NPM_v2 - 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 other. 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. **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. 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).

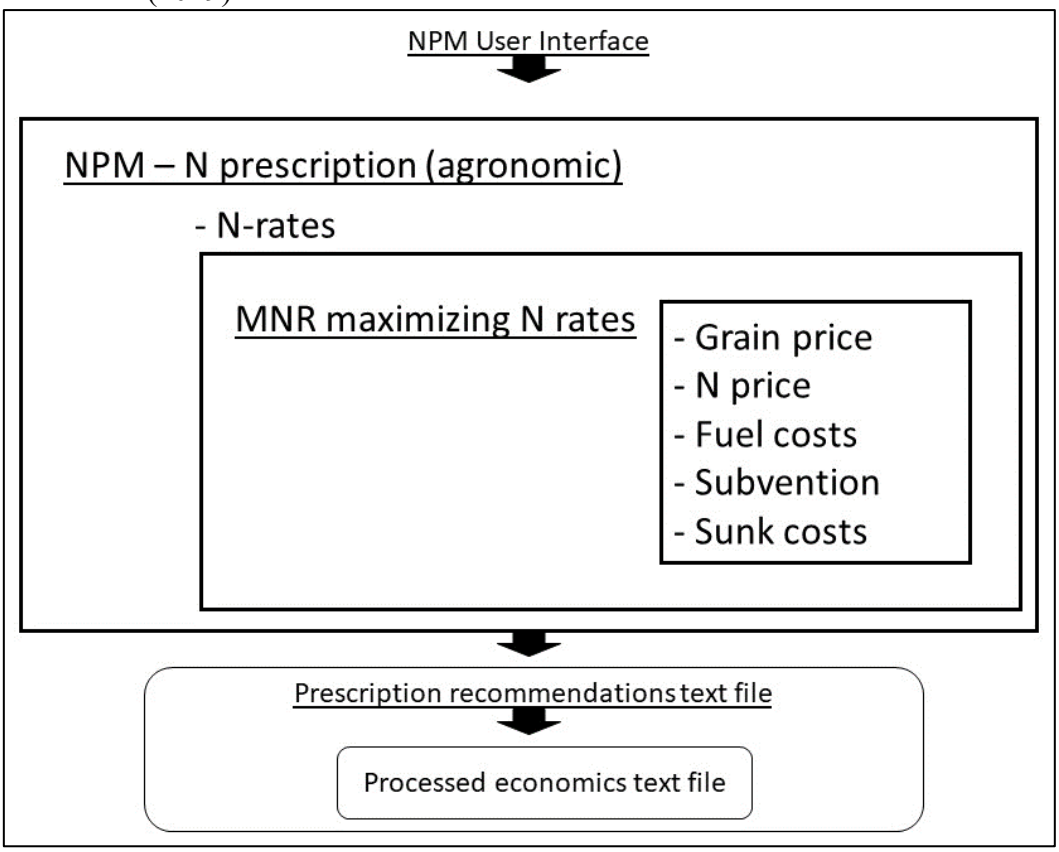

Figure 1 NPM conceptual framework – flow diagram

General NPM program settings overview

The "**NPM_v2.7zip**" must be unzipped and copied to the Tools directory: "**C:\DSSAT48\Tools**" (depending on the DSSAT version "C:\DSSAT**\Tools".

