yield reductions may be slightly greater for no-till in soil group I.

[5]Soybeans: Fall-plow tillage system with mid-May planting, early October harvesting is used as a reference point (1.00) for each soil group, but actual yield potential may be different between soil groups.

[6]As planting is delayed past June 1, no-till yield potential improves relative to plowing for all soil groups.

**Temporary Hired Labor**

In B-21, you do not enter any per acre charge for part-time labor. Instead, you may permit the hiring of part-time labor by entering the availability and per hour cost of temporary labor on Input Form page 5. This is a special type of resource in B-21. You have to pay a per hour rate to get it, but it is only hired when it will increase net returns. (In B-21 you don't have to pay anything to get your present land, machinery or permanent labor. Either you now have those resources or they are not available to you.)

The solver will first try to maximize returns to your resources by growing crop recipes with your present labor. Suppose, however, that for some reason you need more labor. You might have an idle tractor and implement that, if operated, would allow you to plant more acres in the best planting period. If part-time labor is available to be hired, B-21 checks to see if it's more profitable to pay the part-time labor and get the extra acres planted in the high yield period or postpone planting until a less favorable period that has "free" labor. The model *makes the best choice* based on the expected returns and the availability of resources in all 20 time periods.

**Renting Additional Land**

You can explore the effect of renting additional land by completing the information on page 49 of the Input Form. All land that is rented is assumed to be on a cash rent basis. It is also assumed that land will be rented in one acre units up to the maximum allowed. Only those acres that provide a return greater than or equal to the rental cost will be rented by the model. As land is rented, the acreage of crops and the combinations of crops will be adjusted to provide the maximum return to land, labor and machinery resources.

**Charges for Fixed Land, Labor, and Machinery Resources**

In completing the input to be used by the linear programming solver to determine the most profitable use of your land, labor and machinery resources, recognize that charges for these fixed resources were not included. Justification for not including charges for these "fixed" resources is this. Either you have a resource or you don't have it. If you have a resource, you want to find the best way to use it. If you don't have it, you can't use it. As such, the cost of your fixed resources is not a factor in determining the best use of those resources.

The annual cost of having these resources does not vary with use. Rather, costs vary with the quantity of the resource available for use. Annual depreciation, property taxes and insurance costs for your current machinery will be about the same regardless of the crops grown. Similarly, your annual family living expenditures and salaries for full-time employees will not vary by the acres of corn, soybeans, or wheat grown.

To recognize the annual cost of your "fixed" resources, you will need to estimate the annual charge associated with these resources and enter these charges on page 49 of the B-21 Input Form. The charges that you enter for these resources will be subtracted from the return to resources to provide the net return in "Table A-1: Production Summary" and Table "A-3: Income Statement." The resource charge that you enter on page 49 depends on how you want to use this report.

By subtracting the appropriate charges, you can create an economic budget report, a cash flow report, or a change in net worth report. The economic budget provides an estimate of the long term profitability associated with your plan. Developing a cash flow report provides an estimate of the cash flow feasibility of your plan. The way that you have chosen to finance your farm operation will have important implications for the cash flow report. The change in net worth report provides an estimate of how much of the income will be retained for use in the business.

## B-21 Limitations

You describe your resources, production alternatives or recipes, and rewards in B-21. The linear program solver finds the exact best way to use your resources so as to get the highest possible resource returns. All the information is calculated precisely. Of course, it is not accurate. Why? The information you entered is not accurate for any season. Prices vary, input costs vary, yields vary, weather and days suitable for fieldwork vary and machinery breaks down. As you explore alternatives it is important to ask how sensitive your plan is to variations in these important items.

You are responsible for the way you use B-21. You probably won't want to enter unrealistic numbers, since you will get unrealistic returns.

## Economic Budgets

For each solution you obtain, make a new decision about what to include as fixed resource charges. Table 6 includes columns for costs for two different solutions. Actually you will need a column for any solution where you change:

(1) The amount of your permanent labor
(2) Your acreage of land on Input Form page 5,
(not for additional land that can be rented on page 49)
(3) Your dryer or storage capacity
(4) Your machinery size or type

Guidelines for estimating the economic costs for land, labor, and machinery resources are presented below. Subtract your total of these economic costs from the Total Contribution Margin (Returns to Resources) for each solution you make. *Pick the alternative with the largest positive (or smallest negative) bottom line*. If your analysis is correct, that's the most profitable of the alternatives you tested.

### Present Land

Suppose you rent land using a crop share lease. In Table 6, subtract the return above variable costs which the landlord receives. You might approximate that amount by estimating the landlord's returns on some of your crop alternatives. For each crop, calculate the landlord's revenue, variable costs, and returns to resources. An estimate of the landlord's summed total returns to resources should be subtracted from your resource returns. Also subtract your total present cash rental payment. That's the rent for that land.

By doing this, you are assuming that you will continue to rent the same acreage. This land is assumed to be one of your resources. It is available in the linear programming model to be used at no charge. It will be farmed if the receipts are greater than the variable costs, provided you enter sufficient machinery and labor.

What about land you own? Owned land could be cash rented to others. Thus, the cash rent that is foregone is the economic cost of using the owned land.

Occasionally, someone may want to consider if it is profitable to rent some or all of his/her present acreage. If you have that question, delete this acreage from your acreage entered on Input Form page 5 and enter the questionable acreage on page 49 along with a rent cost. Then, test to see if B-21 will rent it for your use.

