Introduction to GAMS Modeling Language

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Extending the MyFarm Model

Ex 5: Crop nutrient need

Background/Approach: Nutrient need

- Crops need fertilization. The source of nutrient can come from different sources
- Animal manure, mineral fertilizer, biological fixation
- Many environmental indicators depend on the nutrient balance
- Aim of the exercise is to define:
  - N/P/K nutrient need of our crops
  - Adding three equation which sums the total N/P/K need during model solve
  - Write gams equation more compact

Ex 5: Crop Nutrient Need

- ✓ Define a new parameter, where the nutrient requirements are stored per crop and fertilizer type
- ✓ **Define parameter always with p_ at the beginning**, similar e_ and v_ for equation and variables (improves readability)

```
Parameter p_nutrientNeedperCrop(*,cols) "kg per
                        hectar crop need of nutrients";

p_nutrientNeedperCrop("NITF","wheat")      =  178;
p_nutrientNeedperCrop("PHOF","wheat")      =   77;
p_nutrientNeedperCrop("POTF","wheat")      =  151;
p_nutrientNeedperCrop("NITF","barley")     =  122;
p_nutrientNeedperCrop("PHOF","barley")     =   77;
p_nutrientNeedperCrop("POTF","barley")     =  120;
p_nutrientNeedperCrop("NITF","rapeseed")   =  218;
p_nutrientNeedperCrop("PHOF","rapeseed")   =  119;
p_nutrientNeedperCrop("POTF","rapeseed")   =   66;
p_nutrientNeedperCrop("NITF","sugarbeet")  =  321;
p_nutrientNeedperCrop("PHOF","sugarbeet")  =  178;
p_nutrientNeedperCrop("POTF","sugarbeet")  =  280;
```

Ex 5: Crop Nutrient Need

- ✓Define three new equations, one for each of the nutrients to multiply the hectare with the nutrient requirements
- ✓Define a new variable that is responsible to sum up during optimisation the total crop need

```
equation
e_NUTNED_NITF "equation for N",
e_NUTNED_PHOF "for P",
e_NUTNED_POTF "for K";
```

alternative:

```
equation e_NUTNED_NITF "equation for N";
equation e_NUTNED_PHOF "for P";
equation e_NUTNED_POTF "for K";
```

Ex 5: Crop Nutrient Need

- ✓ The equation should sum over all crops take the optimized hectare and multiply it with the parameter which contains the crop nutrient need.

```
variable v_Nutrientneed(*) "total fertilzer required";

e_NUTNED_NITF..   sum( cols, v_actLevl(cols) *
p_nutrientNeedperCrop("NITF",cols)) =E= v_Nutrientneed("NITF");

e_NUTNED_PHOF..   sum( cols, v_actLevl(cols) *
p_nutrientNeedperCrop("PHOF",cols)) =E= v_Nutrientneed("PHOF");

e_NUTNED_POTF..   sum( cols, v_actLevl(cols) *
p_nutrientNeedperCrop("POTF",cols)) =E= v_Nutrientneed("POTF");
```

Ex 5: Crop Nutrient Need

- ✓Define a new model and solve it and report what is the production program and answer the questions

```
model myfarm_Nutrientneed /all/;
solve myfarm_Nutrientneed using lp maximizing v_obje;
```

Q7.1: How much N/P/K in tones is used with the baseline production program?

Ex 5: Crop Nutrient Need

- ✓ We now show the real power of GAMS compared to other programs; We reduce the three similar equations by using additional dimensions for the equations, the dimension is defined over the nutrients using a set FNUT.
- ✓ First we define the nutrients as a set.

```
set FNUT / NITF          "Nitrogen in fertiliser"
           PHOF          "Phospate in fertiliser [P2O5]"
           POTF          "Potassium in fertiliser [K2O]" /;
```

- ✓ Define an equation but with one dimension for FNUT and a new model

```
equation e_NUTNED_(FNUT);


e_NUTNED_(FNUT)..   sum( cols, v_actLevl(cols) *
p_nutrientNeedperCrop(FNUT,cols)) =E= v_Nutrientneed(FNUT);

model myfarm_Nutrientneed_compact /all - e_NUTNED_NITF -
e_NUTNED_PHOF - e_NUTNED_POTF/;
solve myfarm_Nutrientneed_compact using lp maximizing v_obje;
```

