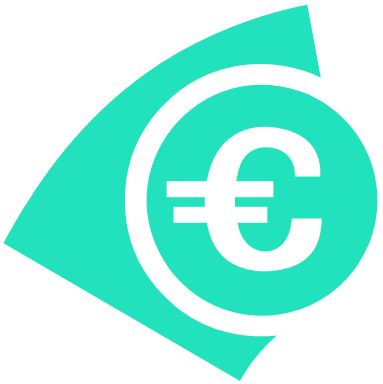
Efficient and safe production processes in sustainable agriculture and forestry
**XXXIV CIOSTA CIGR V Conference 2011**

# An economic analysis of the precision fertilization

***Maria Walczykova***
***Faculty of Production and Power Engineering***
***University of Agriculture***
***Kraków, Poland***

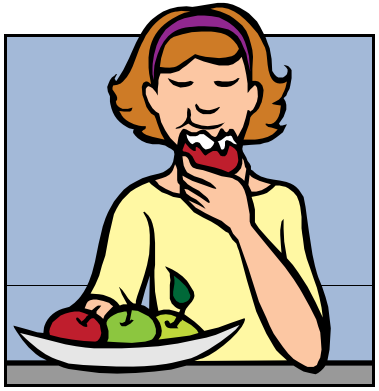
# Increasing problems of the modern agriculture

- economic



- environmetal

- social



## ***Expected:***

(a) the environmental benefit from a more precise targeting the agricultural chemicals

(b) economic benefit from an increase in crop yield and in the input reduction

**SSM practices are used world wide**

**The further studies on VRA economic potential is necessary**

## ***Reasons:***

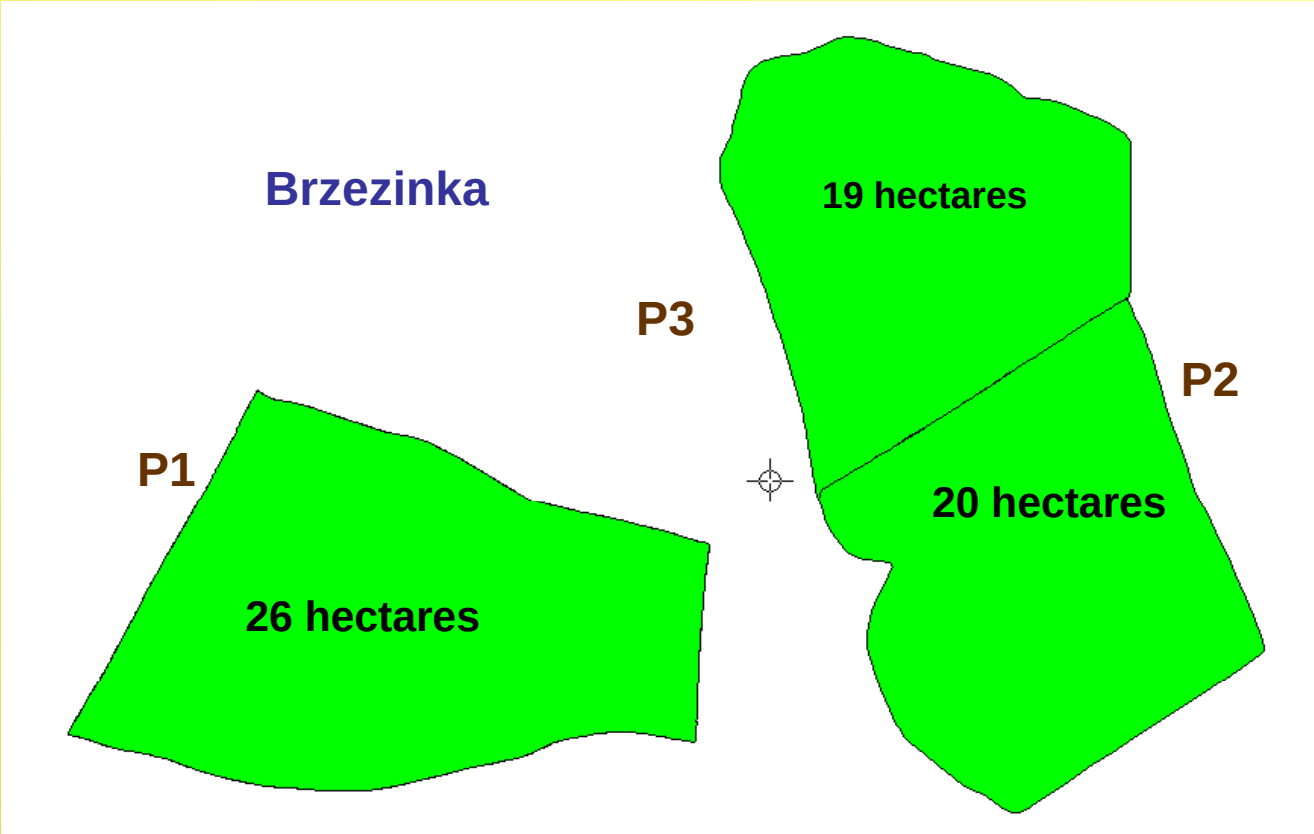
- inborn field variability
- the size of the farm
- the production area positively responding on the variable input
- soil and climatic conditions
- the type of cultivated plant

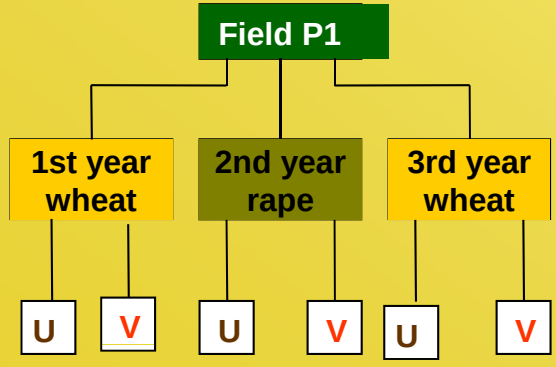
**Profits from using PF technology not possible to express in general numbers:**

