# ECONOMICS OF VARIABLE RATE FERTILIZER APPLICATION

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***Abstract :*** *Fertilizer application is one of the most important operations in agricultural production. Traditionally, fertilizer is applied onto the whole farmland regardless of the variations across the land. Soil cores are taken randomly through the field and mixed into a single sample, which is then analyzed, and consequently a unique fertility recommendation is made in accordance with the results. However, with this new technology of Precision Farming, grid or zone sampling is employed to determine the variability of the farmland soil fertility and fertilizers at variable-rates are applied onto each of these grids or zones. In this study, economics of using variable-rate fertilizer applicators is examined, an investment appraisal and partial budgeting analysis is made to determine the applicable conditions for farmers.*

***Key words:*** *Precision Farming, Economics, Variable Rate Application, Variable Rate Technology, Fertilizer.*

## INTRODUCTION

Besides the existing risk of environmental and economical conditions, generally speaking, gross margins in agricultural crop production is very low and steadily diminishing due to economical measures of countries to approach the world market prices. Farmers should take utmost care of their expenditures and input usage in order to make money or at least to avoid deficits while trying to yield as much as possible by applying the nutrition requirements of plants to the soil and to avoid hazardous effects of weather conditions and natural enemies of the crops, e.g. pests. Fertilizers, sprays, seeds, labour, machinery and mechanical power in terms of tractors and other engines are the major sources of production costs.

On the other hand there has been an increasing concern on the environmental impact of agricultural production in terms of its risk on air, soil and water pollution. This concern had lead scientists to deal with the problem of pollution and study the environment friendly practices and inputs rather than traditional farming and usage of pollutant chemicals in the form of fertilizers, sprays, growth regulators, etc. Sustainability in agricultural production, which is meant to produce crops and animals while keeping an eye on the balance of nature, has become widely accepted approach of farming in the western world.

In many of the member states of the European Union, incomes from agriculture are diminishing at a rate between 1 % to 12 %. Recent developments in agricultural policy, such as in Agenda 2000, the WTO negotiations, and the forthcoming eastward extension of the EU exert a significant influence on agriculture. Those measures planned as part of the Agenda 2000 may lead to a noticeable income reduction for the affected farms.(Matthies and Meier, 2001). The EU's Agenda 2000 has lead the integration of environmental goals into the Common Agricultural Policy (CAP) and managing natural resources and contributing to landscape conservation have become increasingly important objectives for the CAP. The so-called "agri-environmental measures" will support the sustainable development of rural areas and will respond to society's increasing demand for environmental services by encouraging farmers to use farming practices compatible with environmental protection and natural resources conservation.

Precision farming, in this respect, is a promising technology through which;

- crop yields, field performance and operating productivity in agricultural operations could be maximized,,

- performance of various seed types, hybrids, chemicals and soils could be measured,
- fertilizer, chemical application costs could be reduced,
- pollution through poor use of chemicals could be reduced,
- field performance to the square meter could be tracked, mapped and analyzed so that to allow farmer to be able to know how well or poorly each part of a field is producing,
- decision-making process in farm-management could be improved,
- better farm records essential for sale and successions could be provided.

Numerous researchers have studied the economic impact of precision farming. Swinton and De-Boer (1998), and De-Boer (2000) demonstrated basic budgeting methods to measure average profitability of variable rate technology. Pedersen and Have (1998) also presented an estimate of what is to be obtained from precision farming by linking an economic model with data from field experiments of 3 successive years. They also concluded that development of cheaper methods for measurement of soil and crop variables, cheaper precision equipment, improved decision support systems and/or taxes on fertilizer and pesticides would all increase the economic profitability.

In this study, investment analysis by partial budgeting method is demonstrated and minimum savings of fertilizers, sprays and seeds as well as minimum increase in yield that corresponds to investment costs of precision farming are calculated.

## Economic Calculation Methods

Economic analysis of precision farming technology is not different than that applied to any other new technologies. Partial budgeting on a per hectare basis has been the most common tool to estimate the profitability of precision farming.

Partial budgeting is used when only a partial change in the existing plan is being considered, so that some – possibly most – of the cost and receipt items on the farm will not alter. Thus only the changes in costs and receipts are calculated (Barnard and Nix, 1988). There are three main types of change that can be calculated by partial budgeting method. These are; (i) product substitution, (ii) change of enterprises without substitution and (iii) factor substitution.

