

## NPM\_v2.1 - User guidelines

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### IMPORTANT!

This program is still not fully user friendly. Some of the NPM interface features are not fully robust and are not fully tested. The program was developed on specific data sets and tested on multiple others. It's a generic external python plug-in that is expected to work with all crop models available in DSSAT shell. Some of the features are still a work in progress and will be improved.

More detailed description of the NPM program can be found in following publication:

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Memic, E., Trenz, J., Heshmati, S., Graeff, S. 98. **Evaluation of crop model-based marginal net return maximizing nitrogen application rates on site-specific level in maize.** In Precision Agriculture '23 Proceedings of European Conference on Precision Agriculture, Bologna, Italy, 2 July 2023; John V. Stafford, Ed.; Wageningen Academics Publishers: Wageningen, The Netherlands, **2023**, pages: 781-787. <https://doi.org/10.3920/978-90-8686-947-3>

Memic, E., Graeff, S., Claupein, W., & Batchelor, W. D. (2019). **GIS-based spatial nitrogen management model for maize: short- and long-term marginal net return maximising nitrogen application rates.** *Precision Agriculture*, 20(2), 295–312. <https://doi.org/10.1007/s11119-018-9603-4>

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For any additional questions contact the author of the NPM tool!

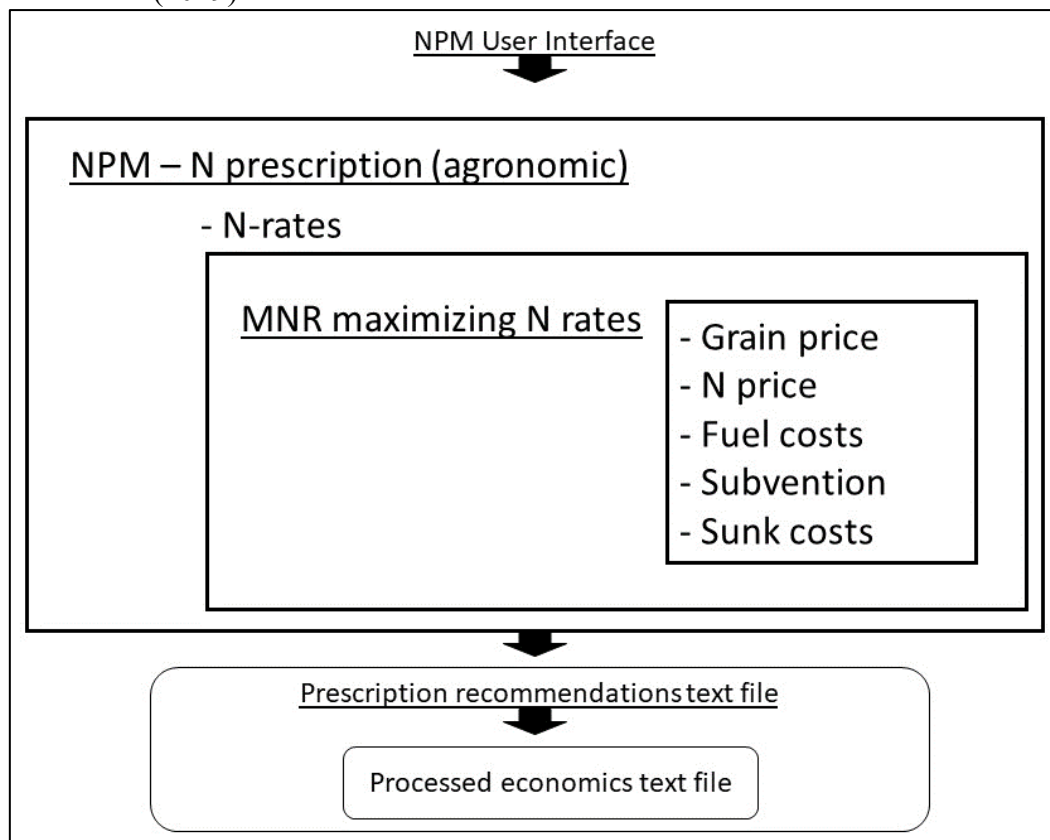
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## Conceptual framework of NPM

### Site-specific nitrogen prescription

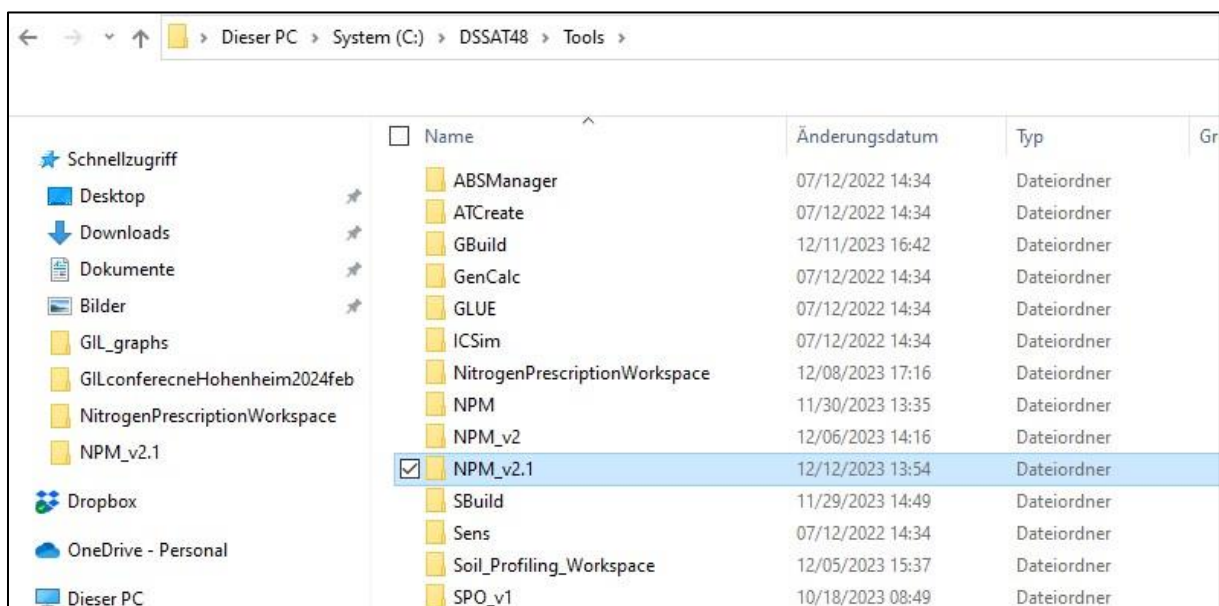
The basic premise of NPM tool and conducted analysis is that crop yield in fully parametrized crop growth model is a result of applied N. This is a form of ceteris paribus analysis, where one parameter is modified and the impact of that parameter on output variables evaluated. The NPM tool conducts a form of marginal return analysis where output variables are evaluated based on additional "one-unit" input increase. The tool is modifying corresponding experiment file (FileX) and executing crop model and capturing the output variables value (e.g. yield). The NPM tool within the marginal return conceptual framework, depending on initial setup, adds at each run additional "one-unit" input e.g. 10 kg N (Figure 1, N-rates) and executing the model, capturing the yield output, and calculating simplified Marginal Net Return (MNR) based on grain and N prices (Figure 1, MNR maximizing N rates). The MNR is calculated for each additional 10 kg N in various sensitivity analysis steps and localizing the N amount that is maximizing MNR based on prices (Figure 1, Processed economics text file). A more detailed description of the underlying procedures and calculations can be found in Memić et al. (2023) and Memić et al. (2019).