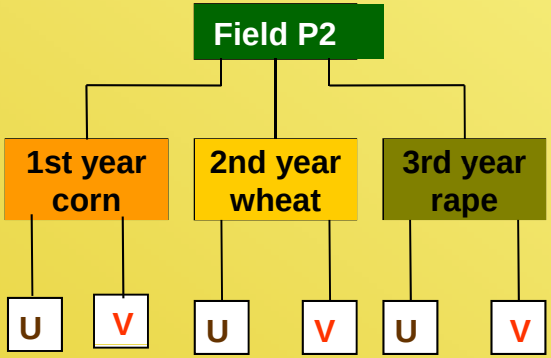
- depend on conditions prevailing on the specific field

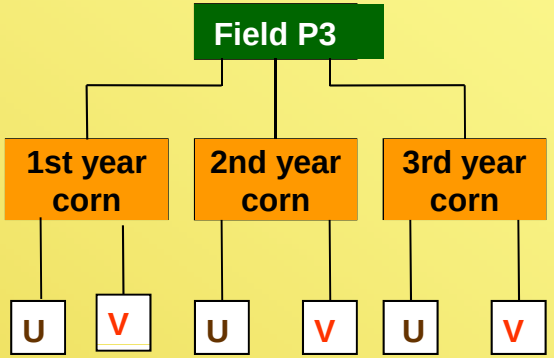
- they are changeable in time, according to the technology development and better understanding of its application

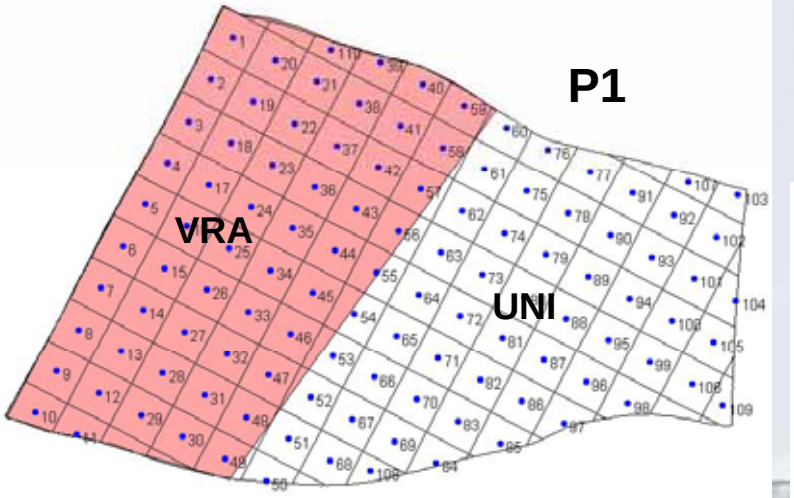
There is lack of evidence on profitability of the PF in Poland