Since you reduced the initial quantity of land available, you will also want to lower your land resource charge on page 49 of the Input Form. Your land resource charge is the charge for land reported on page 5 of the Input Form. The specified rental cost used on page 49 is subtracted from revenue to obtain your total contribution margin or returns to resources.

**Table 6. Adjusting For Economic Cost Of Resources**

| Description | Plan 1 | Plan 2 |
|---|---|---|
| A. Total Contribution Margin (Returns to land, labor, and machinery resources) | $_____________ | $_____________ |
| B. Labor Cost | | |
| Permanent hired labor paid | $_____________ | $_____________ |
| Estimated family living cost | _____________ | _____________ |
| C. Present Land Cost | | |
| Owned land at cash rent equivalent | _____________ | _____________ |
| Cash rented land at cash rent paid | _____________ | _____________ |
| Share rented land at net earnings received by landlords | _____________ | _____________ |
| D. Improvements Cost | | |
| Dryer, storage and other farmstead at, say, 11% of replacement cost | _____________ | _____________ |
| E. Machinery Replacement Cost | | |
| Sum of APPENDIX D annual average costs for field machinery used in this solution | _____________ | _____________ |
| F. Total Resource Costs (B+C+D+E) | $_____________ | $_____________ |
| G. Returns after all costs (A-F) | $_____________ | $_____________ |

**Present Permanent Hired Labor and Present Family Labor**

Suppose you are now hiring permanent labor (some of which may work less than a full-day) and expect to continue to do so. This labor is assumed to be one of your resources. It is available to be used along with your own labor, at no charge. In Table 6, you can subtract permanent labor costs from your resource returns.

Estimated family living cost is suggested as the amount to include for yourself in Table 6. The reasons for using this amount are simple. First, you need this amount if you need to make a cash flow budget, as in Table 6. Second, you likely will not change your living cost regardless of which B-21 solution you choose.

The sum of these two costs can be entered on page 49 of the Input Form as the cost of labor.

**Present Machinery**

You now have a set of machinery. Your present machinery is available to use during the time periods you entered, along with your land and labor, at no charge.

Suppose you want to include a charge for these machinery services. You listed machinery fuel and repair costs for each crop. What do you want to include for other charges? What machinery costs should you consider in Table 6 for Plan 1 and for each of your alternative plans?

The model is intended to be a long-range budget. Therefore, you can use machinery replacement costs for both your present machinery and for other machinery you might want to consider in alternative budgets. Economic replacement costs, called average annual costs, for various machines have been calculated in APPENDIX Table G beginning on page 41. *In Table 6, subtract the average annual costs for machines the same size as your present machines.*

For example, turn to APPENDIX Table G. Find the entries for tractors. Refer to the 155 HP tractor. The list price is $99,500. The average annual cost, is $10,348 per year. This value was found by multiplying the list price by a tractor average cost percentage of 10.4%. This percentage was calculated using the Purdue Machinery Cost Calculator (PMC).

Now turn to Table F on page 40 and find the tractor section. Note that the subtotal column value for Other Average Costs is 10.4% for 150 HP tractors. This percentage is the sum of market depreciation (5.13%) plus opportunity cost interest on each year's beginning inventory value (4.4%) plus property tax and insurance (.89%). To get the 10.4% average annual percentage, machine costs were discounted to today’s dollars and then annualized by converting them to an annual annuity cost.

Planter and combine costs were estimated using seven year trading policies; other machinery, for ten years. While these trading policies may not be quite the least cost years for you to trade, they likely represent trading policies of many farmers.

Make a list of your present machinery. For each machine, get the appropriate average cost from APPENDIX Table G. Sum up these costs for your machines to get an annual cost for your machinery set.

The summed value of average costs is your average annual cost for machinery services. It is your cost if you were to replace all your present machinery with new machines of the same size and type TODAY. That's why you'll likely want to use this cost for machinery in Table 6 to subtract from your resource returns.

**Replacement Machinery**

After you learn to interpret shadow prices, you'll likely want to change some of your machinery. You may want to change sizes and/or types of tillage, etc. You'll need to enter new machinery field working rates on Input Form crop pages 17-41. *You'll also need to subtract the sum of the average costs for each alternative machinery set you test.*

When do you decide to replace your machinery? Is it because, (1) you think a different machine will somehow cause you to be better off from now on and, (2) you can somehow cash flow the transaction? By using the B-21 budget, you can quickly test alternative plans to answer (1). You can also get information which may help you answer (2).

When you change machinery size or type, re-calculate the crop-share landlord's returns and enter this new amount in a new Table 6. By this process, you will subtract the landlord's benefit before arriving at your new *"bottom line"*.

**Improvements**

Improvements can be charged at their approximate average replacement cost. When you replace a machine or building, you could replace it for an identical asset. Just prior to purchase, the average cost for the machine could be found as suggested previously. For a building, find the average cost by multiplying the purchase price by 11%.

**Cash Flow**

For the cash flow report, as presented in Table 7, you would report cash transactions caused by your present resources. These would include:

Cash rent payments or adjustments for rental agreements,
Cash purchases and sales,
Loan principal and interest cash payments,
Property taxes and insurance payments,
Hired labor cash expenses, and
Family living cash expenditures, including income tax payments

**Net Worth Change**

For the balance sheet net worth change report, as presented in Table 8, you can estimate the change in net worth from your crop farming operations, you would include:

Cash rent accrued during the period,
Machinery market depreciation (loss in value) during the period,
Loan interest accrued during the period,
Property taxes and insurance accrued during the period,
Hired labor expenses accrued during the period, and
Family living consumption and income taxes accrued during the period.