**Figure 1** NPM conceptual framework – flow diagram

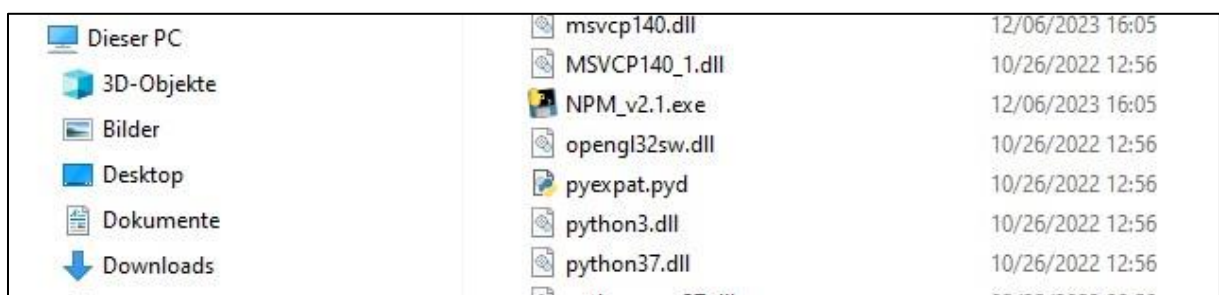
## **General NPM program settings overview**

The “NPM\_v2.1.7zip” must be unzipped and copied to the Tools directory: “C:\DSSAT48\Tools” (depending on the DSSAT version “C:\DSSAT\*\*\Tools”).



**Figure 2** NPM\_v2.1 directory

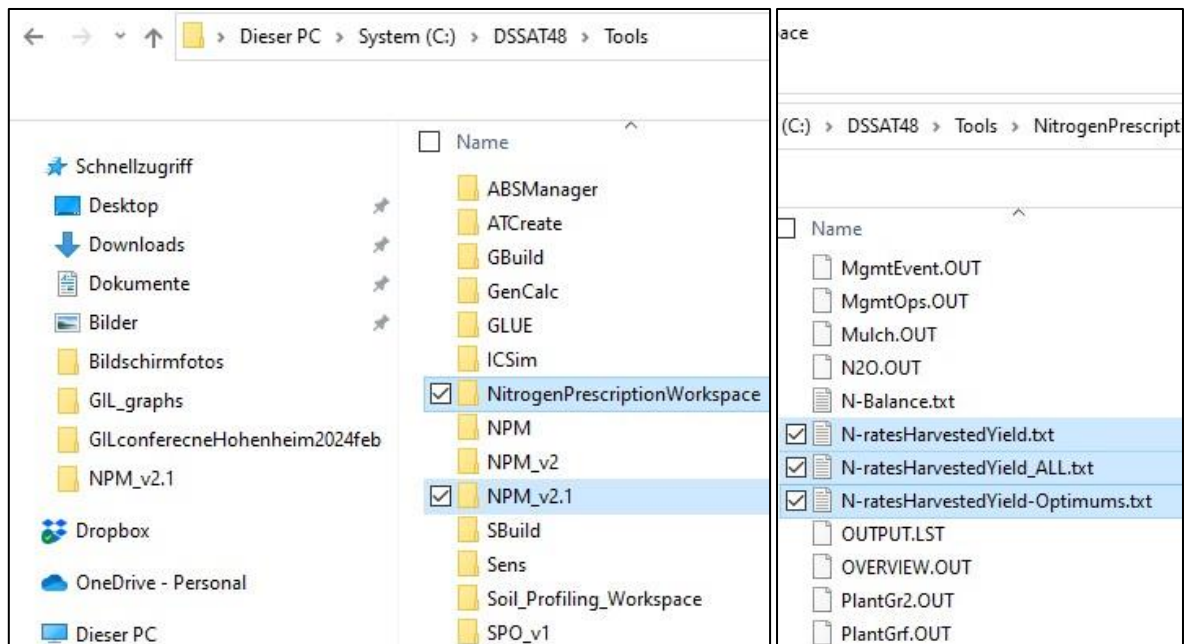
In the folder “NPM\_v2.1” “C:\DSSAT48\Tools\NPM\_v2.1” (Figure 2) “NPM\_v2.1.exe” windows runnable must be executed as “Administrator” (Figure 3).



