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:

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

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

Contents

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 Memic et al. (2023) and Memic et al. (2019).

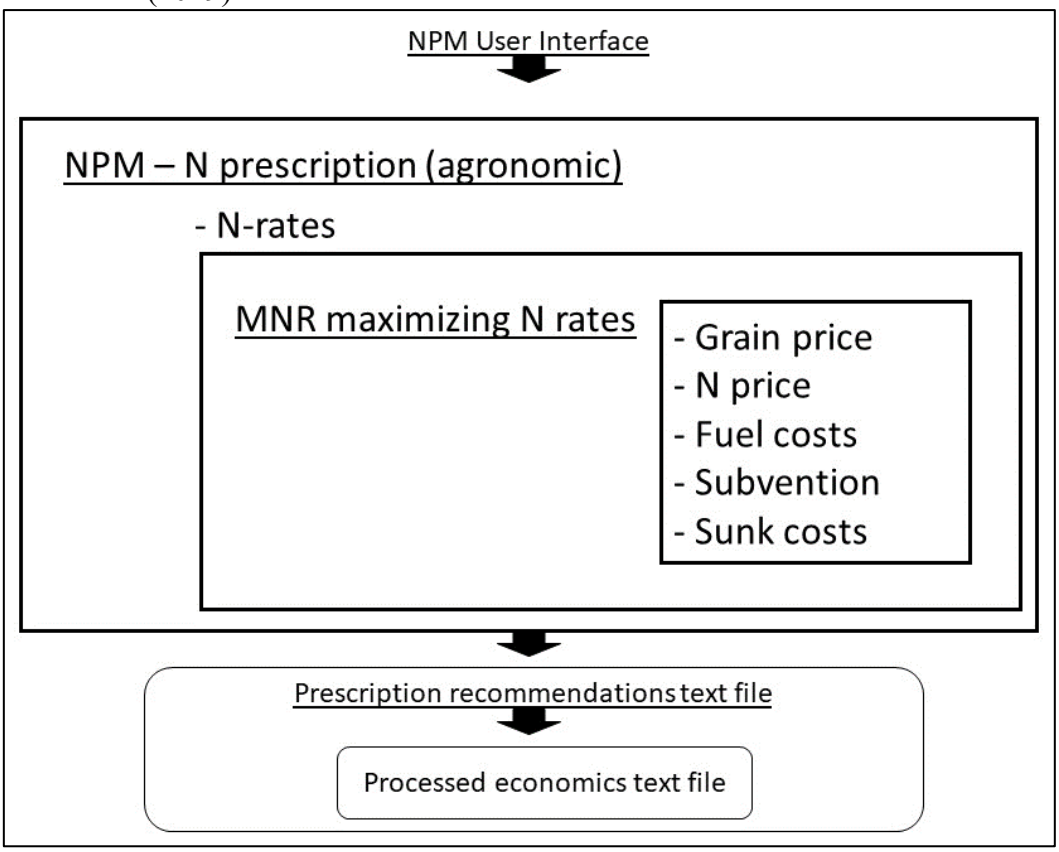


Figure 1 NPM conceptual framework – flow diagram

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".

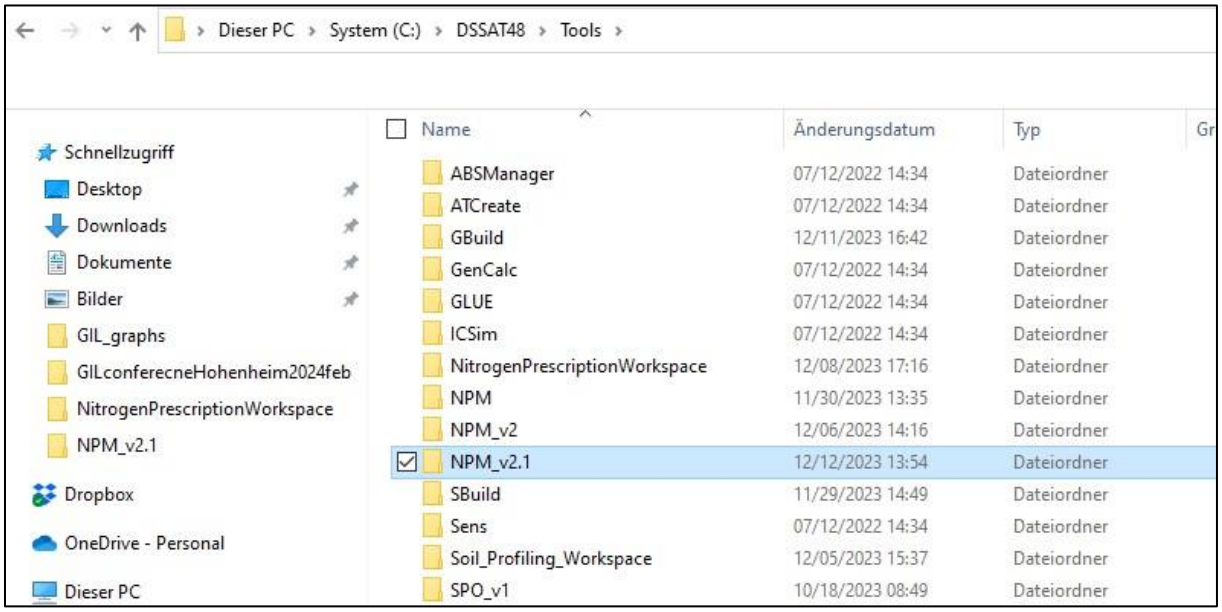


Figure 2 NPM_v2.1 directory

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).

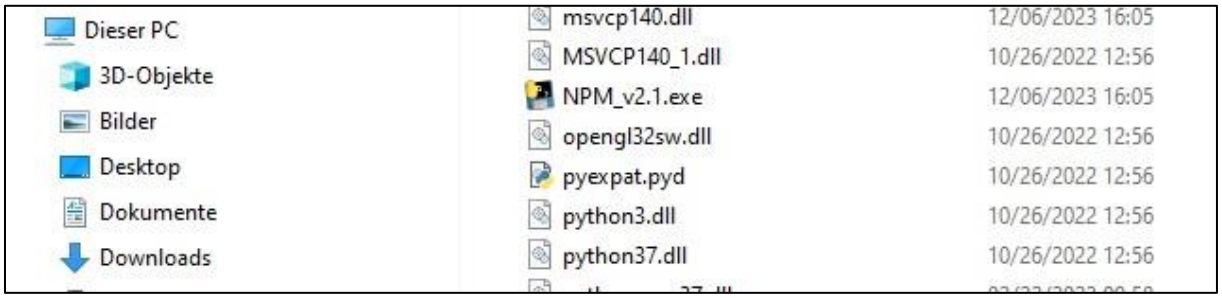


Figure 3 The NPM_v2.1.exe windows runnable

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".