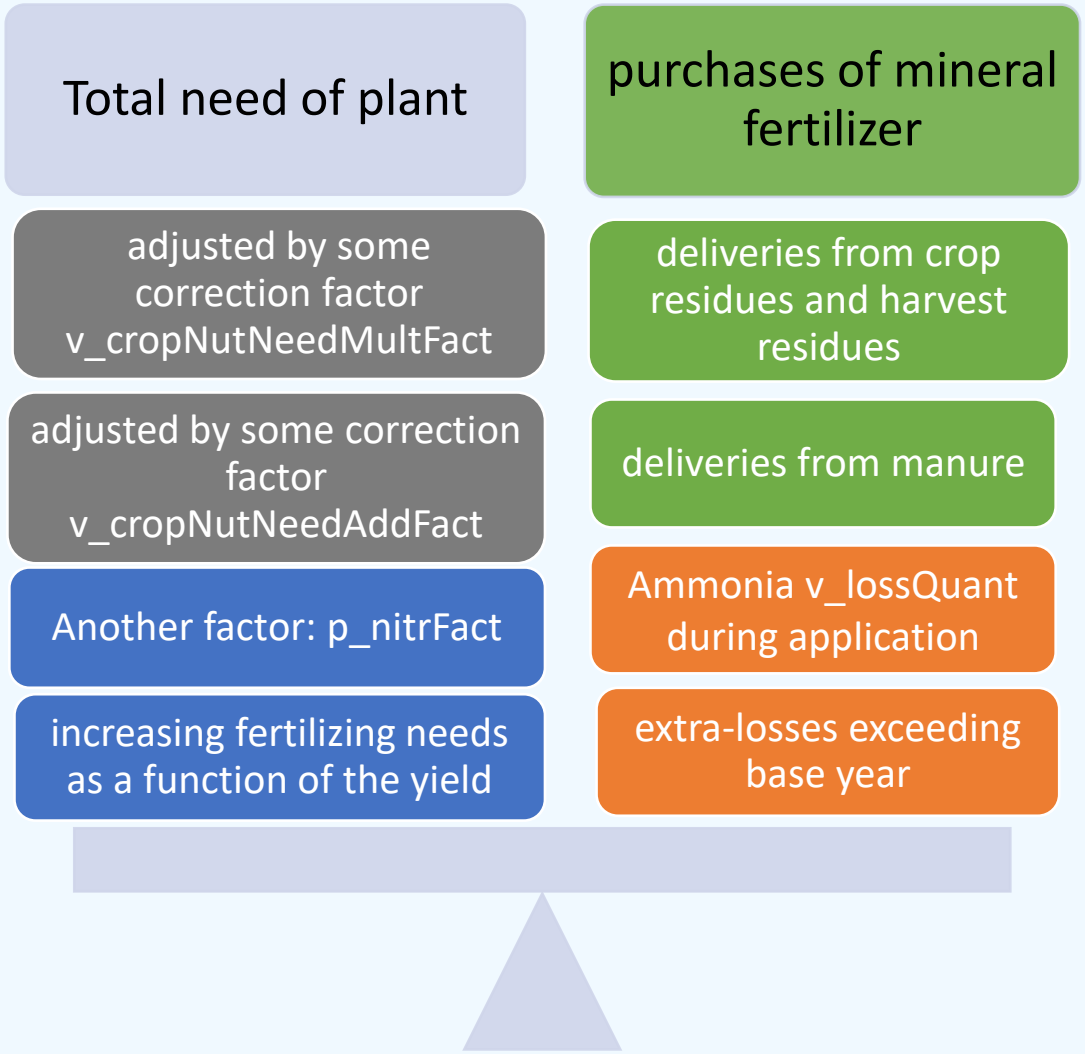
Ex 5: Crop Nutrient Need

- Q7.2: Did the N/P/K in tones is used with the baseline production program changed?
- Q7.3: Do a new simulation and restrict the nutrient requirements for NITF by 10%. How did the production program change? Hint: variables can be upper bounded during solution like

```
v_Nutrientneed.up("NITF") =
v_Nutrientneed.l("NITF")*0.9;
solve myfarm_Nutrientneed using lp maximizing v_obje;
p_results(cols,"compact_10") = v_actLevl.l(cols);
p_results(FNUT,"compact_10") = v_Nutrientneed.l(FNUT);
*reset the upper bound to positive infitity
v_Nutrientneed.up("NITF") = +inf;
```