**Figure 3** The NPM\_v2.1.exe windows runnable

### VERY IMPORTANT:

The NPM program is creating additional directory “NitrogenPrescriptionWorkspace” (C:\DSSAT48\Tools\NitrogenPrescriptionWorkspace) Figure 4. The **NPM** program **does NOT** modify original DSSAT files in their native directories. The program creates copies in “NitrogenPrescriptionWorkspace” and do the sensitivity analysis by modifying targeted files in that directory. After selecting desired files for optimization and setting up sensitivity analysis scenarios all modifications on experiment file (FileX) are conducted in “NitrogenPrescriptionWorkspace”.



**Figure 4** “NitrogenPrescriptionWorkspace” is located in “Tools” directory

**NPM program running through section flow:**

- 1. Select dir.** (select crop model directory, e.g. “C:/DSSAT48/Maize”)
- 2. Create Workspace** (creating NitrogenPrescriptionWorskpace)
- 3. Read in Experiment Files** (based on crop model directory selected in step 1)
- 4. File-X treatment selection** (from List of Experiment Files list widget)
- 5. Select TRT/s for N prescription sensitivity analysis**
- 6. Grain and N prices setup**
- 7. Selecting N application dates – based on experiment file setup**
- 8. Setup N sensitivity analysis**
- 9. Option to check details of sensitivity analysis**

1.

Select dir.

C:/DSSAT48/Wheat

2.

Create Workspace

3.

Read in Experiment Files

4.

List of Experiment Files

5.

Select TRT/s for N prescriptions

Treatments in FileX (F I - Filed, MF - Fertilizer)

☐ ACTIVATED

(This option NOT tested yet!)

Long period of weather

☐ Activate!

Weather file (active):

☐ Show only same WTH station

Weather files:

6.

☐ PLANTING DETAILS

☒ FERTILIZER

Revenue

Crop [Euro/kg]:

min: 0.17

max: 0.17

inc: 0.01

Subvention [Euro/ha]: 0

Costs

N [Euro/kg]:

min: 0.3

max: 0.3

inc: 0.1

Sunk Costs [Euro/ha]: 0

Fuel costs [Euro/ha]

0 [Litar/ha]

0 [Euro/Litar]

Help

7.


8.

	Minimum	Maximum	Increment
N-1	0	200	50
N-2	0	80	40
N-3	0	40	20

Assemble Prescriptions

0%

If selected dir correctly initialized, e.g. "C:/DSSAT48/Wheat" or other crop model or DSSAT version, click "Create Workspace" push button!

If selected dir correctly initialized, e.g. "C:/DSSAT48/Wheat" or other crop model or DSSAT version, click "Create Workspace" push button!

9.