The factor substitution is often a change in production techniques and adoption of precision farming can be considered in this category. It subtracts losses (increased costs plus reduced revenues) from gains (reduced costs plus increased revenues) to estimate the change in net revenue that results from adopting a new practice such as variable rate input control.

Precision Farming as an application of Information Technology in agriculture concerns with the software and hardware required to collect, process and store the information in order to control the farm equipment. Within this definition there are mainly two areas of investment; information and the equipment. The economic analysis of both are presented below.

## Information Cost

Information must be valued in accordance with the easiness and the technology employed to reach it and also the possibilities it provides. There are various ways of estimating, for example the nutrient requirement of the soil for a particular plant. However, although it is the most expensive method, the nutrient analysis is gives the most precise information. Yield maps, soil maps, air photographs are the information that should be considered within the PF cost calculations.

**Costs of Equipment**

It is well known that the cost of an equipment is a function of purchase price of the equipment, its economical life, repair and maintenance frequencies and the market conditions such as interest rate and inflation rate.

The cost of a whole or an additional component of an equipment can be calculated by the following equation [Eq.1] which provides the annual fixed costs, i.e. depreciation and interest charges, as equal annual mortgage payments, considering that the equipment is bought by borrowing the money and paying a series of equal annual mortgage payments;

$$R = (C_0 - C_N)\frac{i_r.(1+i_r)^n}{(1+i_r)^n - 1} + C_N.i_r \qquad \text{[Eq.1]}$$

where;

R : Annual mortgage payment (TL/year)
$C_0$ : Purchase price of the equipment (TL)
$C_N$ : Resale value of the equipment (TL)
$i_r$ : Real interest rate (decimal)

The real interest rate under inflation can be calculated by the following equation [Eq.2];

$$i_r = \frac{i_n - i_g}{1 + i_g} \qquad \text{[Eq.2]}$$

where;

$i_r$ : real interest rate (decimal)
$i_n$ : interest rate on loan capital (decimal)
$i_g$ : inflation rate (decimal)

**A Sample Calculation**

A demonstration of the cost calculation on a sample cotton farm is given below. Assumptions made in this study in order to simplify the problem are as follows;

I. The farm will be using the same size of equipment only with a difference of PF components.
II. The input usage are considered for the worst conditions, e.g. the highest possible attack by pests, the highest possible amount of fertilizer application
III. There is no change in unit input application, farm tractor size and number as the farm size increases up to 500 ha. (Please note that in reality this is not possible because of soil workability due to weather conditions.)

**<u>The Input Data;</u>**

Table 1 gives the yield and unit price (TL/kg, TL/ha) of cotton production in Turkey. Extra equipment required to be purchased for PF application are listed in Table 2. As technology for precision farming is improving very fast and therefore may be out of date long before it is technical obsolete, the expected service life of equipment in calculations are estimated to be 5 years (Table 3). Real interest interest rate is calculated according to the equation given below and presented in Table 3.

**Table 1.** Cotton Yield and Price

| | |
|---|---|
| Yield (kg/ha) | 4.500 |
| Price (TL/kg) | 630.000 |
| Price (TL/ha) | 2.835.000.000 |

**Table 2.** Extra Price of PF Equipment (US$)

| | |
|---|---|
| Boundry Mapping&Surveys | 2.000 |
| Yield Monitor | 4.000 |
| DGPS | 4.000 |
| VRT Equipment | 7.000 |
| Microcomputer & Printer | 1.750 |

**Table 3.** Miscellaneous Financial Data

| | |
|---|---|
| Inflation Rate (%) | 40 |
| Interest Rate (%) | 50 |
| Real Interest Rate (%) | 7,14 |
| Real Interest Rate (decimal) | 0,07 |
| Life of Equipment (years) | 5 |
| Exchange Rate (TL/USD) | 1.360.000 |

Cotton in Turkey has a lot of natural enemies of pests and requires the spraying operation very frequently. The average fertilizer and spray applications and their costs are presented in Table 4.