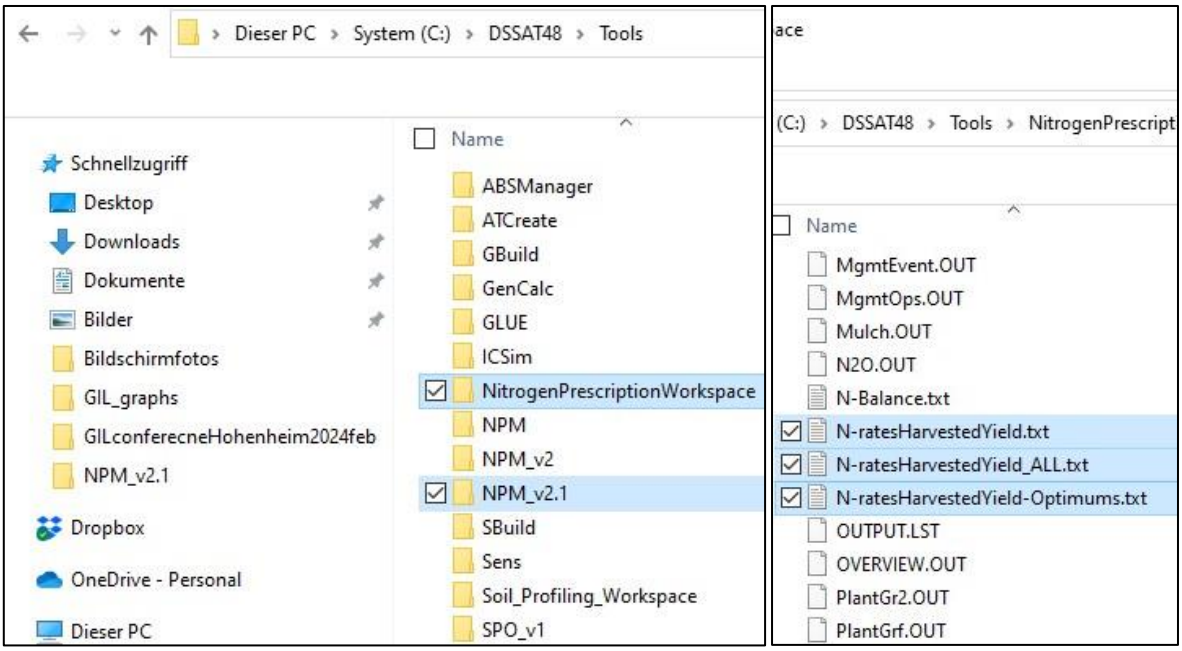


Figure 4 "NitrogenPrescriptionWorkspace" is located in **"Tools"** directory

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**

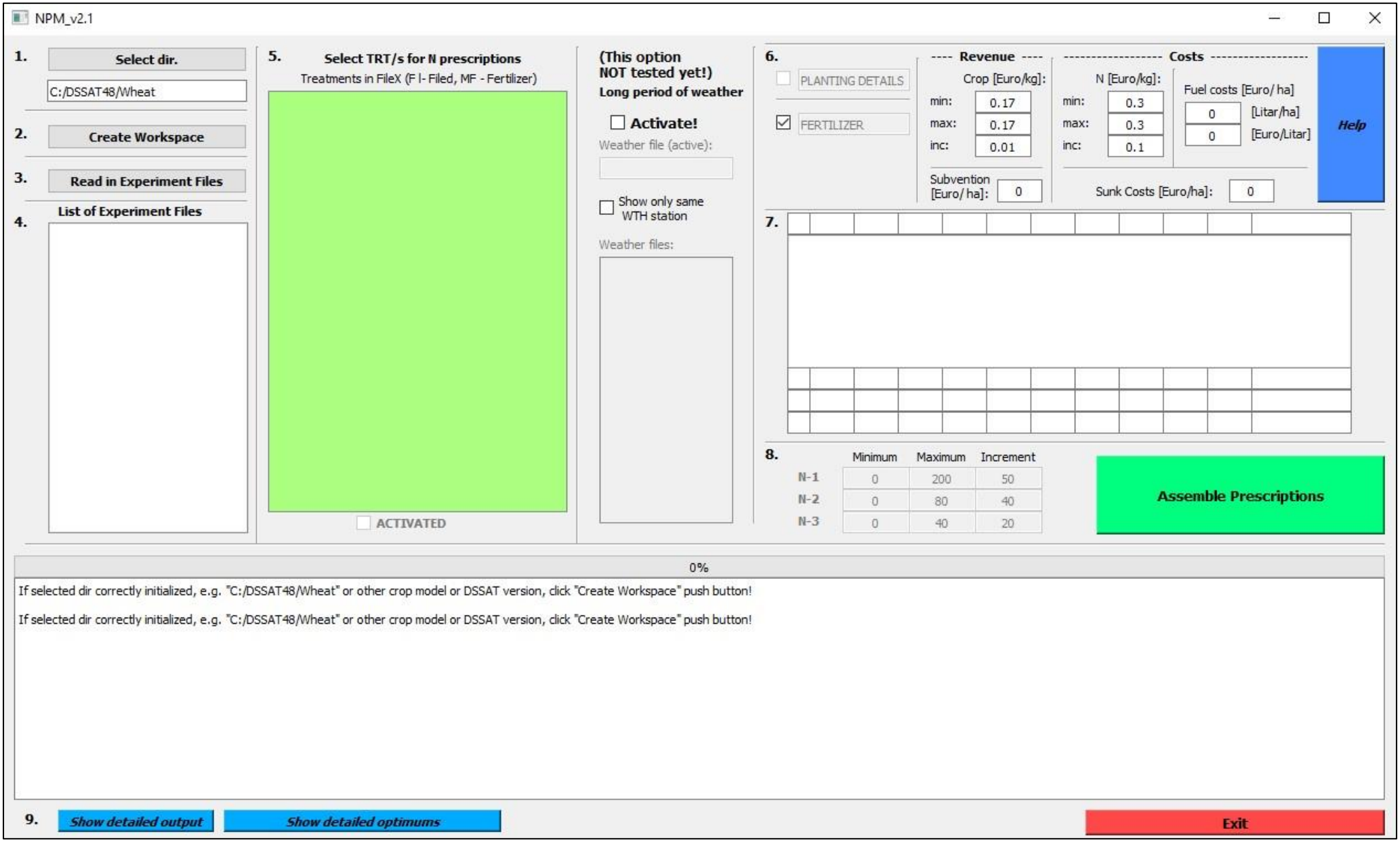


Figure 5 Interface

1. Crop model selection and initialization

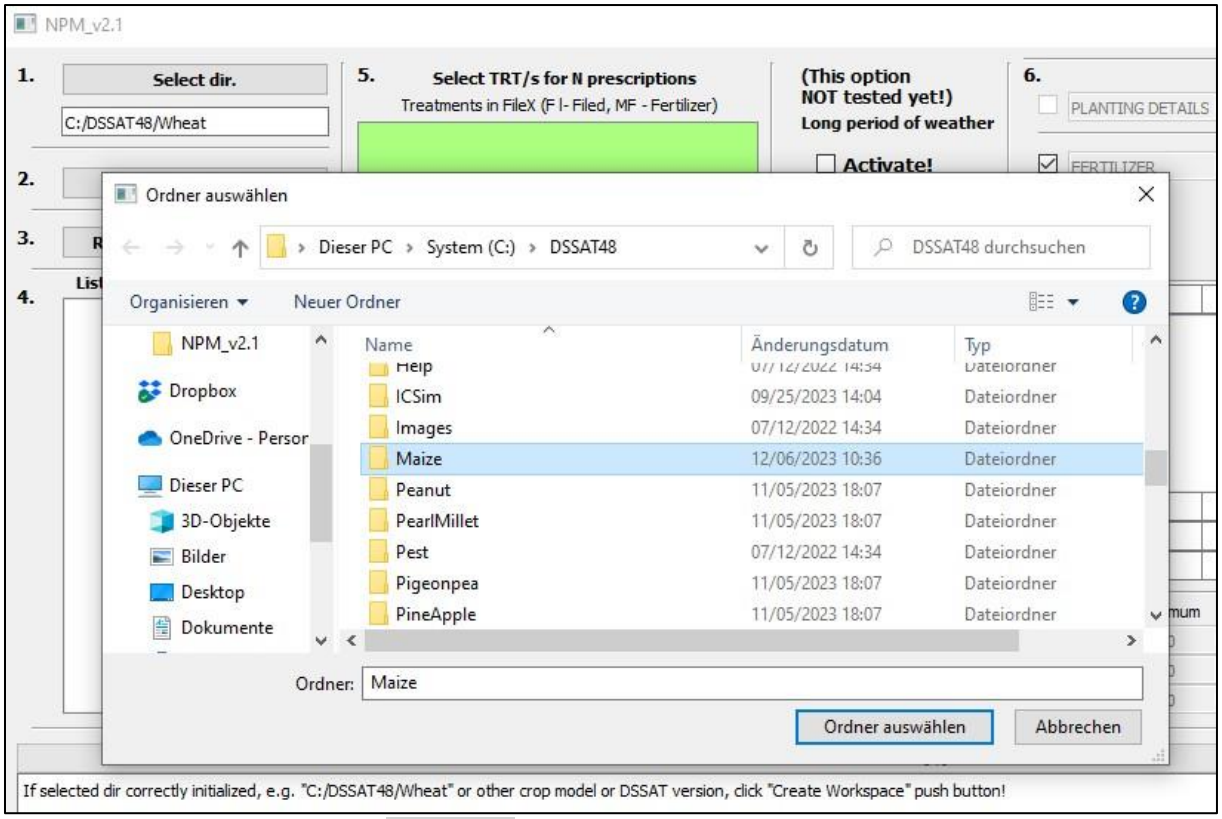