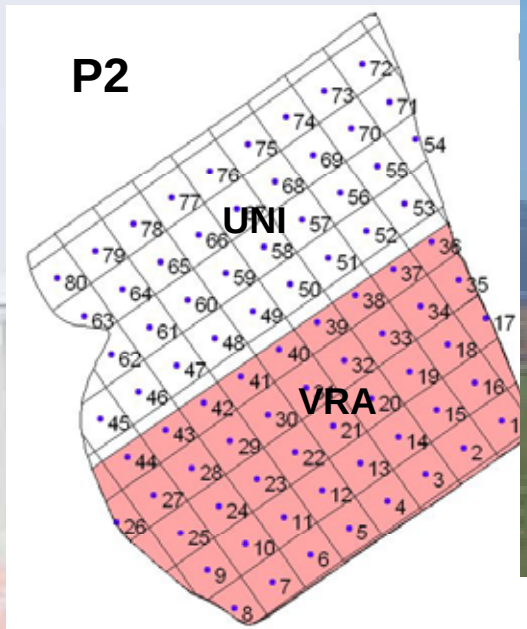

Brzezinka
19 hectares
P3
P2
P1
20 hectares
26 hectares

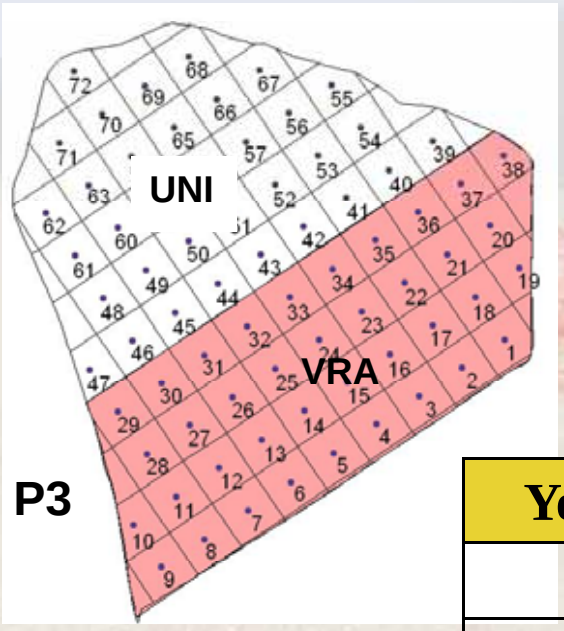

Field P1
1st year wheat
2nd year rape
3rd year wheat
U
V
U
V
U
V


Field P2
1st year corn
2nd year wheat
3rd year rape
U
V
U
V
U
V


Field P3
1st year corn
2nd year corn
3rd year corn
U
V
U
V
U
V





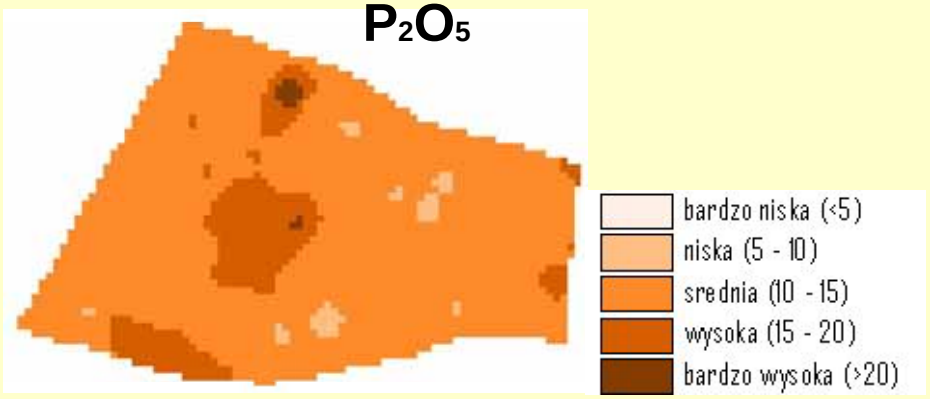

| Yers | P1 | P2 | P3 |
|---|---|---|---|
| 1 | Wheat | Corn | Corn |
| 2 | Rape | Wheat | Corn |
| 3 | Wheat | Rape | Corn |

**Digital maps of fields with monitoring grid 50x50 m**

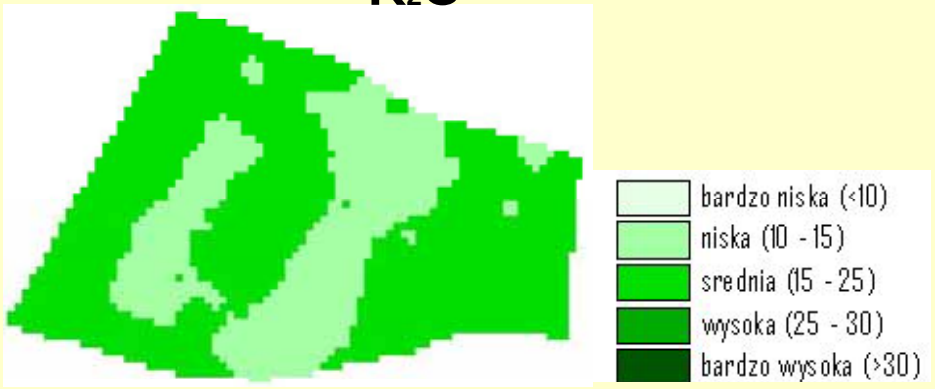
**The uniform application rates – adjusted to the AVERAGE NUTRIENT STATUS** and the **AVERAGE YIELD**

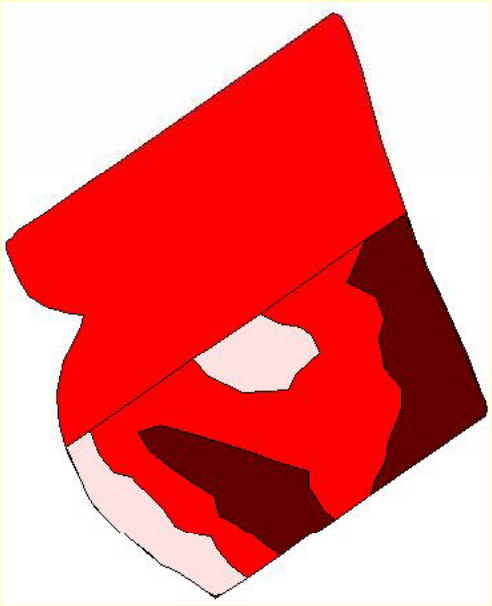
**The application maps based on MANAGEMENT ZONES OF NUTRIENT and the EXPECTED AVERAGE YIELD**