**Table 4.** Cotton Production Inputs and Costs

| | **Amount (kg/ha)** | **Unit Price (TL/kg)** | **TOTAL (TL/ha)** | **Description** |
|---|---|---|---|---|
| Fertilizer (1) | 250 | 320.000 | 80.000.000 | DAP |
| Spray (1) | 2 | 7.500.000 | 15.000.000 | Treflon |
| Seed | 25 | 3.000.000 | 75.000.000 | delinted |
| Spray (2) | 2 | 15.000.000 | 30.000.000 | Trips |
| | 2 | 16.000.000 | 32.000.000 | Growth supporter |
| Spray (3) | 2 | 20.000.000 | 40.000.000 | insecticide |
| | 3 | 18.000.000 | 45.000.000 | insecticide |
| | 1 | 30.000.000 | 30.000.000 | insecticide |
| Fertilizer (2) | 300 | 200.000 | 60.000.000 | Am..Nitrate |
| Spray (4) | 2 | 20.000.000 | 40.000.000 | insecticide |
| | 3 | 18.000.000 | 45.000.000 | insecticide |
| | 1 | 30.000.000 | 30.000.000 | insecticide |
| | 2 | 16.000.000 | 32.000.000 | Growth supporter |
| Spray (5) | 2 | 20.000.000 | 40.000.000 | insecticide |
| | 3 | 18.000.000 | 45.000.000 | insecticide |
| | 1 | 30.000.000 | 30.000.000 | insecticide |
| | 2 | 16.000.000 | 32.000.000 | Growth supporter |
| Spray (6) | 2 | 10.000.000 | 15.000.000 | Growth regulator (Pix) |
| Spray (7) | 3 | 4.000.000 | 10.000.000 | Defoliant |
| **TOTAL** | | | **726.000.000** | |
| ***FERTILIZER*** | 550 | 520.000 | 140.000.000 | |
| ***SPRAY*** | 31 | 288.500.000 | 511.000.000 | |
| ***SEED*** | 25 | 3.000.000 | 75.000.000 | |

## The Results

Table 5 gives the cost calculations of information in terms of soil sample analyses taken from grid cells of 0.4 ha.

Costs per years and per hectares of those extra equipment required to be purchased for PF application are calculated in accordance with the method described before and presented in Table 6.

Cost calculations were made for various farm scales; 50, 100, 150, 200, 250, 300, 350, 400, 450, 500 and the results provided at Table 7.

i. the percentage increase in yield,
ii. the percentage decrease in fertilizer application rate,
iii. the percentage decrease in spray application rate and
iv. the percentage decrease in seed rate

required to cover these extra costs of Precision Farming investment are also calculated and given in Table 7 and Figures 1, 2, 3 and 4.

**Table 5.** Cost of Information (for a 100 ha farm)

| | |
|---|---|
| Total Area (ha) | 100 |
| Grid Cell Area (ha) | 0,40 |
| No of Grid Cells | 250 |
| Grid sampling cost (TL/sample) | 12.500.000 |
| Total Soil Test Cost | 3.125.000.000 |
| SoilTest Cost / ha | 31.250.000 |

**Table 6.** Extra Investment Cost of Equipment (for a 100 ha farm)

| | **(US$/year)** | **(US$/ha)** | **(TL/ha)** |
|---|---|---|---|
| Boundry Mapping&Surveys | 490 | 4,90 | 6.659.221 |
| Yield Monitor | 979 | 9,79 | 13.318.443 |
| DGPS | 979 | 9,79 | 13.318.443 |
| VRT Equipment | 1.714 | 17,14 | 23.307.275 |
| Microcomputer & Printer | 428 | 4,28 | 5.826.819 |

**Table 7.** Costs For Extra Investment for Precision Farming

| | **Farm Scale** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **50** | **100** | **150** | **200** | **250** | **300** | **350** | **400** | **450** | **500** |
| Total Cost of Information (mil.TL/ha) | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 |
| Total Cost of Extra Equipment (mil.TL/ha) | 125 | 62 | 42 | 31 | 25 | 21 | 18 | 16 | 14 | 12 |
| **Total Return Required (mil.TL/ha)** | **156** | **93** | **73** | **62** | **56** | **52** | **49** | **47** | **45** | **43** |
| Equivalent Yield Increase (%) | 5,5 | 3,3 | 2,6 | 2,2 | 2,0 | 1,8 | 1,7 | 1,6 | 1,6 | 1,5 |
| Equivalent Fertilizer Decrease (%) | | 66,9 | 52,0 | 44,6 | 40,2 | 37,2 | 35,1 | 33,5 | 32,2 | 31,2 |
| Equivalent Spray Decrease (%) | 30,6 | 18,3 | 14,3 | 12,2 | 11,0 | 10,2 | 9,6 | 9,2 | 8,8 | 8,6 |
| Equivalent Seed Decrease (%) | | | 97,2 | 83,3 | 75,0 | 69,4 | 65,5 | 62,5 | 60,2 | 58,3 |
| Equivalent Overall Cost Decrease (%) | 21,5 | 12,9 | 10,0 | 8,6 | 7,7 | 7,2 | 6,8 | 6,5 | 6,2 | 6,0 |