Figure 6 With push button Select dir. a user has to navigate to DSSAT crop directory and initialize it, in order to select crop model for conducting sensitivity analysis (e.g. Maize).

2. Create Workspace

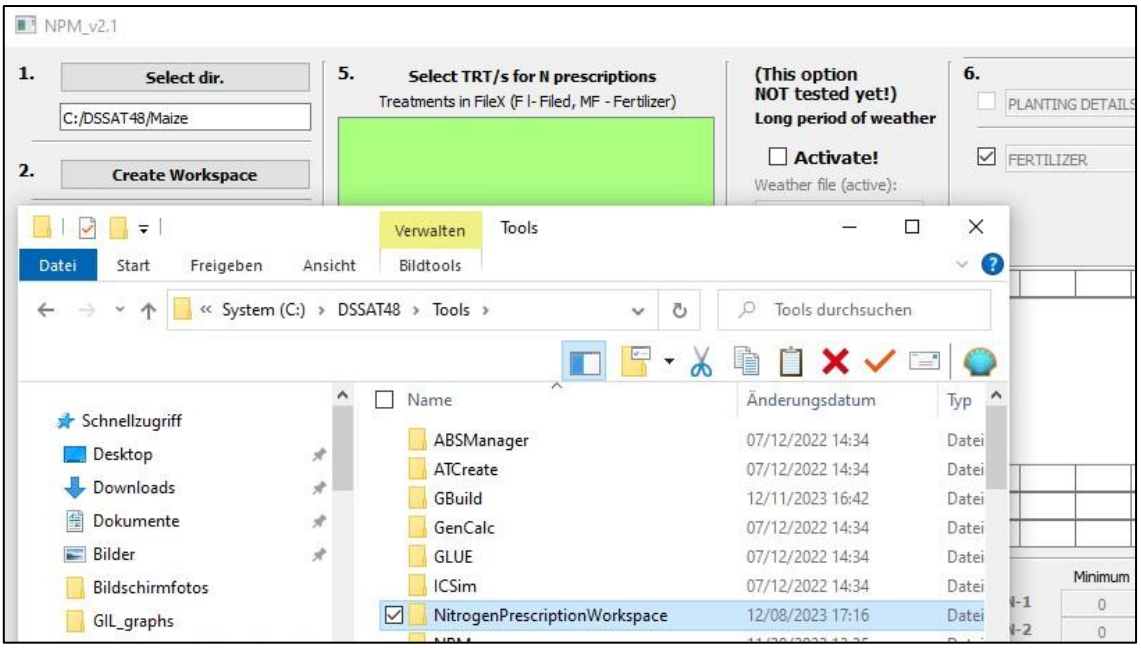


Figure 7 After the model is selected and initialized (Figure 6, "C:/DSSAT48/Maize) the user must click on Create Workspace button, to create NPM NitrogenPrescriptionWorkspace dir.