$P_2O_5$




$K_2O$

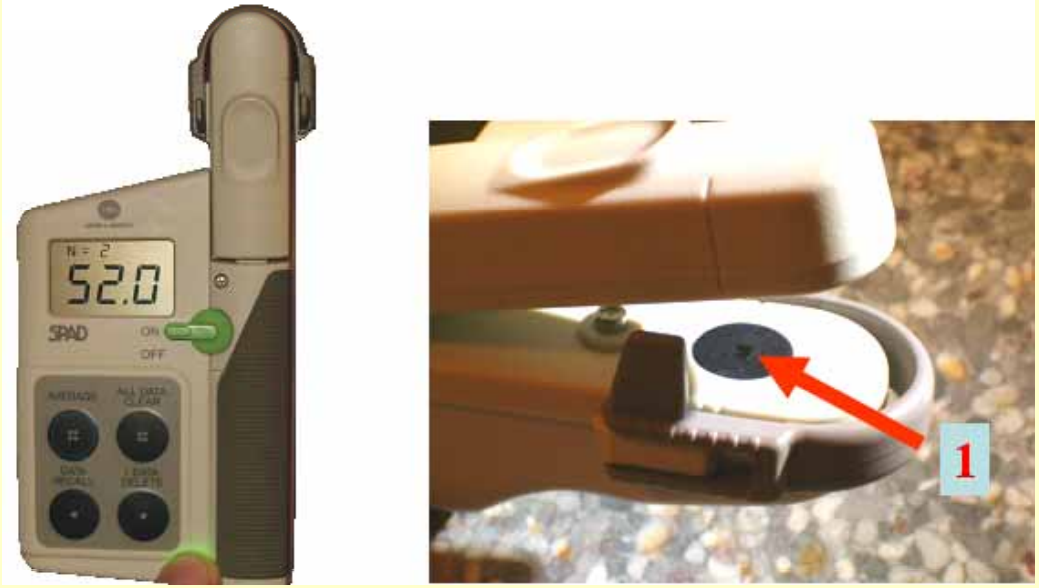




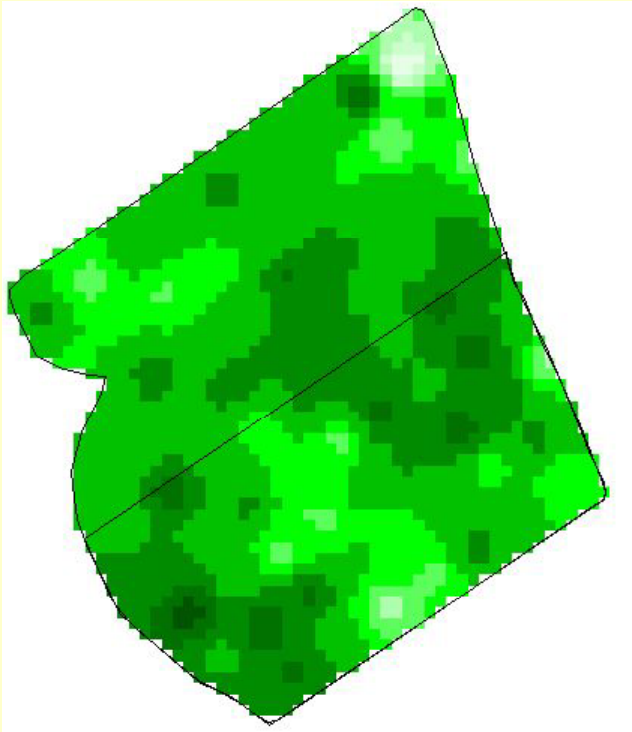
## Production rate of N diversified according to:

- **the terrain features** (wheat and corn)
- **the condition of plants after winter** (winter rape)

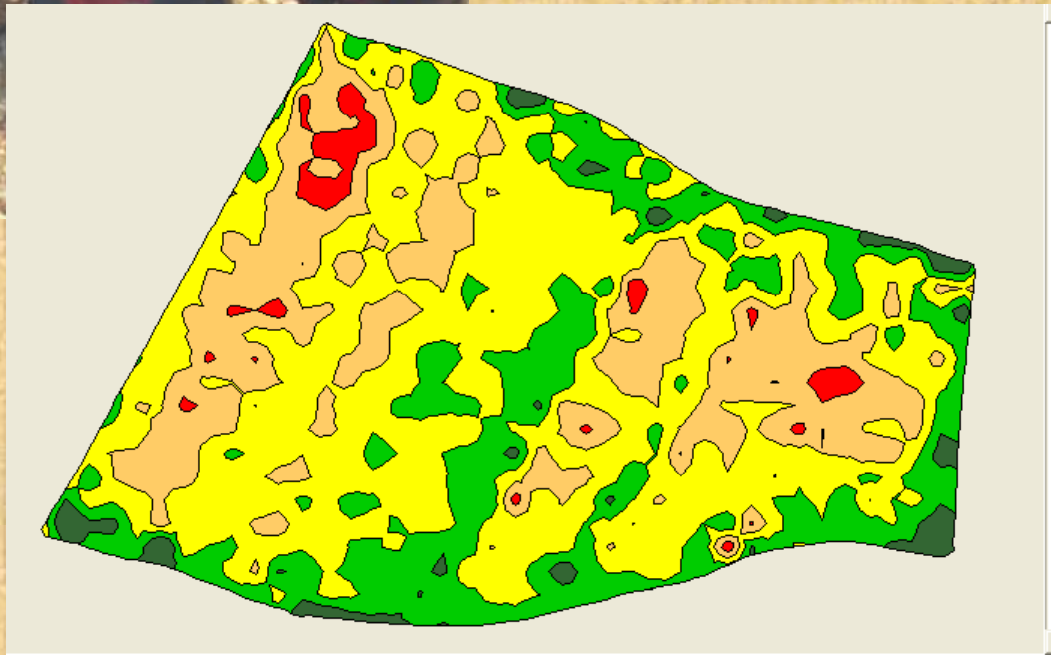
**Remaining N – application based on chlorophyll content or "greenness" of plants, measured by SPAD 502 Plus Chlorophyll Meter**