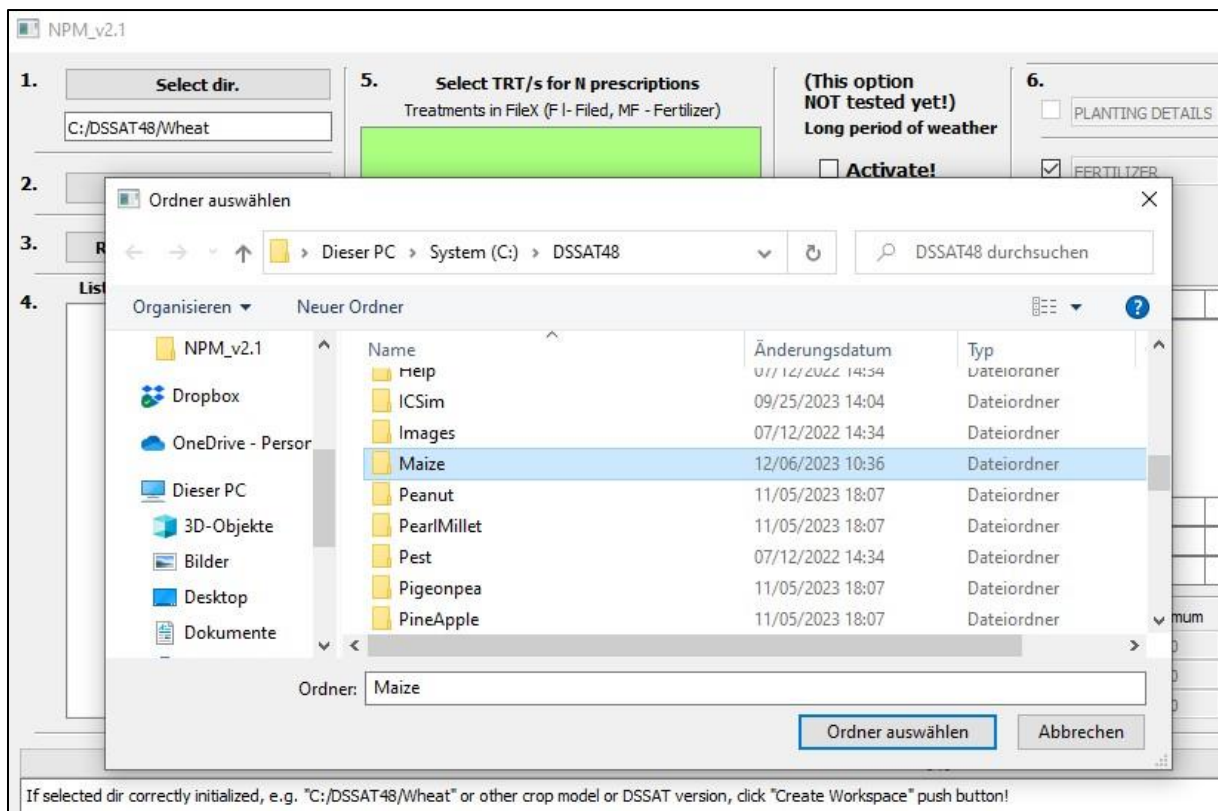
Show detailed output

Show detailed optimums

Exit

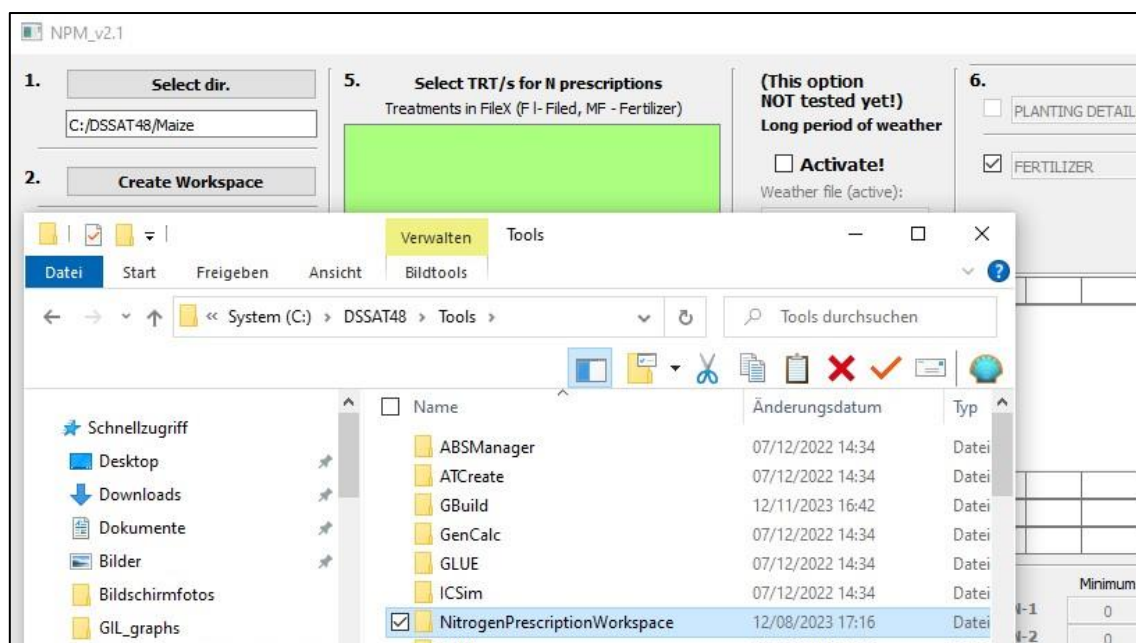
Figure 5 Interface

## 1. Crop model selection and initialization



**Figure 6** With push button **Select dir.** a user has to navigate to DSSAT crop directory and initialize it, in order to select crop model for conducting sensitivity analysis (e.g. Maize).

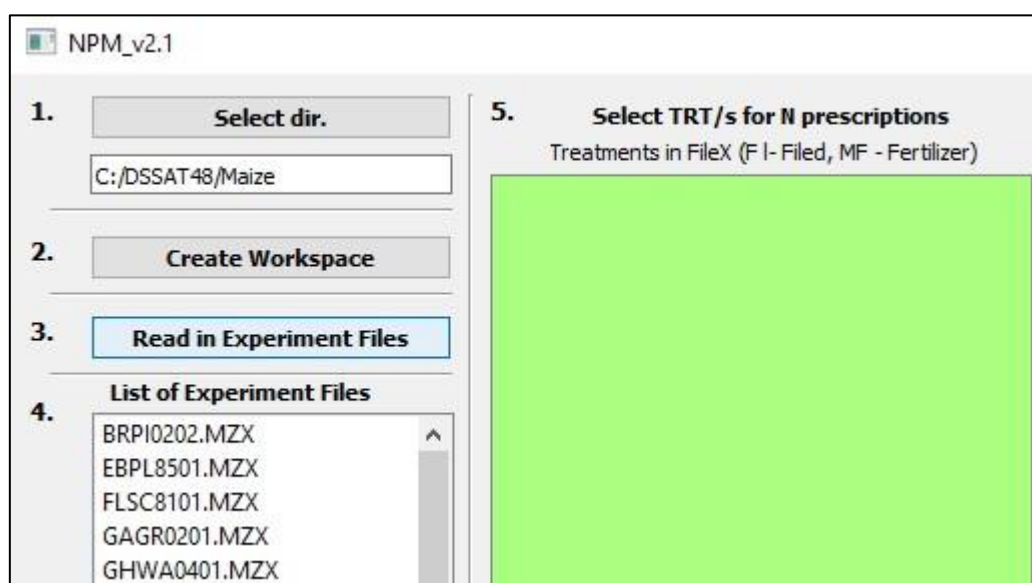
## 2. Create Workspace



**Figure 7** After the model is selected and initialized (Figure 6, "C:/DSSAT48/Maize") the user must click on **Create Workspace** button, to create NPM NitrogenPrescriptionWorkspace dir.