Note the differences between the reports. The cash flow report includes cash transactions actually made. The net worth change report includes period charges, some of which are different from cash actually spent during the period.

Also note you can easily make an accounting income statement (P&L Report) from the net worth change report. Merely subtract the family living and income tax expenditures.

**Table 7. Adjusting For Cash Inflows and Outflows**

| | | Plan 1 | Plan 2 |
|---|---|---|---|
| A. | Total contribution margin (returns to resources) | $____________ | $____________ |
| B. | Cash from sale of machinery, buildings or land | ____________ | ____________ |
| C. | New loans | ____________ | ____________ |
| D. | Total cash inflows (A+B+C) | $____________ | $____________ |
| Less Cash Outflows: | | | |
| E. | Cash rent payments or adjustments for other types of rental | ____________ | ____________ |
| F. | Cash expenditures for machinery, storage and land purchases | ____________ | ____________ |
| G. | Loan principal and interest payments | ____________ | ____________ |
| H. | Property taxes and insurance payments | ____________ | ____________ |
| I. | Hired labor cash expenses | ____________ | ____________ |
| J. | Family living expenditures | ____________ | ____________ |
| K. | Income tax payments | ____________ | ____________ |
| L. | Total cash expenses and expenditures (E+F+G+H+I+J+K) | ____________ | ____________ |
| M. | Net Cash Balance (D-L) | $____________ | $____________ |

**Table 8. Adjustments For Estimating Net Worth Change From Earnings**

| | | Plan 1 | Plan 2 |
|---|---|---|---|
| A. | Total contribution margin (returns to resources) | $____________ | $____________ |
| Less expenses and expenditures accrued during the period | | | |
| B. | Cash rent and landlord share rent | | |
| C. | Machinery and buildings market depreciation (loss in value) | ____________ | ____________ |
| D. | Loan interest | ____________ | ____________ |
| E. | Property taxes and insurance | ____________ | ____________ |
| F. | Hired labor expenses | ____________ | ____________ |
| G. | Family living expenditures | ____________ | ____________ |
| H. | Income taxes | ____________ | ____________ |
| I. | Total adjustments (B+C+D+E+F+G+H+I) | $____________ | $____________ |
| J. | Change in net worth (A-I) | ____________ | ____________ |

**Appendix**

**Table A. Maximum PTO HP/Foot of Implement Width for Various Soil Types, Operating Speeds and Implements[1]**

| Implement | Operating Speed MPH | Sand | Sandy loam | Loam | Silt Loam | Clay |
|---|---|---|---|---|---|---|
| | | Predominant Soil Type | | | | |
| Moldboard Plow | 3 | 9.5 | 10.5 | 11.5 | 13.0 | 16.0 |
| | 4 | 10.0 | 11.0 | 12.0 | 15.0 | 18.0 |
| | 5 | 11.0 | 12.5 | 14.0 | 17.0 | 20.0 |
| | 6 | 11.5 | 13.0 | 16.0 | 19.0 | 23.0 |
| | 7 | 12.0 | 13.5 | 18.0 | 22.0 | 27.5 |
| Chisel Plow | 3 | 6.3 | 7.0 | 7.7 | 8.7 | 10.6 |
| | 4 | 6.6 | 7.3 | 8.0 | 10.0 | 11.5 |
| | 5 | 7.3 | 8.3 | 9.3 | 10.7 | 12.0 |
| | 6 | 7.7 | 8.6 | 10.6 | 11.5 | 13.0 |
| | 7 | 8.0 | 9.0 | 11.0 | 13.0 | 15.0 |
| Offset Disk | 3 | 5.8 | 6.5 | 7.1 | 7.9 | 9.4 |
| | 4 | 6.2 | 6.8 | 7.5 | 8.8 | 10.0 |
| | 5 | 6.8 | 7.5 | 8.3 | 9.4 | 10.4 |
| | 6 | 7.0 | 7.9 | 9.4 | 10.0 | 10.7 |
| | 7 | 7.2 | 8.2 | 9.7 | 10.7 | 12.5 |
| Tandem Disk | 3 | 5.2 | 5.4 | 5.6 | 6.2 | 7.0 |
| | 4 | 5.4 | 5.6 | 6.0 | 6.6 | 7.5 |
| | 5 | 5.6 | 5.8 | 6.4 | 7.1 | 8.0 |
| | 6 | 6.0 | 6.5 | 7.2 | 7.8 | 9.0 |
| | 7 | 7.1 | 7.8 | 8.4 | 8.8 | 9.3 |
| Field Cultivator and $NH^3$ Applicator | 3 | 4.3 | 4.6 | 5.1 | 5.7 | 6.4 |
| | 4 | 4.6 | 5.0 | 5.6 | 6.2 | 7.0 |
| | 5 | 5.1 | 5.5 | 6.1 | 6.8 | 7.6 |
| | 6 | 5.6 | 6.1 | 6.7 | 7.4 | 7.8 |
| | 7 | 6.5 | 7.1 | 7.8 | 8.2 | 8.6 |

[1] Data from an Implement Width Analysis conducted by Donald H. Tyler, Research Assistant, and Samuel D. Parsons, Extension Agricultural Engineer, Purdue University. Maximum PTO HP refers to tractor size, that is, the maximum PTO horsepower developed at rated engine speed during the Nebraska Tractor Test.

Example: Determine the tractor size needed for a 12-foot chisel plow operated at 5 mph in loam soil.