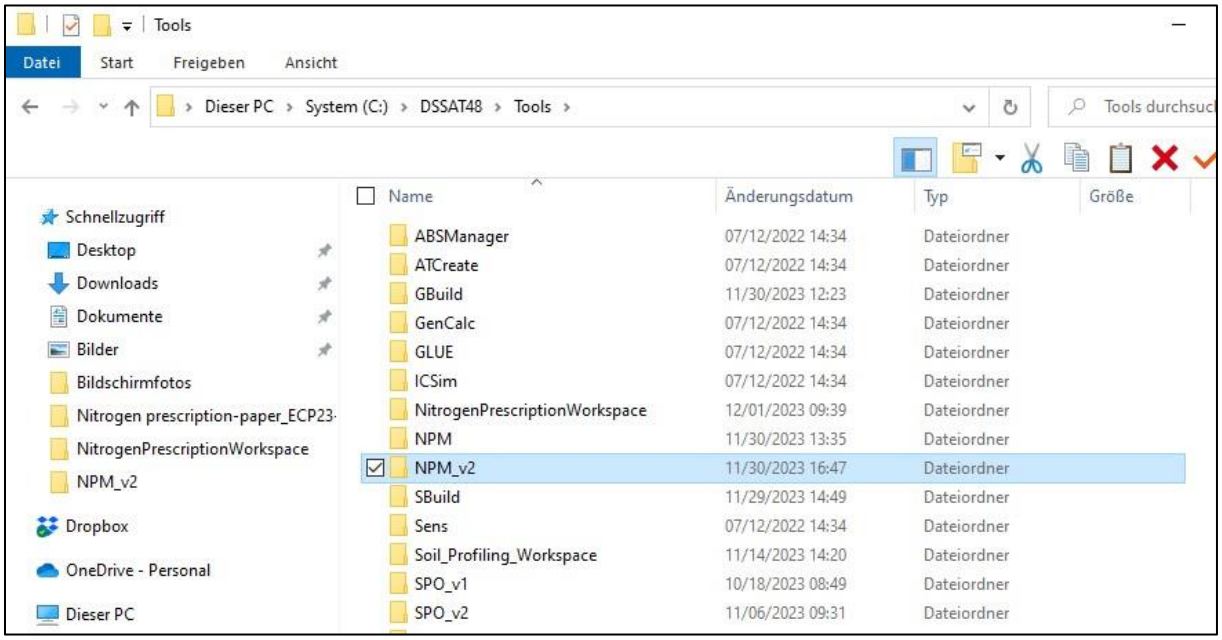

Figure 2 NPM_v2 directory

In the folder "NPM_v2" "**C:\DSSAT48\Tools\NPM_v2**" (Figure 6) "**NPM_v2.exe**" windows runnable must be executed as "**Administrator**" (Figure 7).

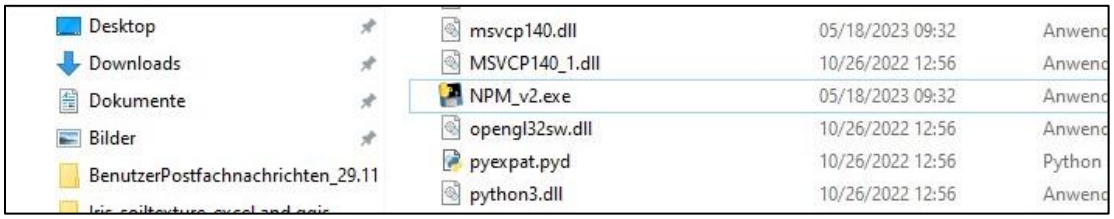

Figure 3 The NPM_v2.exe windows runnable

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".

