Farmer [Based on Practical Management Science] Prepared by Atul Makam

**Farmer.** A farmer owns 4500 acres of land. He is going to plant each acre with wheat, corn or rice. Each acre planted with rice yields $1000 revenue, requires 2 workers, required 5 tons of fertilizer and costs $20 per hour for labor. Each acre planted with wheat yields $2000 revenue, requires 3 workers, required 2 tons of fertilizer and costs $15 per hour for labor. Each acre planted with corn yields $3000 revenue, requires 2 workers, required 4 tons of fertilizer, and costs $15 per hour for labor. 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 and/or the acres of rice 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 4500 acres rather than equal to 4500 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:

Ri :  *Revenue per acre of produce*i*,* where i∈(wheat, corn, rice)

Fi :  *Tons of fertilizers required for unit acre of produce*i*,*where  i∈(wheat, corn, rice)

Ci :  *Labor cost for unit acre of produce*i*,*where  i∈(wheat, corn, rice)

W : *Total number of workers available*

F :  *Total tons of fertilizers available*

L: *Total land available*

Decisions:

xi :*Amount of land to be allocated to produce*i*,*where i∈(wheat, corn)

yi : *Number of workers needed to produce*i*,*where i∈(wheat, corn

Objective: *Maximize profit*

max∑i=wheat,corn,riceRi ∗ xi - Ci ∗ yi

Constraints:

  xi ≥0                                                    (1)

yi ≥0                                                    (2)

 Land allocated cannot be negative

∑i=wheat,corn,ricexi≤   L                           (3) Land allocated to wheat, rice and corn cannot exceed total land available

∑i=wheat,corn,riceyi∗xi≤   W                (4) Workers allocated to work on wheat, rice and corn cannot exceed total workers available

∑i=wheat,corn,ricefi∗xi≤   F                   (5) Fertilizers used for wheat, rice 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 4500 acres and 2250 workers to corn to yield a maximum profit of $13455000.

A screenshot of a social media post

Description automatically generated