Maximum PTO HP = Maximum PTO HP per foot X length in feet = 9.3 X 12 = 112.6

Minimum tractor "size" is "113-hp" (112.6 PTO HP). A "larger" tractor could also be used for the situation described.

**Table B. Tractor Size and Machinery Working Rates[1] for Various Soil Types for Plowing and Discing**

| Operation and Equipment size | | Tractor Size (Max PTO HP) | | | | | Operating | | Field Efficiency (%) | Working Rate (A/Hr) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sand | Sandy Loam | Loam | Silt Loam | Clay | Width (Feet) | Speed (MPH) | | |
| Plow[2] | 2-16" | 28 | 31 | 35 | 43 | 51 | 2.67 | 4.5 | 82 | 1.2 |
| | 3-16" | 42 | 47 | 52 | 64 | 76 | 4.00 | 4.5 | 81 | 1.8 |
| | 4-16" | 56 | 63 | 69 | 85 | 101 | 5.33 | 4.5 | 80 | 2.3 |
| | 5-16" | 70 | 78 | 87 | 107 | 127 | 6.67 | 4.5 | 79 | 2.9 |
| | 6-16" | 84 | 94 | 104 | 128 | 152 | 8.00 | 4.5 | 78 | 3.4 |
| | 7-16" | 98 | 110 | 121 | 149 | 177 | 9.33 | 4.5 | 77 | 3.9 |
| | 8-16" | 112 | 125 | 139 | 171 | 203 | 10.67 | 4.5 | 76 | 4.4 |
| | 8-18" | 126 | 141 | 156 | 192 | 228 | 12.00 | 4.5 | 76 | 5.0 |
| | 10-18" | 158 | 176 | 195 | 240 | 285 | 15.00 | 4.5 | 75 | 6.1 |
| | 12-18" | 189 | 212 | 234 | 288 | 342 | 18.00 | 4.5 | 75 | 7.4 |
| | 14-18" | 221 | 247 | 273 | 336 | 399 | 21.00 | 4.5 | 75 | 8.6 |
| Chisel | 7' | 51 | 58 | 65 | 75 | 84 | 7 | 5 | 75 | 3.2 |
| Plow | 8' | 58 | 66 | 74 | 86 | 96 | 8 | 5 | 74 | 3.6 |
| | 12' | 88 | 100 | 112 | 128 | 144 | 12 | 5 | 73 | 5.3 |
| | 14' | 102 | 116 | 130 | 150 | 168 | 14 | 5 | 72 | 6.1 |
| | 17' | 124 | 141 | 158 | 182 | 204 | 17 | 5 | 72 | 7.4 |
| | 21' | 153 | 174 | 195 | 225 | 252 | 21 | 5 | 70 | 8.9 |
| | 28' | 204 | 232 | 260 | 300 | 336 | 28 | 5 | 68 | 11.5 |
| Disc[2] | 7' | 39 | 41 | 45 | 50 | 56 | 7 | 5 | 83 | 3.5 |
| | 10' | 56 | 58 | 64 | 71 | 80 | 10 | 5 | 82 | 5.0 |
| | 11' | 62 | 64 | 70 | 78 | 88 | 11 | 5 | 82 | 5.5 |
| | 13' | 73 | 75 | 83 | 92 | 104 | 13 | 5 | 82 | 6.5 |
| | 14' | 78 | 81 | 90 | 99 | 112 | 14 | 5 | 82 | 7.0 |
| | 18' | 101 | 104 | 115 | 128 | 144 | 18 | 5 | 80 | 8.7 |
| | 21' | 118 | 122 | 134 | 149 | 168 | 21 | 5 | 80 | 10.2 |
| | 23' | 129 | 133 | 147 | 163 | 184 | 23 | 5 | 79 | 11.0 |
| | 25' | 140 | 145 | 160 | 178 | 200 | 25 | 5 | 79 | 12.0 |
| | 30' | 168 | 174 | 192 | 213 | 240 | 30 | 5 | 78 | 14.2 |
| | 35' | 196 | 203 | 224 | 249 | 280 | 35 | 5 | 78 | 16.5 |
| | 42' | 235 | 244 | 269 | 298 | 336 | 42 | 5 | 77 | 19.6 |
| | 48' | 269 | 278 | 307 | 341 | 384 | 48 | 5 | 77 | 22.4 |

[1] The formula for calculating machinery working rates in acres per hour is:

Width (ft) x Speed (MPH) x Field Efficiency (%) ÷ 8.25 = A/Hr

For Example, 10 x 5 x .82 ÷ 8.25 = 4.97

[2] On clay soil with conventional tillage, size your tractor to complete fall plowing. On sandy soil with conventional tillage, size your tractor to complete two spring discings prior to planting.