*General view of the SPAD 502DL chlorophyll meter: 1- measuring spot.*



**Optical yield monitoring system**



**AgroMap, ArcView GIS software**

Box

2 4

2 4

1 2 3

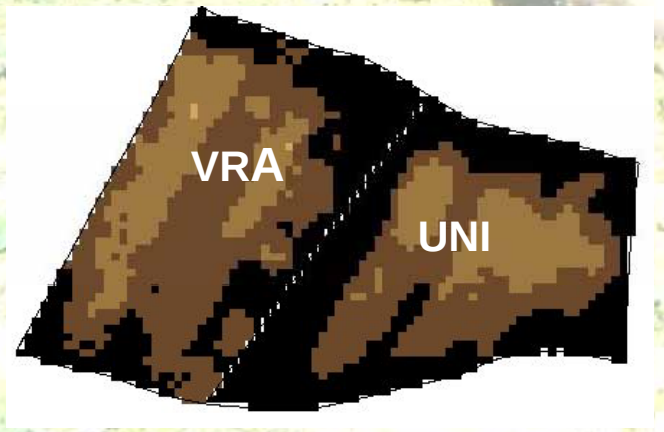
Radar

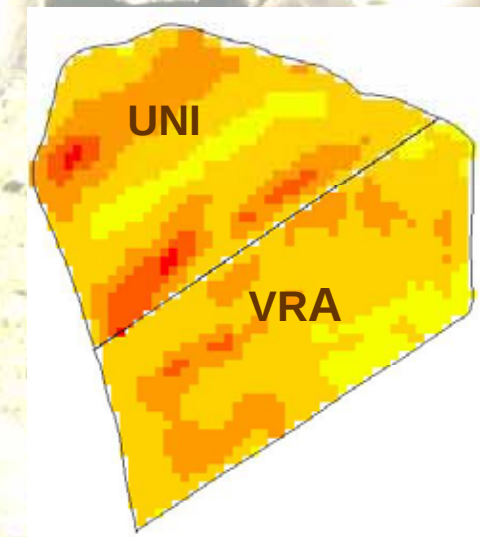
Obroty WOM

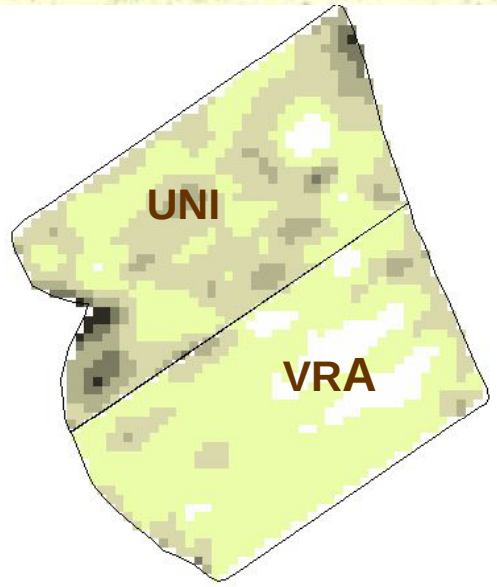
Obroty koła

**Total costs of used fertilizers** calculated for both **uniform and variable** rate application**.**

**The difference presented benefits (or losses) as a result of using VRA.**



*Benefits resulting from variable N application based on SPAD measurements on **winter wheat** .*

| Rate | 1st year, field P2 | | 2nd year, field P1 | |
|---|---|---|---|---|
| | (PLN·ha$^{-1}$) | (%) | (PLN·ha$^{-1}$) | (%) |
| II | 52.26 | 61.3 | 33.16 8€ | 36.1 |
| III | 40.29 | 47.3 | 47.78 | 52.0 |

*Benefits (PLN ha$^{-1}$) resulting from using VRA at **winter wheat** fertilization.*

| Nutrient | 1st year, field P2 | 2nd year, field P1 |
|---|---|---|
| N | 52.00 | 51.65 |
| P | 26.80 | -0.48 |
| K | 2.70 | 8.53 |
| Total | 81.50 ***~ 20 €*** | 38.03 ***~ 9.25 €*** |

*Benefits resulting from variable N application on **winter rape***

| Rate | 1st year, field P1 | | 2nd year, field P2 | |
|---|---|---|---|---|
| | (PLN·ha$^{-1}$) | (%) | (PLN·ha$^{-1}$) | (%) |
| II | 92.00 | 31,75 | 1.25 | 0.04 |

*Benefits (PLN ha$^{-1}$) resulting from using VRA at **winter rape** fertilization*

| Nutrient | 1st year, field P1 | 2nd year, field P2 |
|---|---|---|
| N | 96.95 | 1.22 |
| P | 31.80 | -2.04 |
| K | 8.55 | 12.61 |
| Total | 137.30 ~ ***34 €*** | 11.79 ~ ***3 €*** |

*Benefits resulting from variable N application on **corn**.*

| Rate | 1st year, field P3 | | 2nd year, field P3 | |
|---|---|---|---|---|
| | (PLN·ha$^{-1}$) | (%) | (PLN·ha$^{-1}$) | (%) |
| II | 25.73 | 8.33 | 14.54 | 4.16 |

*Benefits (PLN ha$^{-1}$) resulting from using VRA at **corn** fertilization.*

| Nutrient | 1st year, field P3 | 2nd year, field P3 |
|---|---|---|
| N | 20.61 | 21.00 |
| P | -2.88 | 25.00 |
| K | 11.93 | 5.95 |
| Total | 29.66 ***~ 7,5 €*** | 51.95 ***~ 13 €*** |

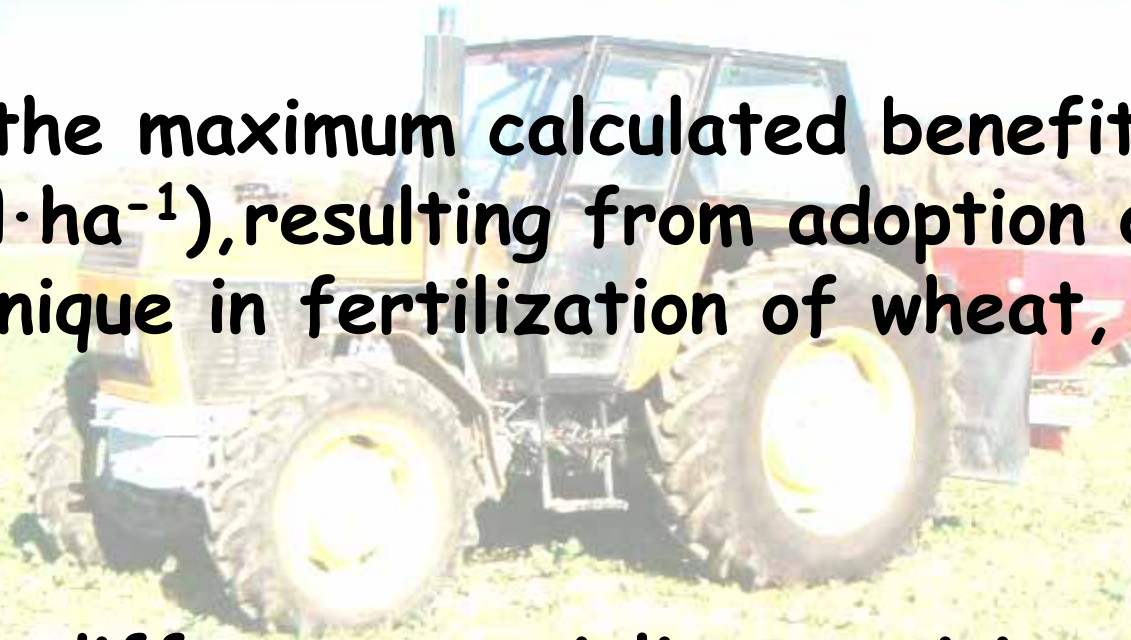
**Nitrogen supply at VRA lower than at UNIFORM application by 5-32 kg**