3. Crop model-based file X list initialization

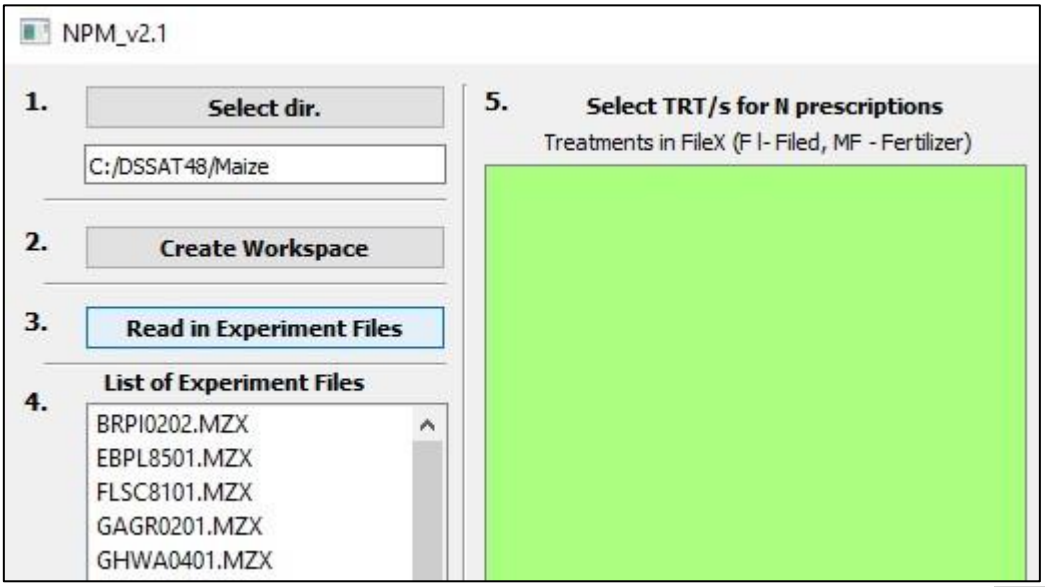


Figure 8 After NitrogenPrescriptionWorkspace is created the user has to click on Read in Experiment Files button to get list of available experiment files (FileX/s) in list widget window in section 4.

4. File X selection

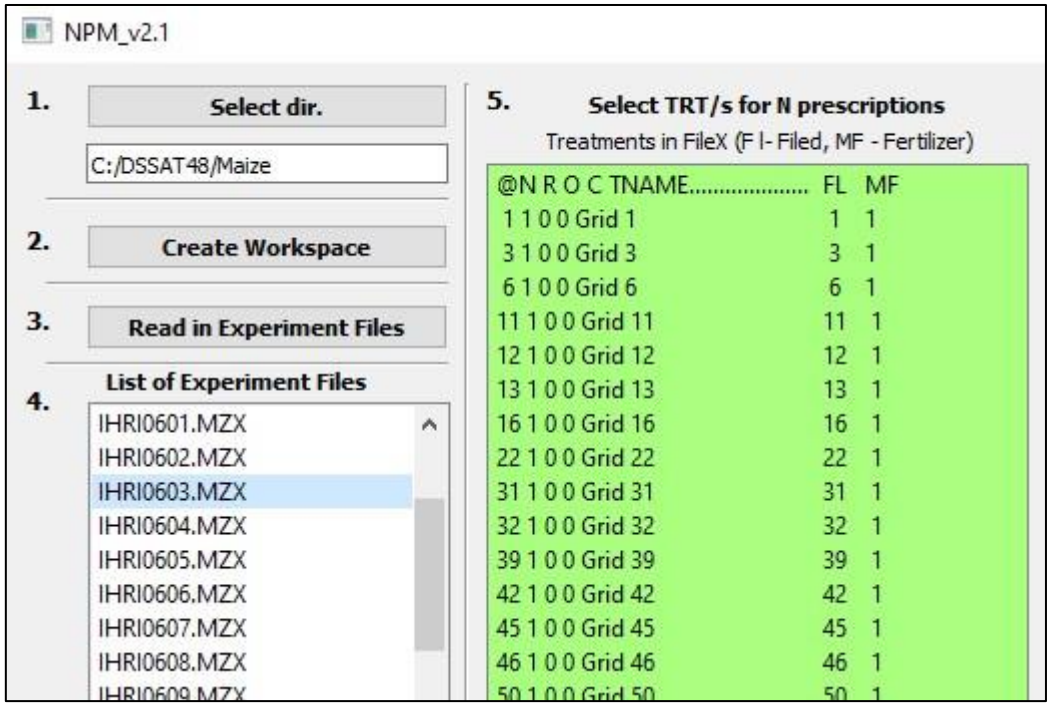


Figure 9 At the time only one FileX can be selected in list widget window in NPM section 4., and after selected FileX corresponding treatments list is loaded into list widget in NPM section 5., for selection.