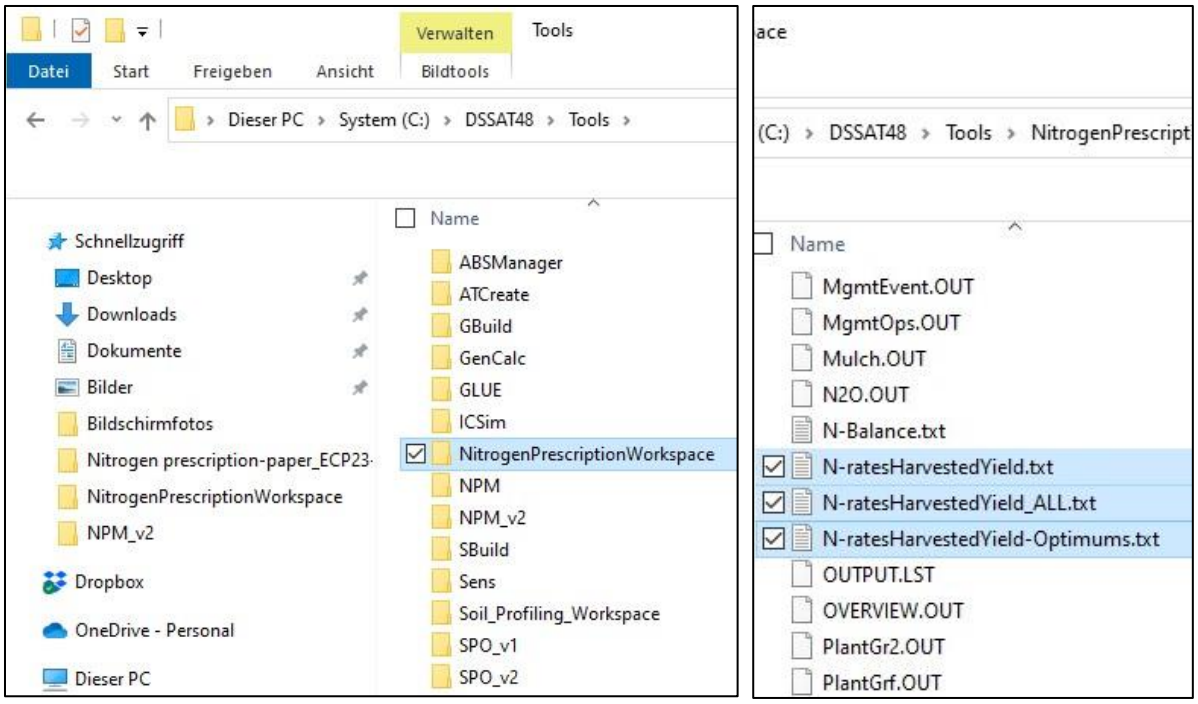

Figure 4 "NitrogenPrescriptionWorkspace" is located in **"Tools"** directory

NPM program running through section flow:

1. **Select dir.** (select crop model directory, e.g. "C:/DSSAT48/Wheat")
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**