**Table C. Machinery Working Rates for Various Field Operations and Machine Sizes**

| Operation and Equipment size | | Operating Width (Feet) | Operating Speed (MPH) | Field Efficiency (%) | Working Rate (A/Hr) |
|---|---|---|---|---|---|
| Spread P&K | (6 tons) | 40 | 6 | 50 | 14.5 |
| Knife in $NH_3$ | | 20 | 5 | 80 | 9.7 |
| | | 30 | 5 | 80 | 14.5 |
| Broadcast Spray | | 60 | 9.5 | 70 | 48.4 |
| Plant[1] | 6-30 | 15 | 5.5 | 70 | 7.0 |
| | 8-30 | 20 | 5.5 | 70 | 9.3 |
| | 12-30 | 30 | 5.5 | 70 | 14.0 |
| | 16-30 | 40 | 5.5 | 70 | 18.7 |
| | 24-30 | 60 | 5.5 | 70 | 28.0 |
| Drill 15 ft.[1] | | 15 | 5.5 | 70 | 7.0 |
| 25 ft. | | 25 | 5.5 | 70 | 11.7 |
| Rotary Hoe | 30 | 30 | 10 | 83 | 30.2 |
| | 40 | 40 | 10 | 83 | 40.2 |
| Field Cultivator | | 21 | 6.5 | 83 | 13.7 |
| | | 28 | 6.5 | 83 | 18.3 |
| | | 42 | 6.5 | 83 | 27.5 |
| Combine Corn[1] | 6-30 | 15 | 4.5 | 62 | 5.1 (6.0)[2] |
| | 8-30 | 20 | 4.5 | 62 | 6.8 (8.0)[2] |
| | 12-30 | 30 | 4.5 | 62 | 10.1 (13.0)[2] |
| Combine Beans & Small Grain | | 20 | 4 | 65 | 6.3 (4.4)[3] |
| | | 25 | 4 | 65 | 7.9 (5.5)[3] |
| | | 30 | 4 | 65 | 9.5 (6.7)[3] |

1 With new planters, drills, and combines, you may be able to perform a high quality job at faster working rates.

2 Increase the corn harvest rate by perhaps 25% for on-the-go unloading. The numbers in parenthesis represent this 25% increased rate.

3 The rates in parenthesis are approximately 70% the calculated rate. Assuming you can operate your bean or small grain combine approximately 70% as many hours per day as you can harvest corn, you will want to use the smaller rate (in parenthesis) in the Input Form.

# Table D. Estimated Per Acre Crop Budgets of Low, Medium, and High Productivity Indiana soils, January 2009

*Both product prices and input prices may have significantly changed since these estimates were prepared.*

**Table 1. Estimated per Acre Crop Budgets for Low, Average, and High Productivity Indiana Soils**

| | Crop Budgets for Three Yield Levels[1] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low Productivity Soil | | | | | Average Productivity Soil | | | | | High Productivity Soil | | | | |
| | **Cont. Corn** | **Rot. Corn** | **Rot. Beans** | **Wheat** | **DC Beans** | **Cont. Corn** | **Rot. Corn** | **Rot. Beans** | **Wheat** | **DC Beans** | **Cont. Corn** | **Rot. Corn** | **Rot. Beans** | **Wheat** | **DC Beans** |
| Expected yield per acre[2] | 118 | 126 | 39 | 62 | 23 | 149 | 158 | 49 | 70 | 29 | 179 | 190 | 59 | 84 | 35 |
| Harvest price[3] | $4.00 | $4.00 | $8.70 | $5.20 | $8.70 | $4.00 | $4.00 | $8.70 | $5.20 | $8.70 | $4.00 | $4.00 | $8.70 | $5.20 | $8.70 |
| Market revenue | $472 | $504 | $339 | $322 | $200 | $596 | $632 | $426 | $364 | $252 | $716 | $760 | $513 | $437 | $305 |
| Less variable costs[4] | | | | | | | | | | | | | | | |
| Fertilizer[5] | $178 | $166 | $74 | $91 | $49 | $192 | $180 | $89 | $104 | $58 | $205 | $194 | $104 | $128 | $67 |
| Seed[6] | 75 | 75 | 52 | 43 | 60 | 89 | 89 | 52 | 43 | 60 | 89 | 89 | 52 | 43 | 60 |
| Pesticides[7] | 41 | 41 | 29 | 8 | 26 | 41 | 41 | 29 | 8 | 26 | 41 | 41 | 29 | 8 | 26 |
| Dryer fuel[8] | 24 | 19 | N/A | N/A | 4 | 30 | 24 | N/A | N/A | 5 | 37 | 29 | N/A | N/A | 6 |
| Machinery fuel @ $2.40 | 18 | 18 | 8 | 11 | 8 | 18 | 18 | 8 | 11 | 8 | 18 | 18 | 8 | 11 | 8 |
| Machinery repairs[9] | 12 | 12 | 9 | 9 | 9 | 12 | 12 | 9 | 9 | 9 | 12 | 12 | 9 | 9 | 9 |
| Hauling[10] | 13 | 14 | 4 | 7 | 3 | 16 | 17 | 5 | 8 | 3 | 20 | 21 | 6 | 9 | 4 |
| Interest[11] | 16 | 16 | 9 | 7 | 8 | 18 | 17 | 9 | 8 | 8 | 9 | 9 | 10 | 9 | 9 |
| Insurance/misc.[12] | 26 | 26 | 22 | 3 | 4 | 27 | 27 | 22 | 3 | 4 | 28 | 28 | 23 | 3 | 4 |
| Total variable cost | $403 | $387 | $207 | $179 | $171 | $443 | $425 | $223 | $194 | $181 | $459 | $441 | $241 | $220 | $193 |
| Contribution margin[13] (Revenue - variable costs) per acre | $69 | $117 | $132 | $143 | $29 | $153 | $207 | $203 | $170 | $71 | $257 | $319 | $272 | $217 | $112 |

[1]Estimated yields and costs are for yields with average management for three different soils representing low, average, and high productivity. The high productivity soils represent soils capable of producing corn and soybeans with yields about 20% higher than average soils. Low productivity soils represent soils capable of producing corn and soybeans with yields about 20% lower than the average soils.