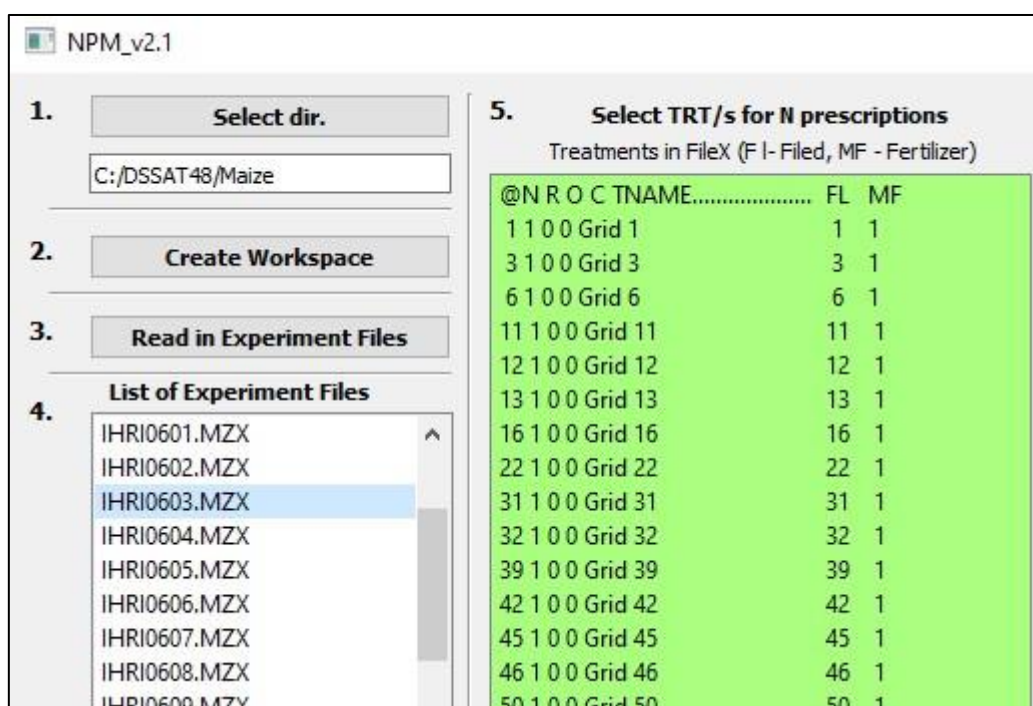


### 3. Crop model-based file X list initialization



**Figure 8** After NitrogenPrescriptionWorkspace is created the user has to click on **Read in Experiment Files** button to get list of available experiment files (FileX/s) in list widget window in section 4.

### 4. File X selection



**Figure 9** At the time only one FileX can be selected in list widget window in NPM section 4., and after selected FileX corresponding treatments list is loaded into list widget in NPM section 5., for selection.



## 5. Select TRT/s for N prescription

**5. Select TRT/s for N prescriptions**  
Treatments in FileX (F-I- Filed, MF - Fertilizer)

@N	R	O	C	TNAME	FL	MF
1	1	0	0	Grid 1	1	1
3	1	0	0	Grid 3	3	1
6	1	0	0	Grid 6	6	1
11	1	0	0	Grid 11	11	1
12	1	0	0	Grid 12	12	1
13	1	0	0	Grid 13	13	1
16	1	0	0	Grid 16	16	1
22	1	0	0	Grid 22	22	1
31	1	0	0	Grid 31	31	1
32	1	0	0	Grid 32	32	1
39	1	0	0	Grid 39	39	1
42	1	0	0	Grid 42	42	1
45	1	0	0	Grid 45	45	1
46	1	0	0	Grid 46	46	1
50	1	0	0	Grid 50	50	1
55	1	0	0	Grid 55	55	1
59	1	0	0	Grid 59	59	1
62	1	0	0	Grid 62	62	1

(This option NOT tested yet!)  
Long period of weather

☐ Activate!  
Weather file (active): UHH0601.WTH

☐ Show only same WTH station

Weather files:

**6.**

☐ PLANTING DETAILS

☒ FERTILIZER

Revenue

Crop [Euro/kg]:

min: 0.17  
max: 0.17  
inc: 0.01

Subvention [Euro/ha]: 0

Costs

N [Euro/kg]:

min: 0.3  
max: 0.3  
inc: 0.1

Fuel costs [Euro/ha]: 0 [Litar/ha]  
0 [Euro/Litar]

Sunk Costs [Euro/ha]: 0

**7.**

@F	FDATE	FMCD	FADC	FDEP	FAMN	FAMP	FAMK	FAMC	FAMO	FOCD	FERNAME
1	06116	FE002	AP001	0	30	0	0	0	0	-99	-99
1	06131	FE002	AP001	0	130	0	0	0	0	-99	-99

[Help](#)

**Figure 10** After selecting treatment/s from list widget window in NPM section 5., N application date/s available in File X will be loaded in NPM section 7. for later selection.

## 6. Grain and N prices setup

**6.**

☐ PLANTING DETAILS

☒ FERTILIZER

Revenue

Crop [Euro/kg]:

min: 0.17  
max: 0.17  
inc: 0.01

Subvention [Euro/ha]: 0

Costs

N [Euro/kg]:

min: 0.3  
max: 0.3  
inc: 0.1

Fuel costs [Euro/ha]: 0 [Litar/ha]  
0 [Euro/Litar]

Sunk Costs [Euro/ha]: 0

[Help](#)

**Help:**

Simplified Marginal Net Return maximizing N application rates!

All calculations are hectare scaled, even if site-specific units are smaller!

MNR = Revenue - Costs

Revenue = Grain(kg) \* GrainPrice(Euro/kg)

Costs = Nitrogen(kg) \* NitrogenPrice(Euro/kg)

In addition to simplified MNR revenue and costs: Subvention, SunkCosts and FuelCosts, can be included in cost analysis

"Extended" MNR = Revenue(Euro) + Subvention(Euro) - Costs(Euro) - SunkCosts(Euro) - FuelCosts(Euro)

**Figure 11** In NPM section 6., price setup can be conducted. It is possible to do grain and N prices sensitivity analysis. If user sets Crop price min and max 0.17, it means that the NPM tool will conduct analysis only based on one price. If a user wants to conduct N prescription sensitivity analysis based on varying prices, then user can set for example Crop price min=0.1 and max=0.3 with inc=0.1. This will result in price sensitivity analysis in addition to the N amount sensitivity analysis, where MNR will be calculated in each step additionally for price 0.1, 0.2 and 0.3 Euro/kg.

## 7. Nitrogen prescriptions – sensitivity analysis – max 3 application dates

7.	@F	FDATE	FMCD	FACD	FDEP	FAMN	FAMP	FAMK	FAMC	FAMO	FOCD	FERNAME
	1	06116	FE002	AP001	0	30	0	0	0	0	-99	-99
	1	06131	FE002	AP001	0	130	0	0	0	0	-99	-99
	1	06116	FE002	AP001	0	30	0	0	0	0	-99	-99

**Figure 12** Based on the available N application dates and setup in File X corresponding treatments the user will get options to choose for corresponding sensitivity analysis. The user can select a maximum of 3 application dates with **CTRL + mouse left click** to initialize the dates for potential sensitivity analysis.