*Total amount of the applied nitrogen.*

| Plant | Applied nitrogen (kg ha$^{-1}$) | | | |
|---|---|---|---|---|
| | 1st year | | 2nd year | |
| | Uniform | VRA | Uniform | VRA |
| Wheat | 145.00 | 125.07 | 145.00 | 121.60 |
| Rape | 140.80 | 109.07 | 142.88 | 137.45 |
| Corn | 138.00 | 130.75 | 138.00 | 129.86 |

**Total amount of N met the Nitrate Directive 676/91 demand**

# Determination of the breakeven areas



- for the maximum calculated benefits (PLN·ha$^{-1}$),resulting from adoption of VRA technique in fertilization of wheat, rape and corn
- using different specialist precision farming equipment

## *Proposed systems for PA*

| No | Components of the proposed PA equipment | Total cost (PLN) *4 PLN~1€)*) |
|---|---|---|
| I | LH 5000 GPS + Data Link+ D-GPS NovAtel SA/AllStar; radar+ wheel rev. counter, **NDVI scanning** and all application maps made as custom service; Rauch Alpha 1131 fertilizer spreader; yields estimated by weighing. | 38 550 |
| II | Palmtop 3R GPS + Site Mate VRA Farm Works software+ D-GPS NovAtel SA/AllStar; radar+ wheel rev. counter, **2x NDVI scanning** and all application maps made as custom service; Rauch Alpha 1131 fertilizer spreader; yields estimated by weighing. | 36 370 |
| III | Agrocom yield monitoring system+ AgroMap PF software; LH 5000 GPS+ D-GPS NovAtel SA/AllStar + CEBIS computer from the yield monitoring system; **NDVI scanning;** yield maps and all application maps made in AgroMap PF on the farm; Rauch Alpha 1131 fertilizer spreader. | 79 950 |
| IV | Agrocom yield monitoring system+ AgroMap PF software; LH 5000 GPS+ D-GPS NovAtel SA/AllStar + CEBIS computer from the yield monitoring system; **NDVI scanning;** yield maps and all application maps made in AgroMap PF on the farm; Rauch Alpha 1131 fertilizer spreader; Palmtop 3R GPS for scouting. | 84 292 |
| V | Agrocom yield monitoring system+ AgroMap PF software; LH 5000 GPS+ D-GPS NovAtel SA/AllStar + CEBIS computer from the yield monitoring system; chlorophyll meter for SPAD measurements; yield maps and all application maps made in AgroMap PF on the farm; Rauch Alpha 1131 fertilizer spreader; palmtop 3R GPS for scouting, guidance (Guide Mate software) and spreading fertilizer (Farm Works Site Mate VRA) simultaneously with the harvest. | 102 020 |

**Assumptions**:

- the price of the fertilizer spreader equals to the difference between conventional one and adapted to VRA performance,
- the farmer owns already a computer.

**Depreciation $K_a$** **5 and 12 yrs**

$$K_a = \frac{C_m}{T_a}$$

( PLN $yr^{-1}$) (1)

$C_m$ – equipment price (PLN)
$T_a$ – time of depreciation (yrs)

**Depreciation time of the specialist equipment installed on machines equal to $T_a$.**

**Cost of maintenance** - the initial capital cost $k_n$ = 3.5%

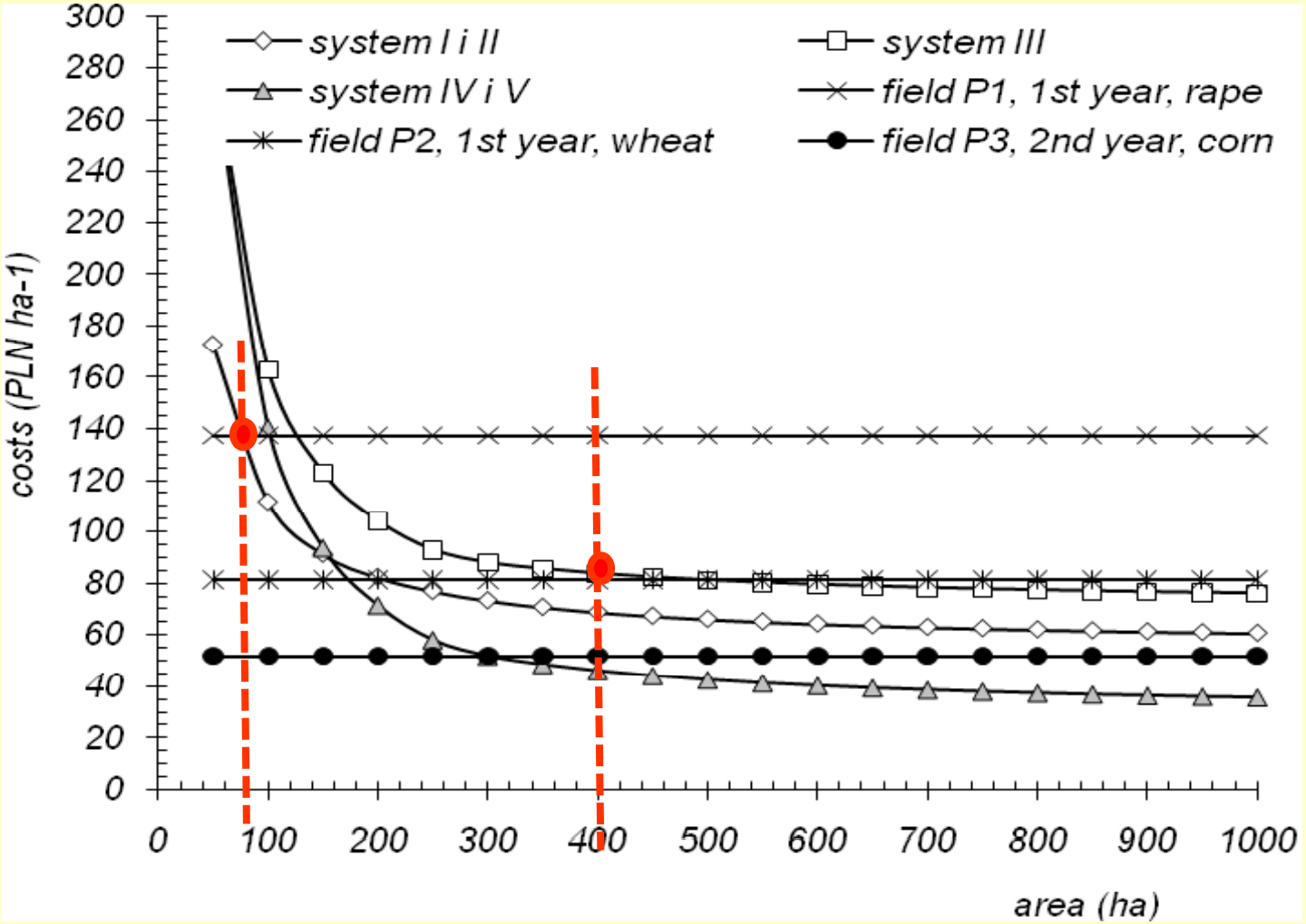
$$K_a = \frac{C_m}{T_a} \quad \text{(PLN yr}^{-1}\text{)} \quad (2)$$