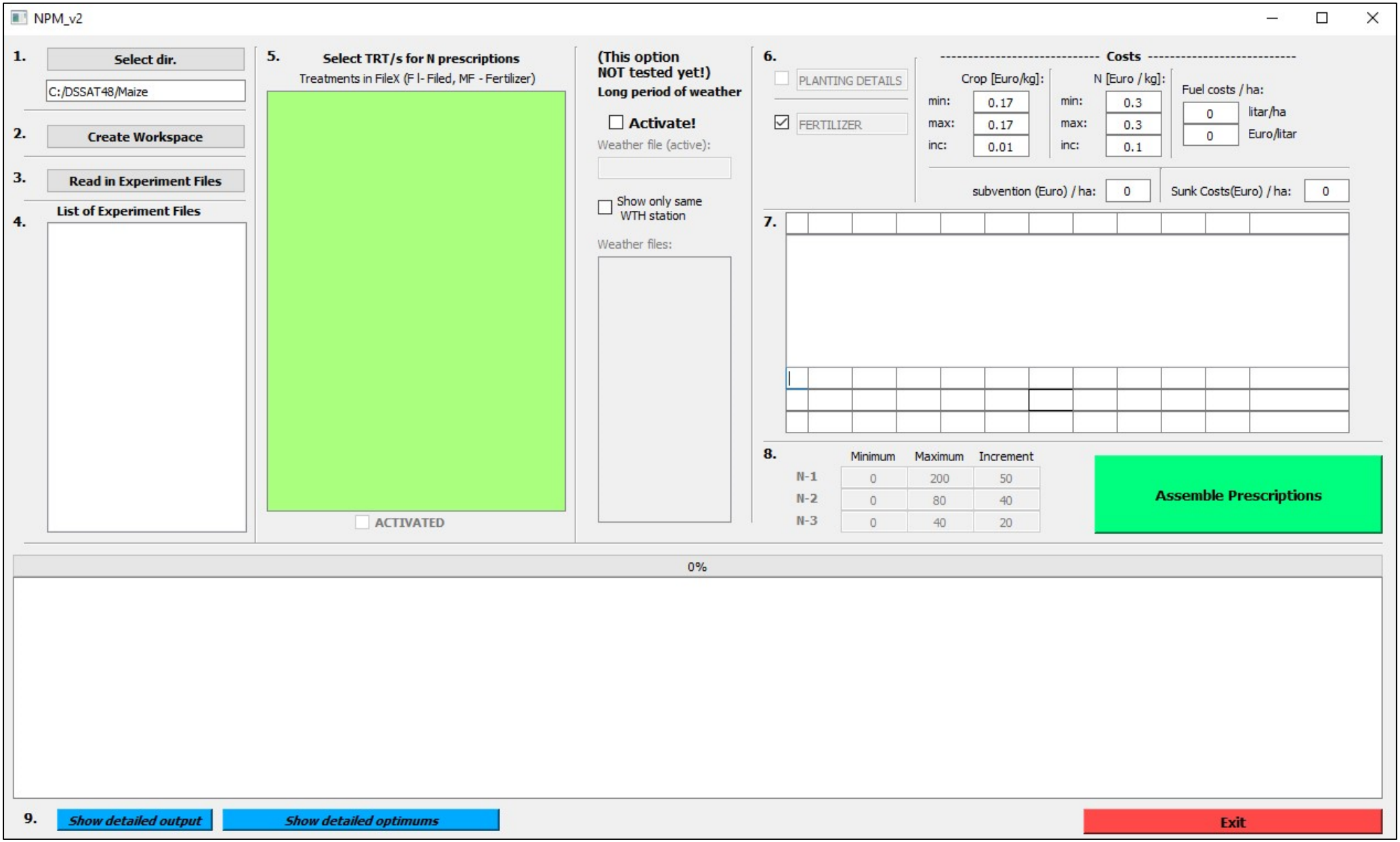

Figure 5 Interface

1. Crop model selection and initialization

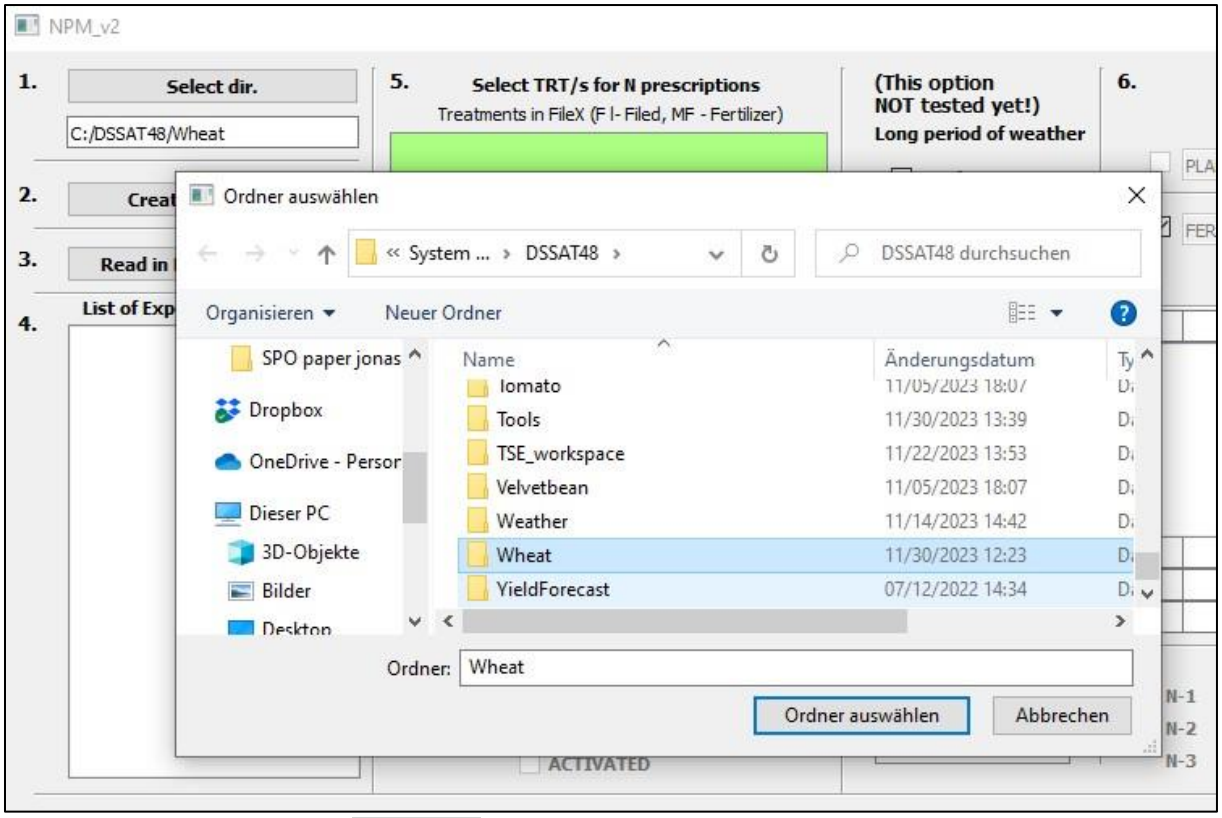

Figure 6 With push button Select dir. a user has to navigate to DSSAT crop directory and initialize it, in order to select crop model for conducting sensitivity analysis (e.g. Wheat).