[2]These yields assume average weather conditions and timely plant/harvest date, except soybean double-crop yield, which is based on a July 1 planting date. Continuous corn, soybean, and wheat yields are a percent of rotation corn yield: continuous corn 94%; rotation soybeans 31%; wheat 49% on low productivity soil and 44% on average and high productivity soils; and double-crop soybeans 18%. Continuous corn yields assume a chisel plow tillage system. Double-crop soybean yields apply to central and southern Indiana.

[3]Harvest corn price is December 2009 Chicago Board of Trade (CBOT) futures price less $0.35 basis. Harvest soybean price is November 2009 CBOT futures price less $0.60 basis. Harvest wheat price is July 2009 CBOT futures price less $1.00 basis. The prices shown were estimated using closing prices on January 28, 2009. These prices will change.

[4]Seed, fertilizer, pesticide, and fuel prices are based on projections for 2009.

**Table D (Continued)**

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[5] Phosphate, potash, and lime applications are based on Tri-State Fertilizer Recommendations (Source: Michigan Extension Bulletin E-2567, July 1995). Lime amounts represent the pounds of standard ag lime needed to neutralize the acidity from the nitrogen supplied from sources other than ammonium sulfate. Nitrogen application rate for corn is based on research from the Department of Agronomy, Purdue University. Anhydrous ammonia is used as the nitrogen source for corn. Urea is used as the nitrogen source for wheat. Pounds of N, $P_20_5$, $K_20$, and lime by crop and soil were as follows: continuous corn, 190-44-52-570, 190-55-60-570, 190-66-68-570; rotation corn, 160-47-54-480, 160-58-63-480, 160-70-71-480; rotation beans, 0-31-75-0, 0-39-89-0, 0-47-103-0; wheat, 61-39-43-183, 75-44-46-225, 99-53-51-299; double crop beans, 0-18-52-0, 0-23-61-0, 0-28-69-0. Fertilizer prices per lb.: $NH_3$ @ $0.49; urea @ $0.53; $P_20_5$ @ $0.66; $K_20$ @ $0.71; lime @ $24/ton spread on the field. 5-10% more nitrogen might be needed on poorly drained soils. All soil tests for phosphorus and potassium are assumed to be in the maintenance range, and the pH is in the recommended range.

[6]Corn seed prices assume a biotech variety with multiple traits. A 20%-refuge is planted with varieties that do not contain insect resistant traits. According to the USDA's Agricultural Prices report for April 2008, biotech corn seed prices averaged 60% more than non-biotech corn seed, which was up from 54% more a year earlier. Seeding rates for corn are 28,000 seeds per acre on low productivity soils and 33,000 seeds per acre on average and high productivity soils. Soybean seed prices include Round-Up Ready® varieties. Rotation soybeans are drilled with a seeding rate of 169,000 seeds per acre with a 90% germination rate. Double-crop soybeans are drilled with a seeding rate of 195,000 seeds per acre.

[7]Includes both insecticides and herbicides. For corn, rootworm insecticide is applied to the refuge acres. In some areas of Indiana, this may not be required. Herbicide costs can vary widely based on both the herbicides selected and the required rate of application.

[8]Fuel used to dry crop to a safe moisture level for storage. For double-crop soybeans, the drying charge represents the drying of wheat in order to allow an earlier planting of soybeans.

[9]Repairs are based on approximately 5-year-old machinery. For older machinery, per acre repairs and downtime cost will be higher.

[10]Hauling charge represents moving grain from field to storage. (Based on Machinery Cost Estimates: Harvesting, University of Illinois, Farm Business Management Handbook, May 2008.)

[11]Interest is based on 7% annual rate for 9 months for seed, fertilizer, and chemicals, and for 6 months for half the machinery fuel and repairs, and all miscellaneous expenses.

[12]The cost of crop insurance represents the premium for a Crop Revenue Coverage (CRC) policy at the 75% level. Since rates for the 2009 crop year are not available, estimates were based on rates in 2008. These rates are based on a base price of $5.25 per bushel for corn and $12.75 per bushel for soybeans. Rates will change based on the price guarantees and other parameters selected for the 2009 crop year. Crop insurance is included in budgets for corn and full-season soybeans, but is not included for wheat and double-crop soybeans.

[13]Contribution margin is the return to labor and management, machinery services, and land resources.