**Cost of capital** $k_{op}$ = 8% annual interest rate

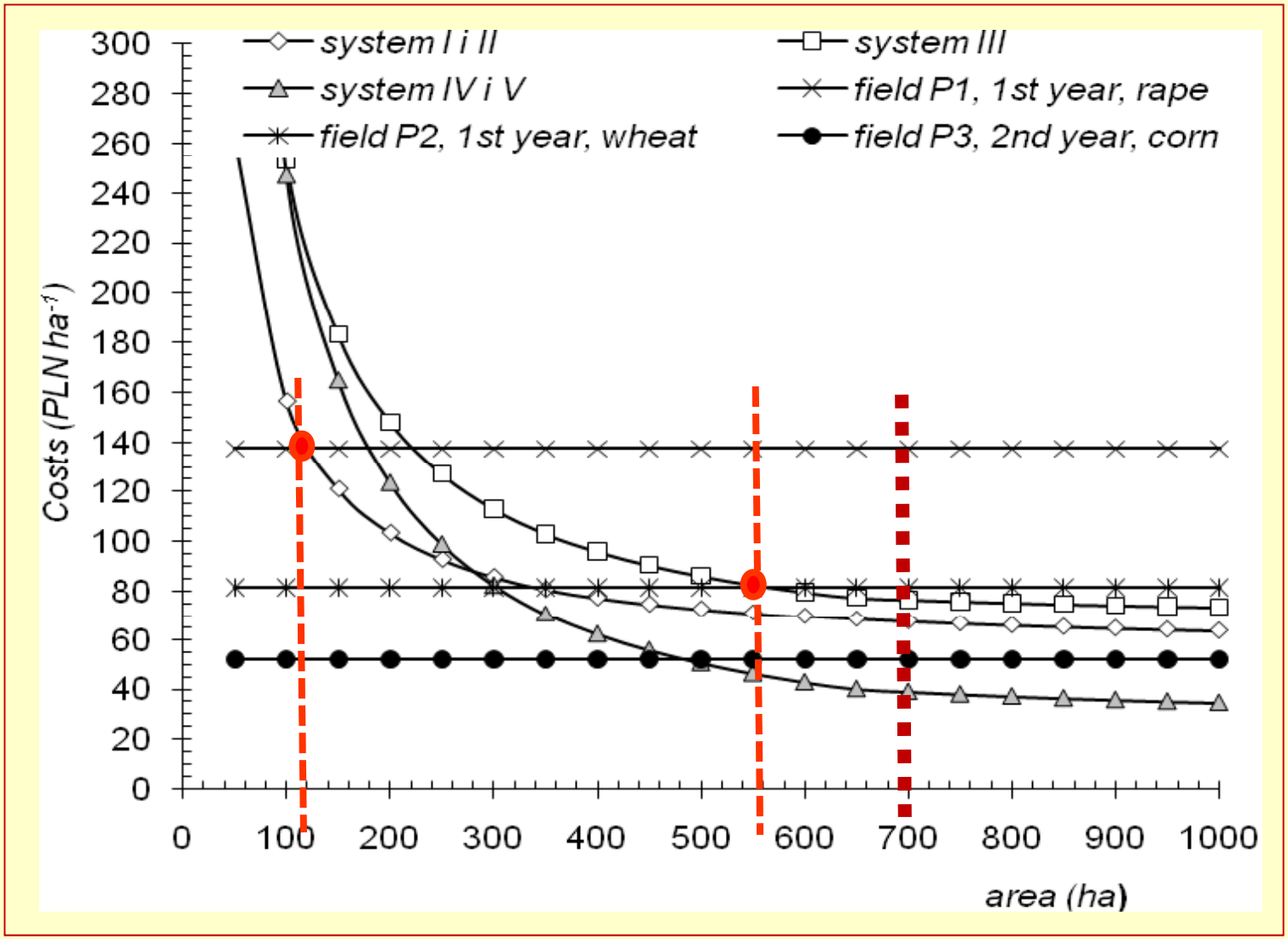
$$K_{op} = \frac{0{,}5\, k_{op} C_m}{100} \quad \text{(PLN yr}^{-1}\text{)} \quad (3)$$