## 8. NPM gradient increase of N applied and Assemble Prescriptions

7.	@F	FDATE	FMCD	FACD	FDEP	FAMN	FAMP	FAMK	FAMC	FAMO	FOCD	FERNAME
	1	06116	FE002	AP001	0	30	0	0	0	0	-99	-99
	1	06131	FE002	AP001	0	130	0	0	0	0	-99	-99
	1	06116	FE002	AP001	0	30	0	0	0	0	-99	-99

8.		Minimum	Maximum	Increment
	N-1	0	300	10
	N-2	0	80	40
	N-3	0	40	20

**Assemble Prescriptions**

**Figure 13** In NPM section 8., the user can set NPM marginal return sensitivity analysis by defining min, max and inc. steps. If user sets min=0, max=300 and inc.=10, the NPM algorithm will execute crop model by conducting marginal return analysis with one-unit inputs of 10 kg N (inc.=10) and at each step calculate MNR based on prices.

Fuel costs are included on a hectare bases, but dependent on number of application dates (e.g. two application dates will res

IHRI0603.MZX 1 1 0 0 Grid 1 1 1

Simplified Marginal Net Return maximizing N application rates!

All calculations are hectare scaled, even if site-specific units are smaller!  
MNR = Revenue - Costs  
Revenue = Grain(kg) \* GrainPrice(Euro/kg)  
Costs = Nitrogen(kg) \* NitrogenPrice(Euro/kg)

\*Extended\* MNR = Revenue(Euro) + Subvention(Euro) - Costs(Euro) - SunkCosts(Euro) - FuelCosts(Euro)

N-P	G-P	Pn/Pg	WTH_file:	Grid(TRT)	N-1	N-2	N-3	NSum
0.3	0.17	1.765	UHIH0601	1	90	0	0	90

9. [Show detailed output](#) [Show detailed optimums](#)

**Figure 14** After NPM setup and **Assemble Prescriptions** push button is clicked (Figure 13) the NPM algorithm will conduct sensitivity analysis and show MNR maximizing N application rate in text browser window. In case if multiple N applications result in same MNR, all of them will be shown in text browser window as “optimum”.

## 9. Show detailed outputs

Detailed output									
N-P	G-P	Pn/Pg	WTH_file:	Grid(TRT)	N-1	N-2	N-3	NSum	Yield(kg/ha)
0.3	0.17	1.765	UHIH0601	1	0	0	0	0	3572
0.3	0.17	1.765	UHIH0601	1	10	0	0	10	3851
0.3	0.17	1.765	UHIH0601	1	20	0	0	20	4169
0.3	0.17	1.765	UHIH0601	1	30	0	0	30	4636
0.3	0.17	1.765	UHIH0601	1	40	0	0	40	4987
0.3	0.17	1.765	UHIH0601	1	50	0	0	50	5382
0.3	0.17	1.765	UHIH0601	1	60	0	0	60	5673
0.3	0.17	1.765	UHIH0601	1	70	0	0	70	6020
0.3	0.17	1.765	UHIH0601	1	80	0	0	80	5963
0.3	0.17	1.765	UHIH0601	1	90	0	0	90	6092
0.3	0.17	1.765	UHIH0601	1	100	0	0	100	6011
0.3	0.17	1.765	UHIH0601	1	110	0	0	110	5911
0.3	0.17	1.765	UHIH0601	1	120	0	0	120	5930
0.3	0.17	1.765	UHIH0601	1	130	0	0	130	6032
0.3	0.17	1.765	UHIH0601	1	140	0	0	140	6047
0.3	0.17	1.765	UHIH0601	1	150	0	0	150	5794
0.3	0.17	1.765	UHIH0601	1	160	0	0	160	5671
0.3	0.17	1.765	UHIH0601	1	170	0	0	170	5619
0.3	0.17	1.765	UHIH0601	1	180	0	0	180	5739
0.3	0.17	1.765	UHIH0601	1	190	0	0	190	5738
0.3	0.17	1.765	UHIH0601	1	200	0	0	200	5734
0.3	0.17	1.765	UHIH0601	1	210	0	0	210	5739
0.3	0.17	1.765	UHIH0601	1	220	0	0	220	5731
0.3	0.17	1.765	UHIH0601	1	230	0	0	230	5732
0.3	0.17	1.765	UHIH0601	1	240	0	0	240	5734
0.3	0.17	1.765	UHIH0601	1	250	0	0	250	5735
0.3	0.17	1.765	UHIH0601	1	260	0	0	260	5735
0.3	0.17	1.765	UHIH0601	1	270	0	0	270	5736
0.3	0.17	1.765	UHIH0601	1	280	0	0	280	5736
0.3	0.17	1.765	UHIH0601	1	290	0	0	290	5737
0.3	0.17	1.765	UHIH0601	1	300	0	0	300	5731

**Figure 15** Based on the setup in Figure 13, detailed outputs can be displayed in additional popout window as shown in this figure, with N-P (nitrogen price), G-P (grain price), Pn/Pg (price ratio) etc.