**Table E. Approximate Diesel Fuel Requirements for Selected Field Operations[1,2]**

| | | Gallons Diesel[3] Per Acre By Soil Type | | |
|---|---|---|---|---|
| Field Operation | | Sandy | Silt Loam | Clay Loam |
| Tiling | | | | |
| Shred Corn Stalks | | .75 | .75 | .75 |
| Moldboard Plow (8 in.) | | 1.15 | 1.85 | 2.60 |
| Chisel Plow (8 in.) | | .75 | 1.25 | 1.75 |
| Field Cultivate Plowed Ground | | .55 | .60 | .65 |
| Disc, Corn Stalks | | .40 | .45 | .50 |
| Disc, Plowed Ground | | .50 | .55 | .60 |
| Disc, Second Trip | | .45 | .50 | .55 |
| Fertilizing | | | | |
| $NH_3$ Plowed Ground, No-Till or Side dress | | .60 | .70 | .80 |
| Spread Dry Bulk Fertilizer | | .20 | .20 | .20 |
| Planting | | | | |
| Planter, Conv., Ridge, No-Till | | .40 | .50 | .60 |
| Grain Drill | | .30 | .35 | .40 |
| Control Weeds | | | | |
| Spray, Trail Type | | .15 | .15 | .15 |
| Rotary Hoe | | .25 | .25 | .25 |
| Cultivate Sweeper or Tires | | .30 | .35 | .40 |
| Cultivate Disc Hillers | | .35 | .40 | .45 |
| Form Ridges | | .40 | .45 | .50 |
| Mowing | | | | |
| Cutter Bar Mowing | | | .43 | |
| Mowing/Conditioning PTO | | | .65 | |
| Raking | | | .22 | |
| Harvest Corn, Beans, Wheat | | Combine | Haul 1st Mile[4] | Haul Added Mile |
| Ear Corn | | 1.16 | .29 | .17 |
| Shelled Corn | | 1.62 | .18 | .11 |
| Soybeans | | 1.19 | .07 | .04 |
| Small Grain | | 1.08 | .09 | .05 |
| Harvest Hay, Silage | Harvesting | Haul 1st Mile | Haul Added Mile | Blow |
| Conventional Baling | .54 | .14 | .11 | -- |
| Round Baling | .45 | .29 | .22 | 00 |
| Green Chop | .95 | .35 | .14 | .35 |
| Haylage | 1.25 | .20 | .20 | .25 |
| Corn Silage | 3.60 | 1.40 | .90 | 1.40 |

1 Based on information reported in Estimating Fuel Requirements For Field Operations Purdue AE-110 and Energy Requirements for Various Tillage Planting Systems, Purdue ID-141.

2 For whole farm budgets, add 3-5 gallons per acre to account for driving field machinery to and from fields and for pickup driving to observe crop conditions, etc.

3 To adjust to gasoline rate, multiply diesel rate by 1.4.

4 Hauling is by trucks, double these rates for tractors and wagons.

**Table F: Annual Farm Machinery Costs Expressed as a Percent of List Price; Combines and Planters, Seven Year Trading Policy; Other Machinery, Ten Year Trading Policy, No Downtime Cost**

| Machine Type | Annual Hours Used | Trade Year | Other Annualized Costs[1] Market Depreciation | Opportunity Cost Interest | Property Tax and Insurance | Sub-Total[1] | Annualized Repairs[2] | Total |
|---|---|---|---|---|---|---|---|---|
| 150+ HP Tractor (1)[3] | 200 | 10 | 4.89 | 4.46 | .93 | 10.28 | .25 | 10.53 |
| | 400 | 10 | 5.13 | 4.40 | .89 | 10.41 | .99 | 11.40 |
| | 600 | 10 | 5.29 | 4.35 | .86 | 10.50 | 2.23 | 12.73 |
| | 800 | 10 | 5.42 | 4.32 | .83 | 10.57 | 3.97 | 14.54 |
| 110 HP | 200 | 10 | 3.94 | 4.72 | .98 | 9.63 | .25 | 9.88 |
| Tractor (2) | 400 | 10 | 4.25 | 4.63 | .92 | 9.81 | .99 | 10.80 |
| | 600 | 10 | 4.49 | 4.57 | .88 | 9.94 | 2.23 | 12.17 |
| | 800 | 10 | 4.69 | 4.51 | .85 | 10.05 | 3.97 | 14.02 |
| 50 HP | 200 | 10 | 3.95 | 4.71 | .88 | 9.54 | .25 | 9.79 |
| Tractor (3) | 400 | 10 | 4.20 | 4.65 | .84 | 9.69 | .99 | 10.68 |
| | 600 | 10 | 4.44 | 4.58 | .80 | 9.83 | 2.23 | 12.06 |
| | 800 | 10 | 4.66 | 4.52 | .77 | 9.95 | 3.97 | 13.92 |
| Combine (4) | 200 | 7 | 6.73 | 4.52 | .89 | 12.15 | 1.06 | 13.21 |
| | 250 | 7 | 6.98 | 4.48 | .87 | 12.32 | 1.70 | 14.02 |
| | 300 | 7 | 7.21 | 4.43 | .84 | 12.49 | 2.49 | 14.98 |
| | 350 | 7 | 7.43 | 4.39 | .82 | 12.64 | 3.44 | 16.08 |
| Planter (5) | 75 | 7 | 5.15 | 4.82 | .91 | 10.87 | 1.09 | 11.96 |
| Drill | 100 | 7 | 5.15 | 4.82 | .91 | 10.87 | 1.99 | 12.86 |
| | 125 | 7 | 5.15 | 4.82 | .91 | 10.87 | 3.18 | 14.05 |
| | 150 | 7 | 5.15 | 4.82 | .91 | 10.87 | 4.66 | 15.54 |
| Baler (6) | 75 | 10 | 4.27 | 4.63 | .95 | 9.84 | 2.35 | 12.19 |
| | 100 | 10 | 4.27 | 4.63 | .95 | 9.84 | 3.94 | 13.78 |
| | 125 | 10 | 4.27 | 4.63 | .95 | 9.84 | 5.88 | 15.73 |
| | 150 | 10 | 4.27 | 4.63 | .95 | 9.84 | 8.17 | 18.01 |
| P&K Spreader (7) | 100 | 10 | 6.13 | 4.13 | .75 | 11.01 | 2.61 | 13.62 |
| Plow | 150 | 10 | 6.13 | 4.13 | .75 | 11.01 | 5.41 | 16.42 |
| $NH_3$ | 200 | 10 | 6.13 | 4.13 | .75 | 11.01 | 9.08 | 19.99 |
| Sprayer | 250 | 10 | 6.13 | 4.13 | .75 | 11.01 | 13.56 | 24.57 |
| Disc (8) | 100 | 10 | 6.13 | 4.13 | .75 | 11.01 | 2.51 | 13.62 |
| Chisel | 150 | 10 | 6.13 | 4.13 | .75 | 11.01 | 4.42 | 15.43 |
| Rotary Hoe | 200 | 10 | 6.13 | 4.13 | .75 | 11.01 | 6.62 | 17.73 |
| Cultivator | 250 | 10 | 6.13 | 4.13 | .75 | 11.01 | 9.04 | 20.05 |