**Figure 1.**

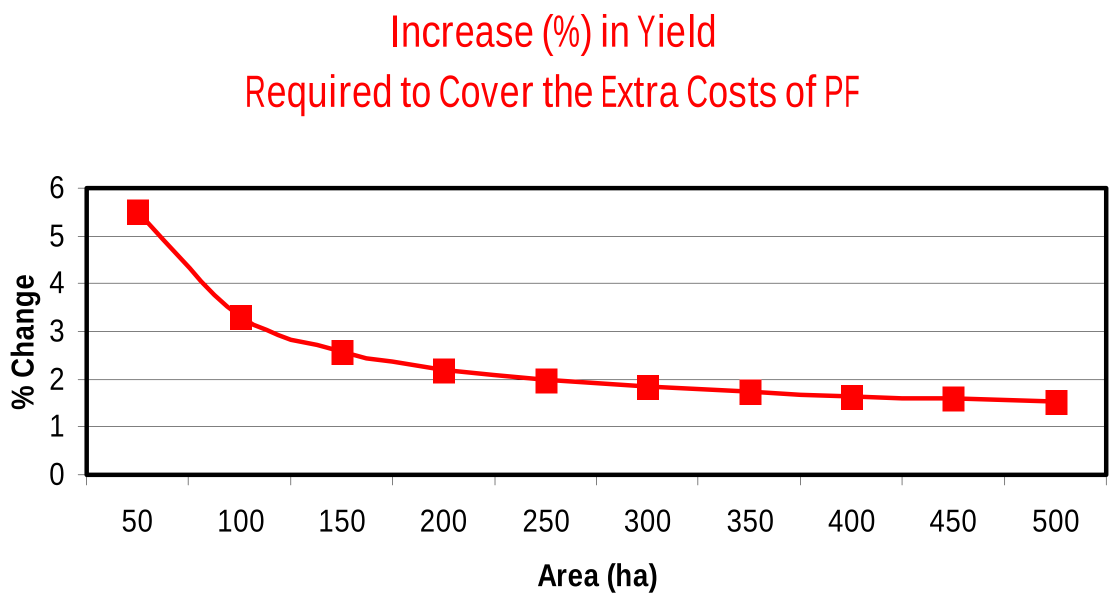



**Figure 2.**

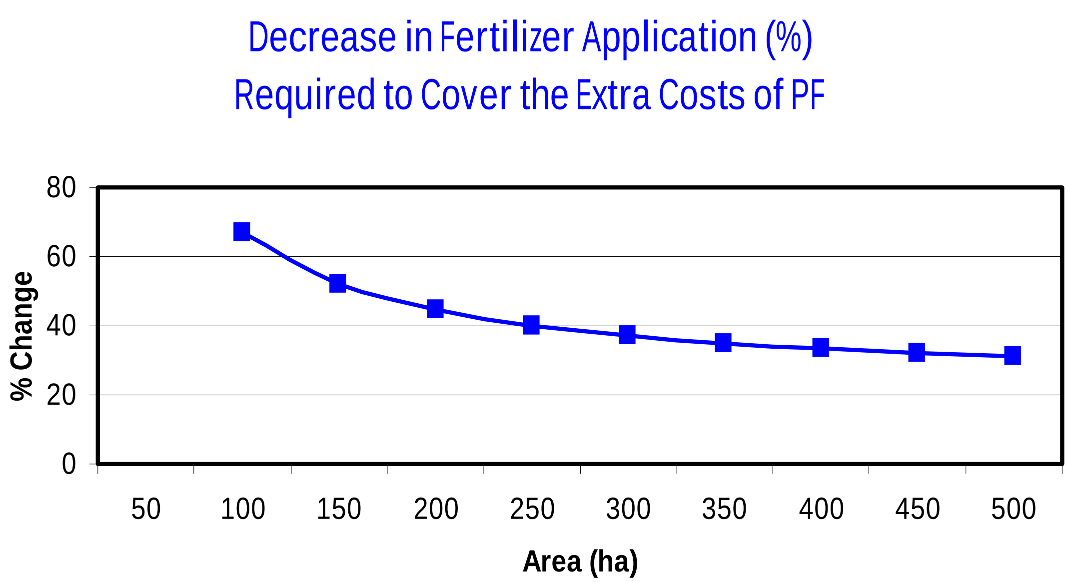


**Figure 3.