5. Select TRT/s for N prescription

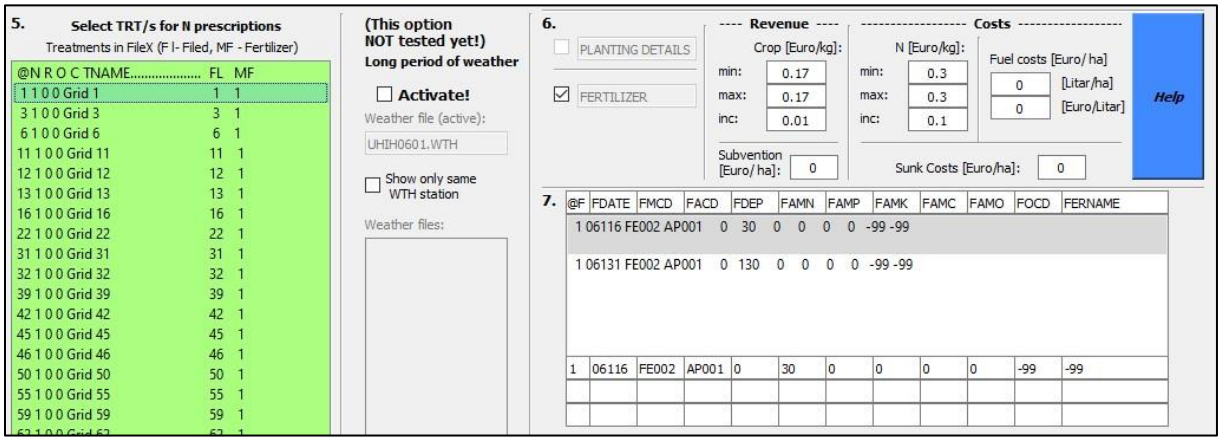
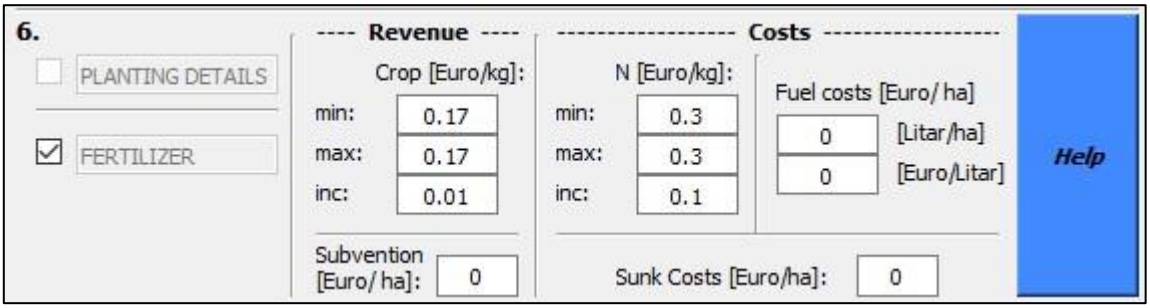


Figure 10 After selecting treatment/s from list widget window in NPM section 5., N application date/s available in File X will be loaded in NPM section 7. for later selection.

6. Grain and N prices setup



Help:

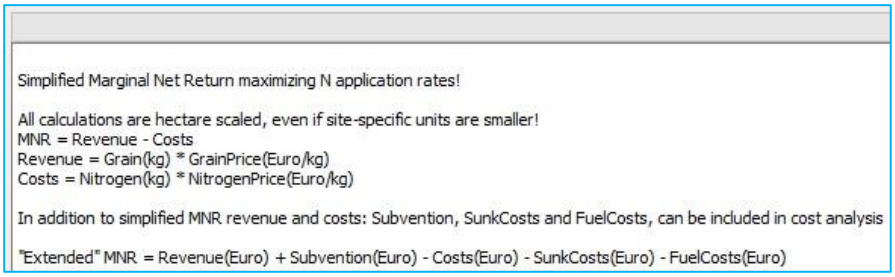


Figure 11 In NPM section 6., price setup can be conducted. It is possible to do grain and N prices sensitivity analysis. If user sets Crop price min and max 0.17, it means that the NPM tool will conduct analysis only based on one price. If a user wants to conduct N prescription sensitivity analysis based 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

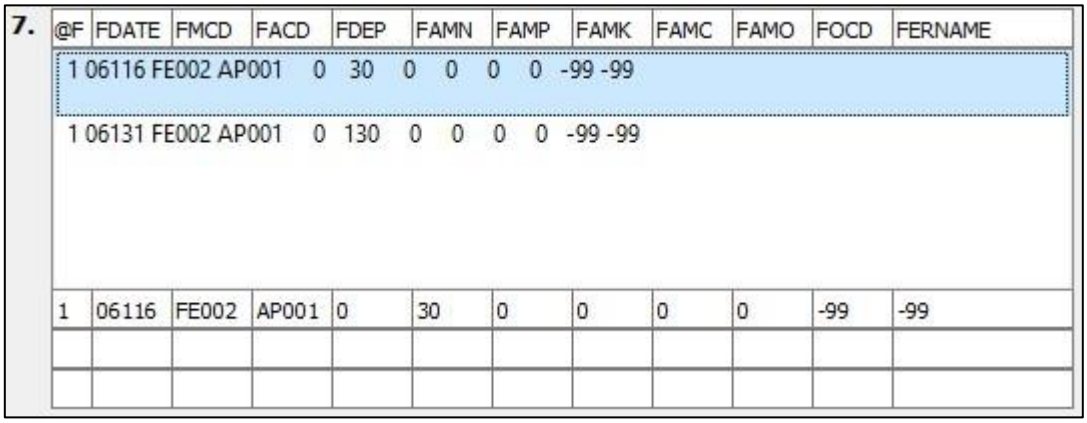


Figure 12 Based on the available N application dates and setup in File X corresponding treatments the user will get options to choose for corresponding sensitivity analysis. The user can select a maximum of 3 application dates with *CTRL + mouse left click* to initialize the dates for potential sensitivity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

