

Farmer. A farmer owns 450 acres of land. He is going to plant each acre with wheat or corn. Each acre planted with wheat yields \$2000 profit, requires 3 workers, and required two tons of fertilizer. Each acre planted with corn yields \$3000 profit, requires 2 workers, and required four tons of fertilizer. There are currently 1000 workers and 1200 tons of fertilizer available. Help the farmer maximize the profit from his land.

Discussion. Our objective is to maximize profit as mentioned in the problem statement. This profit is determined by the acres of wheat present and/or the acres of corn present. Suppose we feel that since corn gives a larger profit per unit area, we can grow the entire land with corn. But looking further we see that in this case, the amount of fertilizers needed to produce corn in all of the land would exceed the maximum amount of fertilizers available. Similar scenario holds for growing wheat throughout the land. Hence, we need to understand what combination of corn and wheat can give us the maximum profit subject to the constraints of land, worker and fertilizer availability. Therefore, our decision variable is how much land needs to be allocated for wheat and corn respectively. In this problem, as the amount of land to be allocated to each produce increases to maximize the profit, the limit on the workers available tends to give an upper boundary to the possible increase in the amount of land that can be allocated for each produce. Note that in the optimal solution, all of the land available may not be utilized because of the worker and fertilizer availability constraints.

A factor to note is that in the excel solver, the constraint for land available must be less than or equal to 450 acres rather than equal to 450 acres, the latter might result in no feasible solution to be present. This is because we might not have enough workers and fertilizers to cover the whole land. Our objective is only to maximize profit within the constraints present, we do not have to care whether the entire land is utilized or not.

Model.

Parameters:

P_i : Profit margin for unit acre of produce i , where $i \in (\text{wheat}, \text{corn})$

W_i : Number of workers required for unit acre of produce i , where $i \in (\text{wheat}, \text{corn})$

F_i : Tons of fertilizers required for unit acre of produce i , where $i \in (\text{wheat}, \text{corn})$

W : Total number of workers available

F : Total tons of fertilizers available

L : Total land available

Decisions:

x_i : Amount of land to be allocated to produce i , where $i \in (\text{wheat}, \text{corn})$

Objective: Maximize profit

$$\max \sum_{i=\text{wheat}, \text{corn}} P_i * x_i$$

Constraints:

- | | |
|---|---|
| $x_i \geq 0$ | (1) Land allocated cannot be negative |
| $\sum_{i=\text{wheat}, \text{corn}} x_i \leq L$
land available | (2) Land allocated to wheat and corn cannot exceed total land available |
| $\sum_{i=\text{wheat}, \text{corn}} w_i * x_i \leq W$
exceed total workers available | (3) Workers allocated to work on wheat and corn cannot exceed total workers available |
| $\sum_{i=\text{wheat}, \text{corn}} f_i * x_i \leq F$
available fertilizer | (4) Fertilizers used for wheat and corn cannot exceed total available fertilizer |

Notes:

1. The constraints (2), (3), (4) ensures that the amount of land, workers, and fertilizers utilized stay within their respective availability.

Optimal Solution. The following is the solution obtained from Excel Solver.



The optimal solution is to allocate 200 acres to wheat and 200 acres to corn to yield a maximum profit of 1000000\$.

Commented [YW1]: Maybe insert excel screen shot as a 'picture'?

Input	wheat	corn		
Profit Margin	2000	3000		
Workers needed	3	2		
Fertilizer needed	2	4		
Decision				
Area of land allocated	200	200		
	400	<=		450
Land available	450			
Amt of Fertilizer available	1200			
No. of workers available	1000			
Fertilizer used	1200	<=	1200	
Workers utilized	1000	<=	1000	
Objective				
Total Profit	1000000			

Input	wheat	corn		
Profit Margin	2000	3000		
Workers needed	3	2		
Fertilizer needed	2	4		
Decision				
Area of land allocated	200	200		
	400	<=		450
Land available	450			
Amt of Fertilizer available	1200			
No. of workers available	1000			
Fertilizer used	1200	<=	1200	
Workers utilized	1000	<=	1000	
Objective				
Total Profit	1000000			

Farmer [Based on Practical Management Science]

Prepared by Athira Praveen