2. Create Workspace

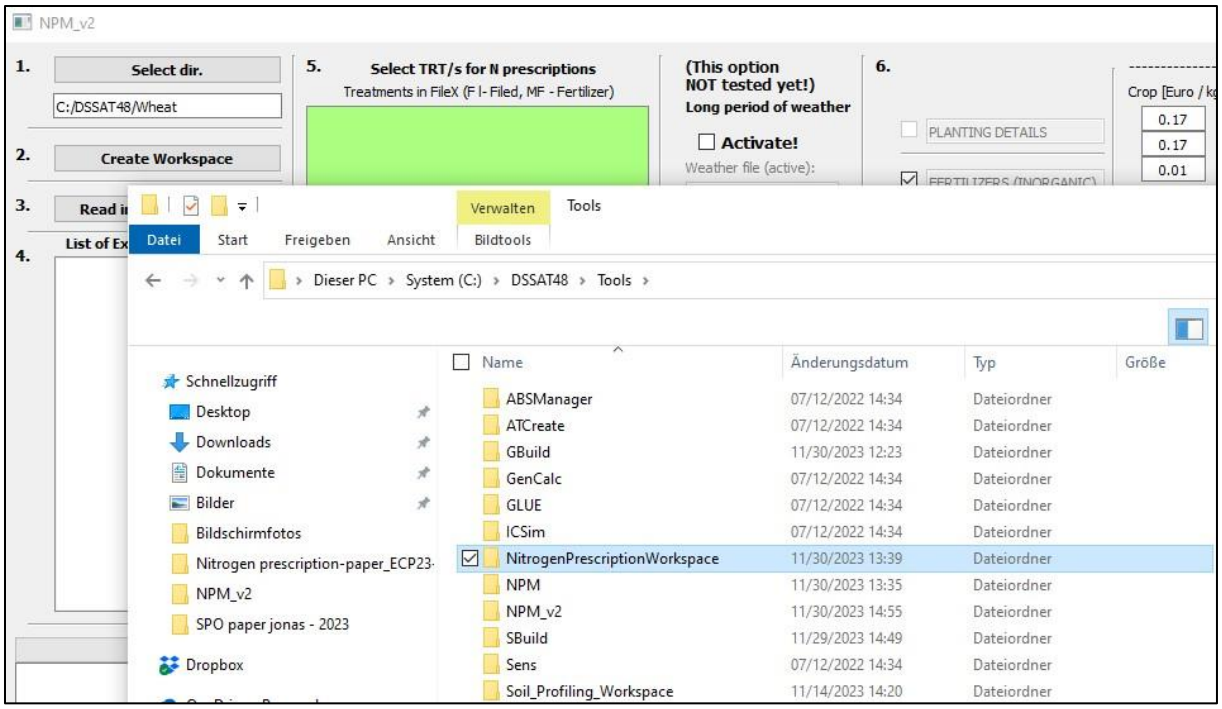

Figure 7 After the model is selected and initialized (Figure 6, "C:/DSSAT48/Wheat) the user must click on Create Workspace button, to create NPM NitrogenPrescriptionWorkspace dir.

3. Crop model-based file X list initialization

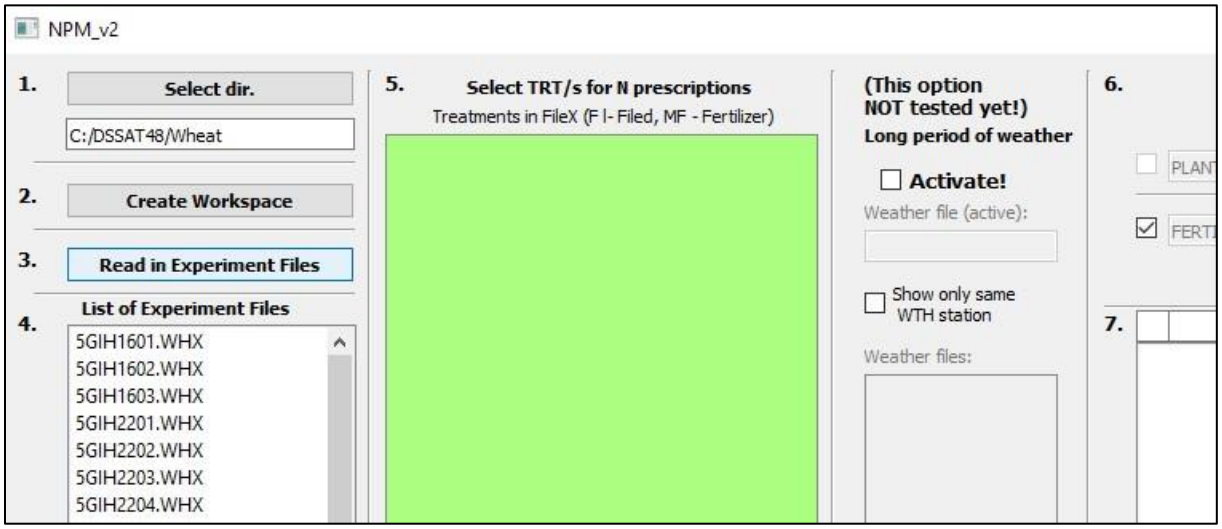

Figure 8 After NitrogenPrescriptionWorkspace is created the user has to click on Read in Experiment Files button to get list of available experiment files (FileX/s) in list widget window in section 4.