8. NPM gradient increase of N applied and Assemble Presriptions

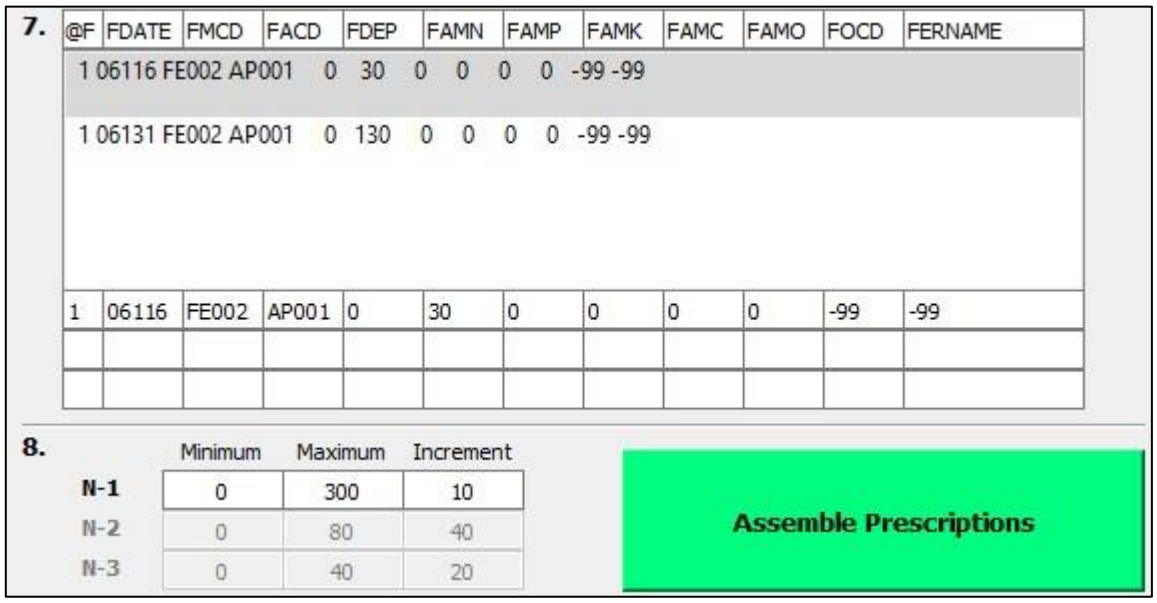


Figure 13 In NPM section 8., the user can set NPM marginal return sensitivity analysis by defining min, max and inc. steps. If user sets min=0, max=300 and inc.=10, the NPM algorithm will execute crop model by conducting marginal return analysis with one-unit inputs of 10 kg N (inc.=10) and at each step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

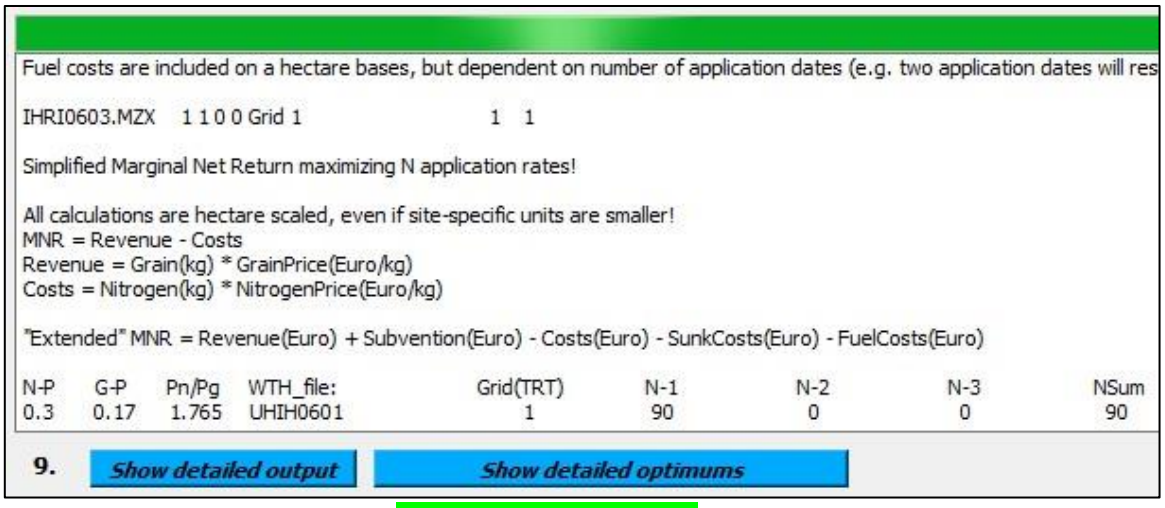


Figure 14 After NPM setup and Assemble Prescriptions push button is clicked (Figure 13) the NPM algorithm will conduct sensitivity analysis and show MNR maximizing N application rate in text browser window. In case if multiple N applications result in same MNR, all of them will be shown in text browser 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	Pn/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	UHIH0601	1	0	0	0	0	3572	607.24	0.0	0.0	0.0	0.0	607.24
0.3	0.17	1.765	UHIH0601	1	10	0	0	10	3851	654.67	0.0	3.0	0.0	0.0	651.67
0.3	0.17	1.765	UHIH0601	1	20	0	0	20	4169	708.73	0.0	6.0	0.0	0.0	702.73
0.3	0.17	1.765	UHIH0601	1	30	0	0	30	4636	788.12	0.0	9.0	0.0	0.0	779.12
0.3	0.17	1.765	UHIH0601	1	40	0	0	40	4987	847.79	0.0	12.0	0.0	0.0	835.79
0.3	0.17	1.765	UHIH0601	1	50	0	0	50	5382	914.94	0.0	15.0	0.0	0.0	899.94
0.3	0.17	1.765	UHIH0601	1	60	0	0	60	5673	964.41	0.0	18.0	0.0	0.0	946.41
0.3	0.17	1.765	UHIH0601	1	70	0	0	70	6020	1023.4	0.0	21.0	0.0	0.0	1002.4
0.3	0.17	1.765	UHIH0601	1	80	0	0	80	5963	1013.71	0.0	24.0	0.0	0.0	989.71
0.3	0.17	1.765	UHIH0601	1	90	0	0	90	6092	1035.64	0.0	27.0	0.0	0.0	1008.64
0.3	0.17	1.765	UHIH0601	1	100	0	0	100	6011	1021.87	0.0	30.0	0.0	0.0	991.87
0.3	0.17	1.765	UHIH0601	1	110	0	0	110	5911	1004.87	0.0	33.0	0.0	0.0	971.87
0.3	0.17	1.765	UHIH0601	1	120	0	0	120	5930	1008.1	0.0	36.0	0.0	0.0	972.1
0.3	0.17	1.765	UHIH0601	1	130	0	0	130	6032	1025.44	0.0	39.0	0.0	0.0	986.44
0.3	0.17	1.765	UHIH0601	1	140	0	0	140	6047	1027.99	0.0	42.0	0.0	0.0	985.99
0.3	0.17	1.765	UHIH0601	1	150	0	0	150	5794	984.98	0.0	45.0	0.0	0.0	939.98
0.3	0.17	1.765	UHIH0601	1	160	0	0	160	5671	964.07	0.0	48.0	0.0	0.0	916.07
0.3	0.17	1.765	UHIH0601	1	170	0	0	170	5619	955.23	0.0	51.0	0.0	0.0	904.23
0.3	0.17	1.765	UHIH0601	1	180	0	0	180	5739	975.63	0.0	54.0	0.0	0.0	921.63
0.3	0.17	1.765	UHIH0601	1	190	0	0	190	5738	975.46	0.0	57.0	0.0	0.0	918.46
0.3	0.17	1.765	UHIH0601	1	200	0	0	200	5734	974.78	0.0	60.0	0.0	0.0	914.78
0.3	0.17	1.765	UHIH0601	1	210	0	0	210	5739	975.63	0.0	63.0	0.0	0.0	912.63
0.3	0.17	1.765	UHIH0601	1	220	0	0	220	5731	974.27	0.0	66.0	0.0	0.0	908.27
0.3	0.17	1.765	UHIH0601	1	230	0	0	230	5732	974.44	0.0	69.0	0.0	0.0	905.44
0.3	0.17	1.765	UHIH0601	1	240	0	0	240	5734	974.78	0.0	72.0	0.0	0.0	902.78
0.3	0.17	1.765	UHIH0601	1	250	0	0	250	5735	974.95	0.0	75.0	0.0	0.0	899.95
0.3	0.17	1.765	UHIH0601	1	260	0	0	260	5735	974.95	0.0	78.0	0.0	0.0	896.95
0.3	0.17	1.765	UHIH0601	1	270	0	0	270	5736	975.12	0.0	81.0	0.0	0.0	894.12
0.3	0.17	1.765	UHIH0601	1	280	0	0	280	5736	975.12	0.0	84.0	0.0	0.0	891.12
0.3	0.17	1.765	UHIH0601	1	290	0	0	290	5737	975.29	0.0	87.0	0.0	0.0	888.29
0.3	0.17	1.765	UHIH0601	1	300	0	0	300	5731	974.27	0.0	90.0	0.0	0.0	884.27