Detailed output															
N-P	G-P	Ph/Pg	WTH file:	Grid(TRT)	N-1	N-2	N-3	NSum	Yield(kg/ha)	Revenue	Subvention	Cost	Fuel	SunkCost	MNR
0.3	0.17	1.765	UH-H0601	1	0	0	0	0	3572	607.24	0.0	0.0	0.0	0.0	607.24
0.3	0.17	1.765	UH-H0601	1	10	0	0	10	3851	654.67	0.0	3.0	0.0	0.0	651.67
0.3	0.17	1.765	UH-H0601	1	20	0	0	20	4169	708.73	0.0	6.0	0.0	0.0	702.73
0.3	0.17	1.765	UH-H0601	1	30	0	0	30	4636	788.12	0.0	9.0	0.0	0.0	779.12
0.3	0.17	1.765	UH-H0601	1	40	0	0	40	4987	847.79	0.0	12.0	0.0	0.0	835.79
0.3	0.17	1.765	UH-H0601	1	50	0	0	50	5382	914.94	0.0	15.0	0.0	0.0	899.94
0.3	0.17	1.765	UH-H0601	1	60	0	0	60	5673	964.41	0.0	18.0	0.0	0.0	946.41
0.3	0.17	1.765	UH-H0601	1	70	0	0	70	6020	1023.4	0.0	21.0	0.0	0.0	1002.4
0.3	0.17	1.765	UH-H0601	1	80	0	0	80	5963	1013.71	0.0	24.0	0.0	0.0	989.71
0.3	0.17	1.765	UH-H0601	1	90	0	0	90	6092	1035.64	0.0	27.0	0.0	0.0	1008.64
0.3	0.17	1.765	UH-H0601	1	100	0	0	100	6011	1021.87	0.0	30.0	0.0	0.0	991.87
0.3	0.17	1.765	UH-H0601	1	110	0	0	110	5911	1004.87	0.0	33.0	0.0	0.0	971.87
0.3	0.17	1.765	UH-H0601	1	120	0	0	120	5930	1008.1	0.0	36.0	0.0	0.0	972.1
0.3	0.17	1.765	UH-H0601	1	130	0	0	130	6032	1025.44	0.0	39.0	0.0	0.0	986.44
0.3	0.17	1.765	UH-H0601	1	140	0	0	140	6047	1027.99	0.0	42.0	0.0	0.0	985.99
0.3	0.17	1.765	UH-H0601	1	150	0	0	150	5794	984.98	0.0	45.0	0.0	0.0	939.98
0.3	0.17	1.765	UH-H0601	1	160	0	0	160	5671	964.07	0.0	48.0	0.0	0.0	916.07
0.3	0.17	1.765	UH-H0601	1	170	0	0	170	5619	955.23	0.0	51.0	0.0	0.0	904.23
0.3	0.17	1.765	UH-H0601	1	180	0	0	180	5739	975.63	0.0	54.0	0.0	0.0	921.63
0.3	0.17	1.765	UH-H0601	1	190	0	0	190	5738	975.46	0.0	57.0	0.0	0.0	918.46
0.3	0.17	1.765	UH-H0601	1	200	0	0	200	5734	974.78	0.0	60.0	0.0	0.0	914.78
0.3	0.17	1.765	UH-H0601	1	210	0	0	210	5739	975.63	0.0	63.0	0.0	0.0	912.63
0.3	0.17	1.765	UH-H0601	1	220	0	0	220	5731	974.27	0.0	66.0	0.0	0.0	908.27
0.3	0.17	1.765	UH-H0601	1	230	0	0	230	5732	974.44	0.0	69.0	0.0	0.0	905.44
0.3	0.17	1.765	UH-H0601	1	240	0	0	240	5734	974.78	0.0	72.0	0.0	0.0	902.78
0.3	0.17	1.765	UH-H0601	1	250	0	0	250	5735	974.95	0.0	75.0	0.0	0.0	899.95
0.3	0.17	1.765	UH-H0601	1	260	0	0	260	5735	974.95	0.0	78.0	0.0	0.0	896.95
0.3	0.17	1.765	UH-H0601	1	270	0	0	270	5736	975.12	0.0	81.0	0.0	0.0	894.12
0.3	0.17	1.765	UH-H0601	1	280	0	0	280	5736	975.12	0.0	84.0	0.0	0.0	891.12
0.3	0.17	1.765	UH-H0601	1	290	0	0	290	5737	975.29	0.0	87.0	0.0	0.0	888.29
0.3	0.17	1.765	UH-H0601	1	300	0	0	300	5731	974.27	0.0	90.0	0.0	0.0	884.27

Figure 16 Detailed outputs

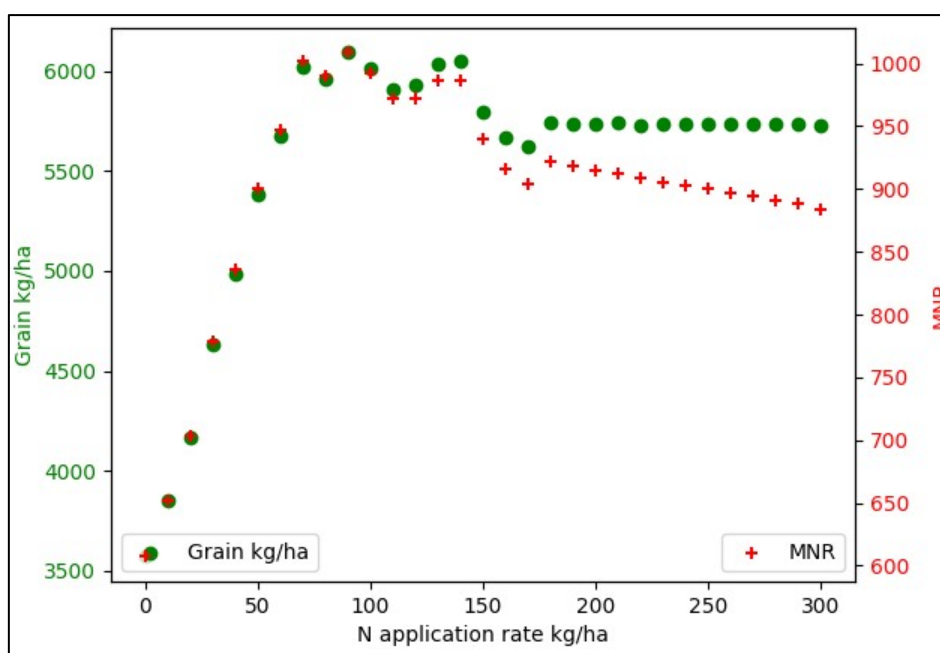


Figure 17 This is graphic depiction of the corresponding agronomic yield and MNR.