**

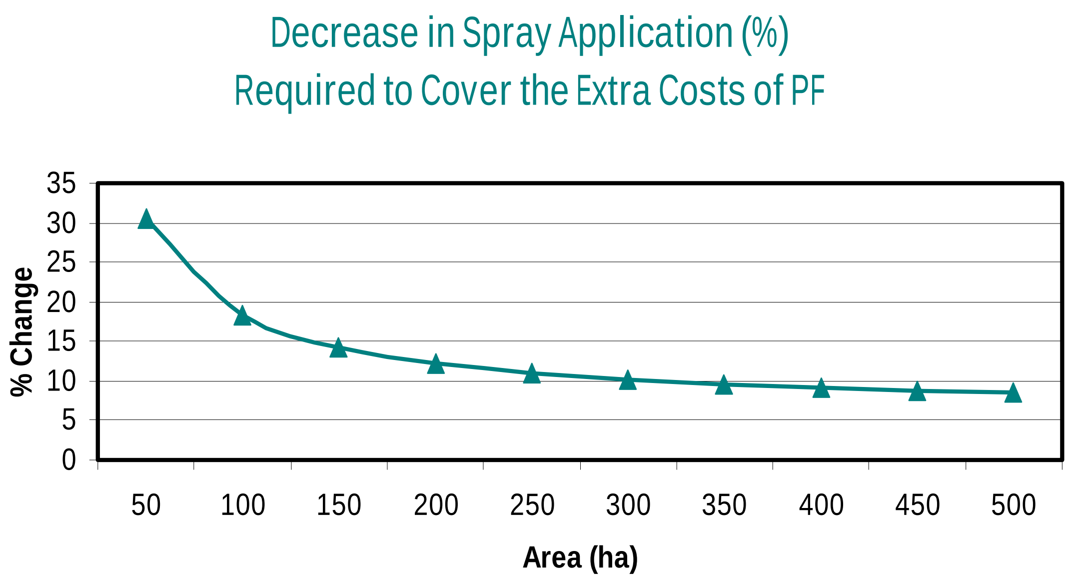
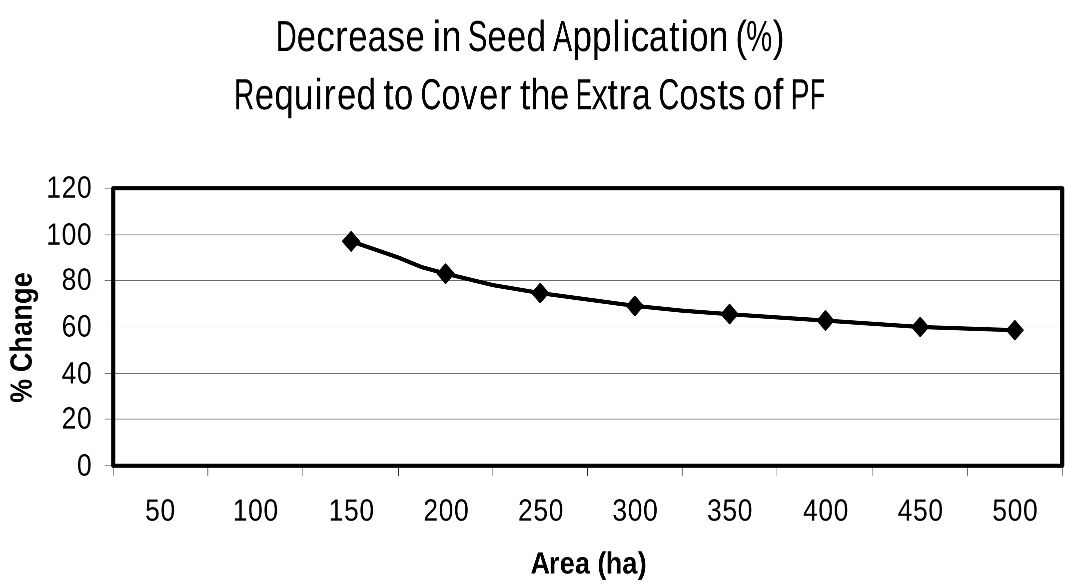



**Figure 4.**



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