Figure 16 Detailed outputs

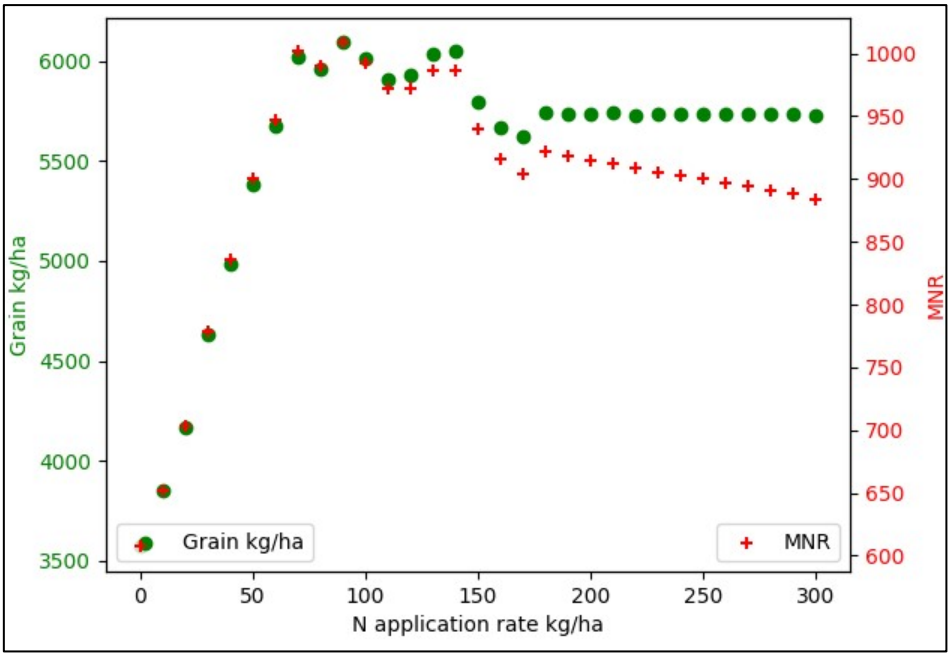


Figure 17 This is graphic depiction of the corresponding agronomic yield and MNR.

Price sensitivity analysis

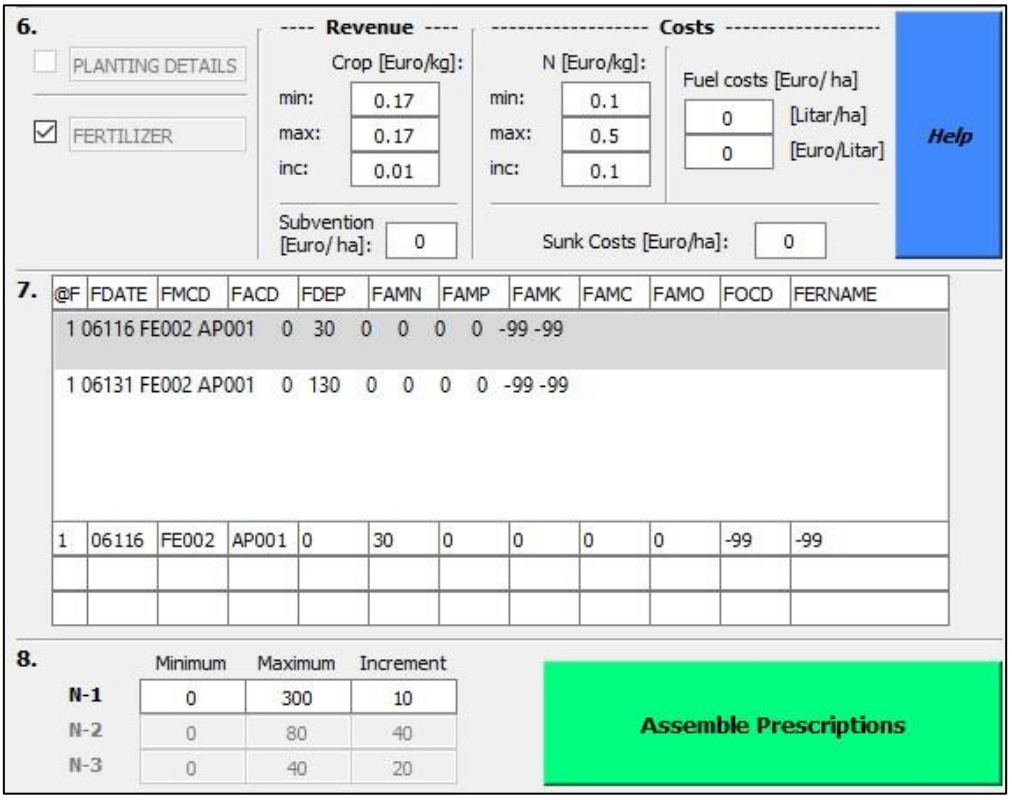


Figure 18 N price setup min=0.1, max=0.5 and inc.=01 will result in running MNR maximization based on 0.1, 0.2, 0.3, 0.4 and 0.5 Euro/kg prices. This will result in five MNR scenarios as can be seen in Figure 19.