## Price sensitivity analysis

**6.**

☐ PLANTING DETAILS

☒ FERTILIZER

**Revenue**

Crop [Euro/kg]:

min: 0.17

max: 0.17

inc: 0.01

Subvention [Euro/ha]: 0

**Costs**

N [Euro/kg]:

min: 0.1

max: 0.5

inc: 0.1

Fuel costs [Euro/ha]

0 [Litar/ha]

0 [Euro/Litar]

Sunk Costs [Euro/ha]: 0

**7.**

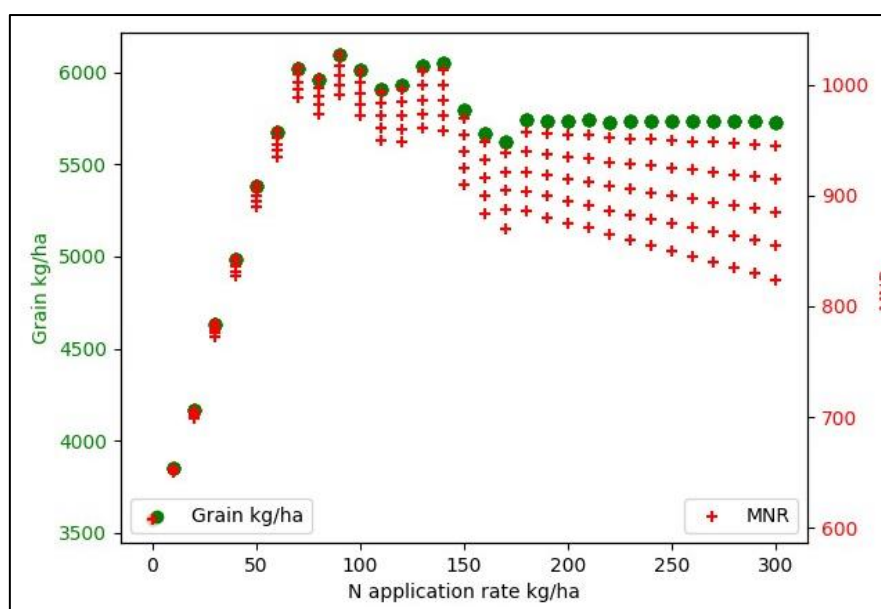
@F	FDATE	FMCD	FACD	FDEP	FAMN	FAMP	FAMK	FAMC	FAMO	FOCD	FERNAME
1	06116	FE002	AP001	0	30	0	0	0	0	-99	-99
1	06131	FE002	AP001	0	130	0	0	0	0	-99	-99

**8.**

	Minimum	Maximum	Increment
N-1	0	300	10
N-2	0	80	40
N-3	0	40	20

**Assemble Prescriptions**

**Figure 18** N price setup min=0.1, max=0.5 and inc.=01 will result in running MNR maximization based on 0.1, 0.2, 0.3, 0.4 and 0.5 Euro/kg prices. This will result in five MNR scenarios as can be seen in Figure 19.



**Figure 19** Yield response to N based MNR scenarios



## Multiple data N application

**6.**

☐ PLANTING DETAILS  
☒ FERTILIZER

**Revenue**

Crop [Euro/kg]:

min: 0.17  
max: 0.17  
inc: 0.01

Subvention [Euro/ha]: 0

**Costs**

N [Euro/kg]:

min: 0.3  
max: 0.3  
inc: 0.1

Fuel costs [Euro/ha]:  
0 [Litar/ha]  
0 [Euro/Litar]

Sunk Costs [Euro/ha]: 0

[Help](#)

**7.**

@F	FDATE	FMCD	FACD	FDEP	FAMN	FAMP	FAMK	FAMC	FAMO	FOCD	FERNAME
1	06116	FE002	AP001	0	30	0	0	0	0	-99	-99
1	06131	FE002	AP001	0	130	0	0	0	0	-99	-99

1	06116	FE002	AP001	0	30	0	0	0	0	-99	-99
1	06131	FE002	AP001	0	130	0	0	0	0	-99	-99

**8.**

	Minimum	Maximum	Increment
N-1	0	200	10
N-2	0	100	10
N-3	0	40	20

**Assemble Prescriptions**

Figure 19 Multiple data N application with one MNR scenario

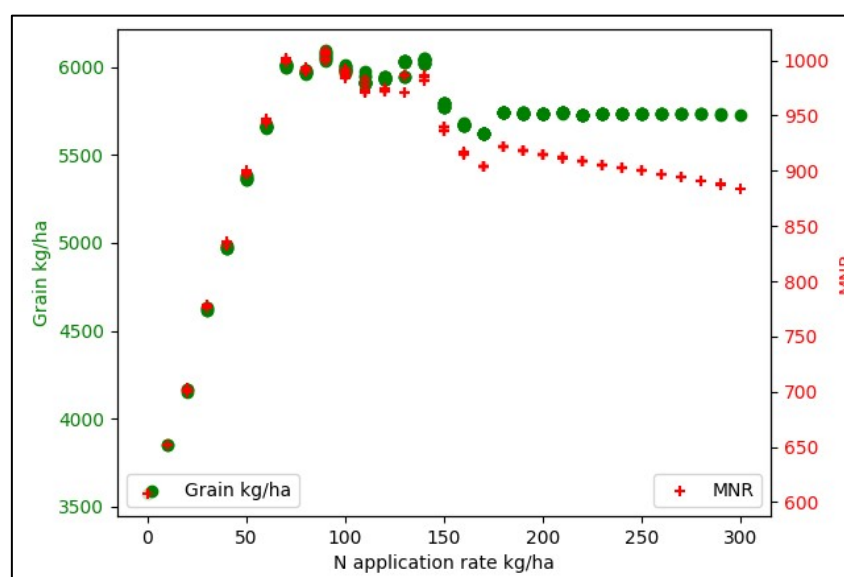


Figure 20 MNR scenario



## References

### Interface:

*The NPM\_v2.1 user interface was created in Qt Designer 5*  
(<https://doc.qt.io/qtcreator/index.html>)

### Programming language:

*The NPM\_v2.1 algorithm was written in python 3.7*

Python Software Foundation. Python Language Reference, version 3.7. Available at <http://www.python.org>

### Windows runnable:

*NPM\_v2.1 was compiled into windows runnable with Pyinstaller*  
(<https://www.pyinstaller.org/>)

**NPM\_v2.1 algorithm** and interface development/setup by Emir Memic.