Calculated costs increased by the costs of services per hectare, if included in the proposed system

Overall annual maintenance costs of each system per hectare for a range of arable areas 50-1000 ha




***Determination of the breakeven area ( 4 PLN~1€) -12 yrs depreciation***



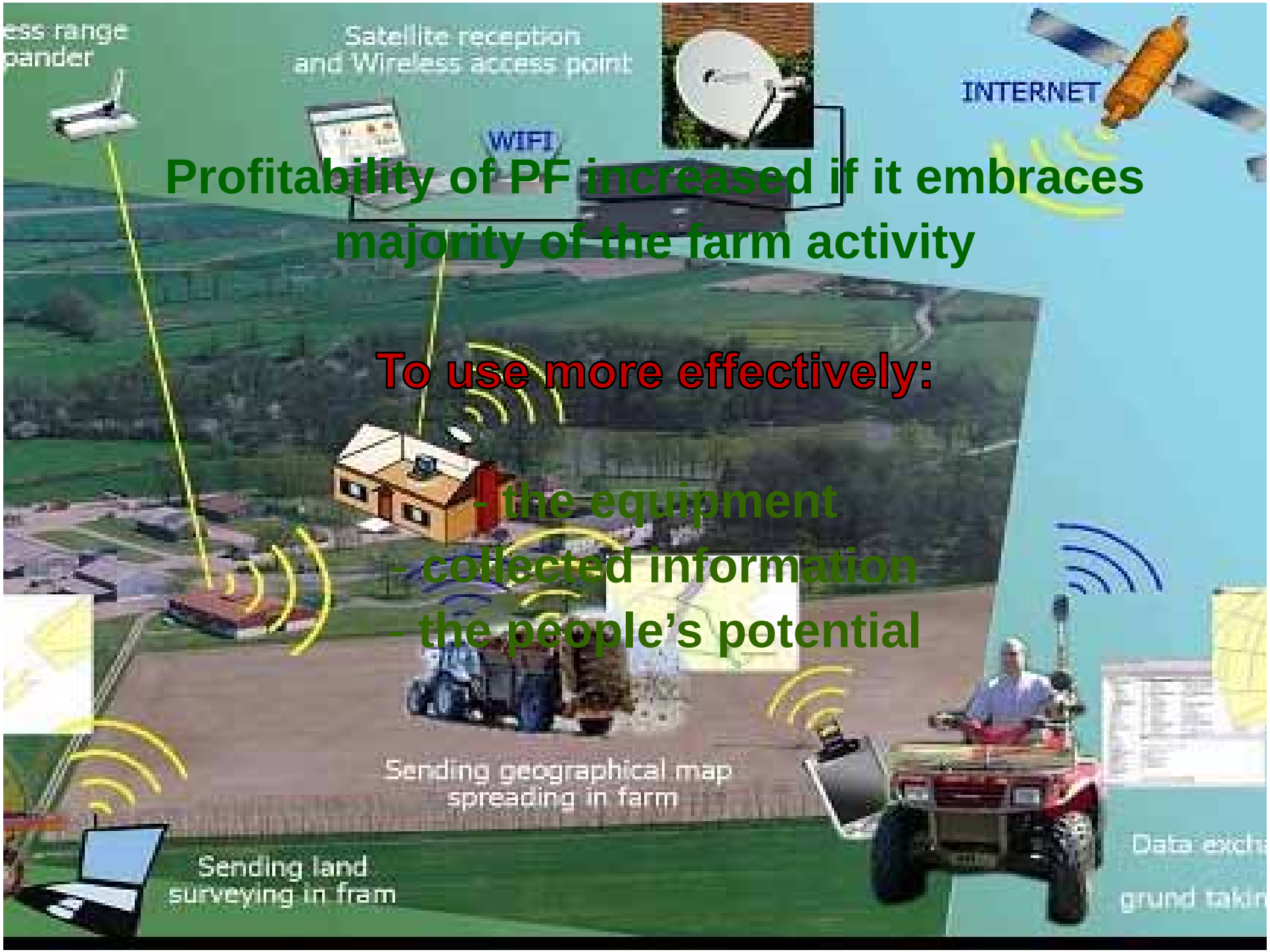
***Determination of the breakeven area ( 4 PLN~1€) -5 yrs depreciation***

## *Breakeven areas (ha) for maximum benefits obtained in carried out research*

| Plant | Benefits *(PLN ha$^{-1}$)* | 12 yrs depreciation | | | 5 yrs depreciation | | |
|---|---|---|---|---|---|---|---|
| | | proposed system for VRA | | | proposed system for VRA | | |
| | | I, II | III | IV, V | I, II | III | IV, V |
| wheat | 137.3 | 80 | 130 | 100 | 120 | 220 | 180 |
| rape | 81.5 | 200 | 400 | 175 | 360 | 560 | 300 |
| corn | 51.9 | - | - | 300 | - | - | 500 |

**Determined breakeven area depends on:**

- ❑ used PF equipment and its price
- ❑ input of chemicals
- ❑ type of crop




**Profitability of PF increased if it embraces majority of the farm activity**

**To use more effectively:**

**- the equipment**

**- collected information**

**- the people's potential**

## C

1. The biggest benefits arose from variable nitrogen application based on SPAD measurements on winter wheat.

2. Benefits resulting from using VRA at fertilizer application differed greatly between plants and years of growing.

3. Depending on crop, the PF system components and assumed time of depreciation, the breakeven area varied between 80 and 560 hectares.

# Expectations

dissemination of PF technology

- to increase of competitiveness and decrease of equipment prices.