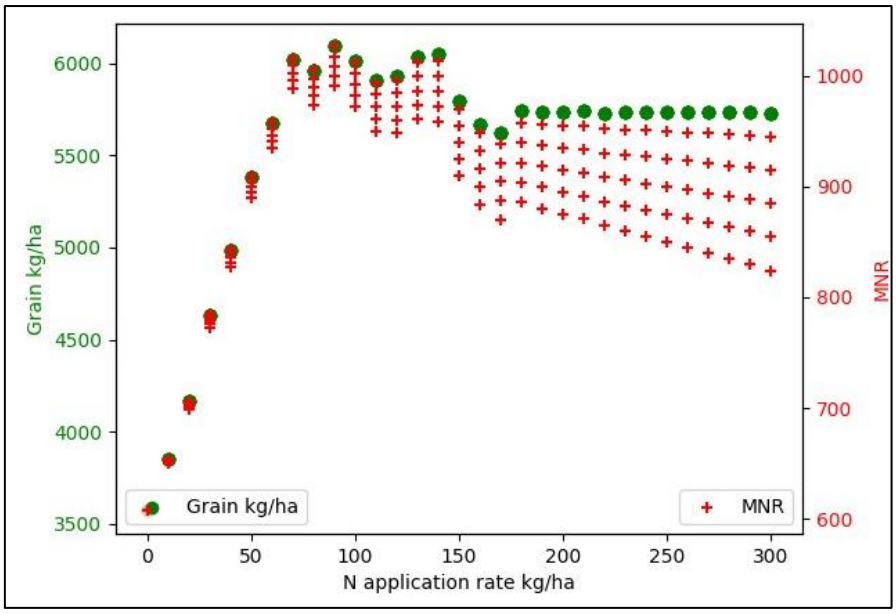


Figure 19 Yield response to N based MNR scenarios

Multiple data N application

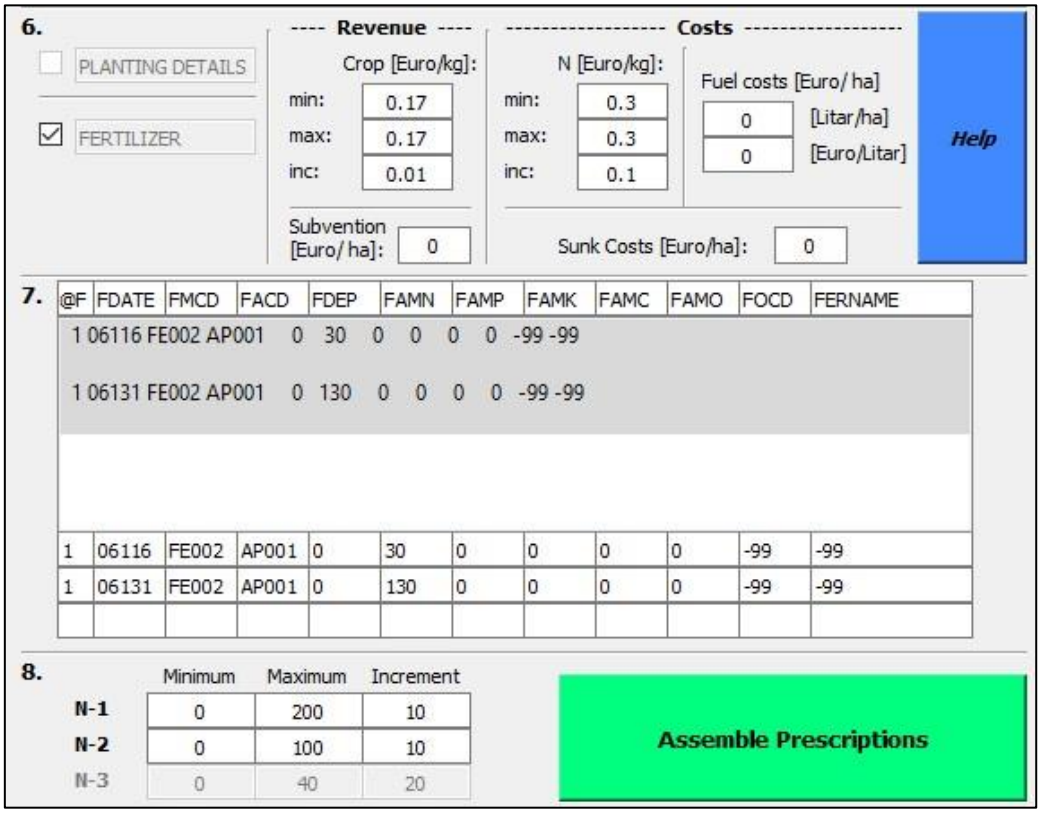


Figure 19 Multiple data N application with one MNR scenario

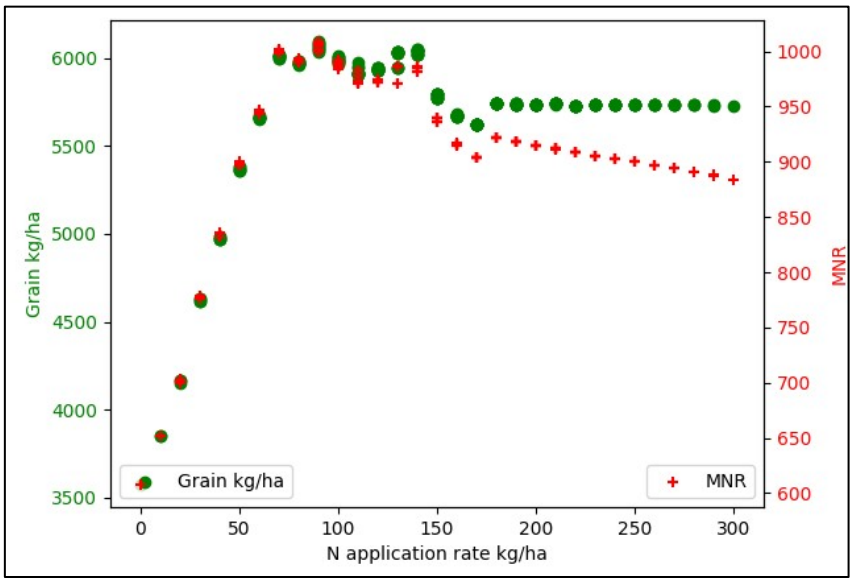


Figure 20 MNR scenario

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.