Ex 5: Crop Nutrient Need

Nutrient balance in CAPRI



```
NUTNED_(RUNR,NGRP,FNUT) $ SUM(
(CACT_TO_NGRP(MCACT,NGRP),A) $
[p_technFact(RUNR,MCACT,"LEVL",A) and
%data%(RUNR,MCACT,"levl","Y")], 1) ..

SUM( (CACT_TO_NGRP(MCACT,NGRP),A) $
p_technFact(RUNR,MCACT,"LEVL",A), v_actLevl(RUNR,MCACT,A)
*
* --- total nutrient need of crops (retention - biolog. fixation for
certain crops) * nutrient factor
*
* (%data%(RUNR,MCACT,FNUT,"Y")
* (1-p_nitrFact(RUNR,MCACT,"BioFix") $ SAMEAS(FNUT,"NITF")
)
* v_cropNutNeedMultFact(RUNR,FNUT,A)
*
* --- plus constant term of nutrient factor
*
+ v_cropNutNeedAddFact(RUNR,FNUT))
*
* --- soil property effect
*
* (p_nitrFact(RUNR,"ALL","DEFR") $ SAMEAS(FNUT,"NITF") + 1 $
(NOT SAMEAS(FNUT,"NITF")))
*
* --- increasing fertilizing needs as a function of the yield
*
* SQRT(
[1.+p_technFact(RUNR,MCACT,"Yield",A)
+ 0.2 $ SAMEAS(MCACT,"GRAI") - 0.2 $ SAMEAS(MCACT,"GRAE")
] $ %data%(RUNR,MCACT,FNUT,"Y")
)
) =E=
```

Continue>>>

```
*
* --- purchases of anorganic fertiliser minus Ammonia v_lossQuant
during application
*
+ v_fertDist(RUNR,NGRP,FNUT,"Mine") * (1.-
p_emiLoss(RUNR,"NETF","N","GasRunTot") $ SAMEAS(FNUT,"NITF") )
*
* --- deliveries from manure
+ v_fertDist(RUNR,NGRP,FNUT,"Excr") * SUM(
FOUT_T_N(FOUT,FNUT),v_nutAvailFactExcr(RUNR,FOUT,"T"))
*
* --- deliveries from crop residues (distribution across arable crops)
*
+ (v_fertDist(RUNR,NGRP,FNUT,"Cres")
* SUM( FOUT_T_N(FOUT,FNUT),v_nutAvailFactCRes(RUNR,FOUT,"T"))
* (1.-p_emiLoss(RUNR,"NETF","N","GasRunTot") $
SAMEAS(FNUT,"NITF") )) $ (NOT PERM_NGRP(NGRP))
*
* --- delivery from harvest residues and atmospheric deposition (only
for grass land, where it remains)
*
+ SUM( (CACT_TO_NGRP(MCACT,NGRP),FOUT_T_N(FOUT,FNUT),A)
$ (p_technFact(RUNR,MCACT,"LEVL",A) and PERM_NGRP(NGRP)),
v_actLevl(RUNR,MCACT,A)
* %data%(RUNR,MCACT,FOUT,"Y")
* (p_technFact(RUNR,MCACT,FOUT,A)+1.)
* (1.-p_emiLoss(RUNR,"NETF","N","GasRunTot") $
SAMEAS(FNUT,"NITF") )
* v_nutAvailFactCRes(RUNR,FOUT,"T"));
```

Ex 5: Crop Nutrient Need

Results

	Nutrientneed	compact	compact_10
barley	145.098	145.098	162.85
sugarbeet	54.902	54.902	37.1505
NITF	35325.5	35325.5	31792.9
PHOF	20945.1	20945.1	19152.2
POTF	32784.3	32784.3	29944.1