[1] The annual cost percentage refers to percent of list price. Machinery is assumed to be purchased at 85% of list price. Property taxes are 1% and insurance is .6% of annual market value. An economic interest opportunity cost is charged at 10% with inflation at 3%. The relationship between the 10% opportunity cost interest rate and the 3% inflation rate gives a so-called real opportunity cost interest rate of approximately 6.8%.

[2] Average annual repairs are expressed as a percent of list price. Repairs plus other annual costs are included in the total cost percent. If downtime cost were included, repair cost would increase.

[3] The number in parenthesis is the machine type used to calculate annual costs, using PMC.

**Table G: Selected 2005 Machinery List Prices[1] and Annual Average Costs for Market Depreciation, 6.8% Opportunity Cost Interest, Property Tax, and Insurance**

Ten Year Trading Policy

| TRACTORS (all diesel) | | Annual Average Cost Percentage = 10.4% | |
|---|---|---|---|
| Maximum PTO HP | | List Price | Annual Average Cost |
| 65 | | $43,000 | $4,472 |
| 95 | | 62,000 | 6,448 |
| 105 | | 66,500 | 6,916 |
| 115 | | 72,500 | 7,540 |
| 155 | | 99,500 | 10,348 |
| 190 | | 135,000 | 14,040 |
| 215 | FWA | 149,000 | 15,496 |
| 235 | FWA | 162,000 | 16,848 |
| 255 | FWA | 174,500 | 18,148 |

| MULCH FINISHER | | Annual Average Cost Percentage = 11.0% |
|---|---|---|
| 21’ | $28,000 | $3,080 |
| 30’ | 37,500 | 4,125 |

[1]Based on 2005 prices reported in Schnitkey, Gary and Dale Lattz, *Machinery Cost Estimates: Tractors*. Department of Agricultural and Consumer Economics, University of Illinois, University of Illinois Farm Management Handbook FBM 0204, April 2005. <http://www.farmdoc.uiuc.edu/manage/pdfs/Mach_tractors_2005.pdf>, Schnitkey, Gary and Dale Lattz, *Machinery Cost Estimates: Field Operations*. Department of Agricultural and Consumer Economics, University of Illinois, University of Illinois Farm Management Handbook FBM 0201, April 2005. <http://www.farmdoc.uiuc.edu/manage/pdfs/Mach_field_operations_2005.pdf> , and Schnitkey, Gary and Dale Lattz, *Machinery Cost Estimates: Harvesting*. Department of Agricultural and Consumer Economics, University of Illinois, University of Illinois Farm Management Handbook FBM 0201, April 2005. <http://www.farmdoc.uiuc.edu/manage/pdfs/mach_harvest_2005.pdf>

| | | |
|---|---|---|
| CHISEL PLOWS[2] | | |
| 15' Mounted | 9,500 | 1,045 |
| DISC CHISELS (Mulch Tiller) | Annual Average Cost Percentage = 11.0% | |
| 15' | 17,100 | 1,881 |
| 21' | 28,000 | 3,080 |
| 30' | 37,500 | 4,125 |
| DISC | | |
| 26' | 30,700 | 3,377 |
| 29' | 35,600 | 3,916 |
| 32' | 37,000 | 4,070 |
| FIELD CULTIVATORS | | |
| 21' | 16,900 | 1,859 |
| 28' | 18,200 | 2,002 |
| 42' | 27,300 | 3,003 |
| PLANTERS | Annual Average Cost Percentage = 10.9% | |
| 6-30 | 26,000 | 2,834 |
| 8-30 | 28,000 | 3,052 |
| 12-30 | 38,000 | 4,142 |
| 16-30 | 60,000 | 6,540 |
| 24-30 | 111,000 | 12,099 |
| GRAIN DRILLS | | |
| 15' | 28,000 | 3,052 |
| 25' | 38,000 | 4,142 |
| 20' no-till | 47,400 | 5,167 |
| 30' no-till | 70,000 | 7,630 |

| CULTIVATORS[2] | | |
|---|---|---|
| 8-30" | 9,200 | 1,003 |
| 12-30" | 18,300 | 1,995 |
| ROTARY HOES[2] | | |
| 40 | 15,100 | 1,646 |

| COMBINES | Annual Average Cost Percentage = 12.4% | |
|---|---|---|
| Size | List Price | Annual Average Cost |
| 265 HP | $186,000 | $23,064 |
| 6-30 Corn Head | 30,000 | 3,720 |
| 20’ Grain Table | 23,000 | 2,852 |
| 305 HP | 217,000 | 26,908 |
| 8-30 Corn Head | 41,000 | 5,084 |
| 30’ Grain Table | 29,000 | 3,596 |
| 340 HP | 232,000 | 28,768 |
| 12-30 Grain Head | 64,000 | 7,936 |
| 30’ Grain Table | 29,000 | 3,596 |