4. File X selection

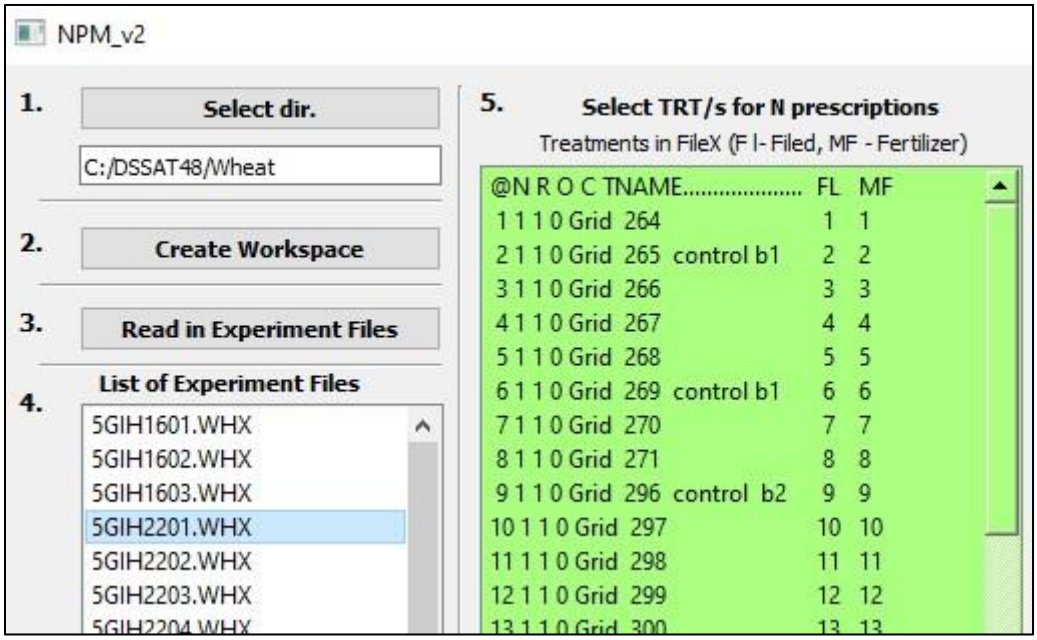

Figure 9 At the time only one File X can be selected in list widget window in NPM section 4., and after selected FileX corresponding treatments list is loaded into list widget in NPM section 5., for selection.

5. Select TRT/s for N prescription

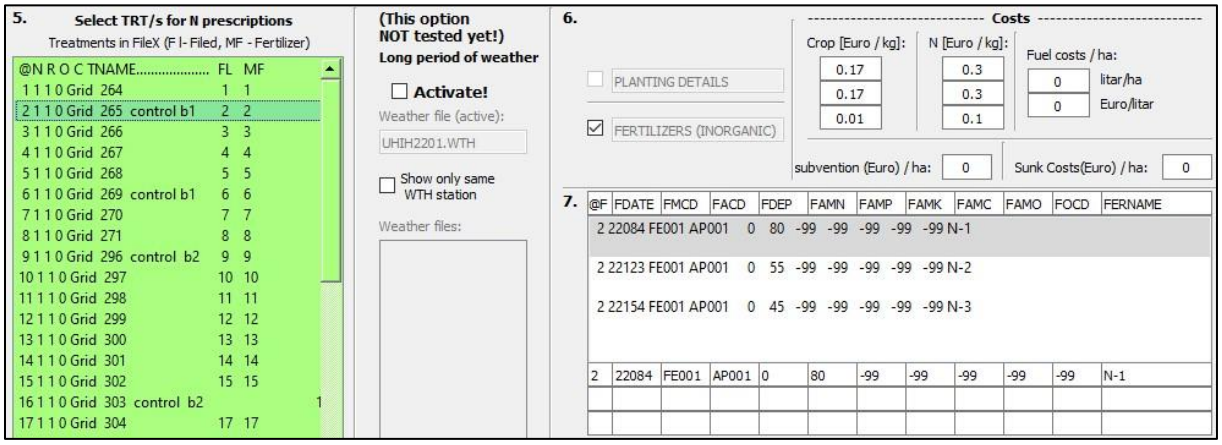

Figure 10 After selecting treatment/s from list widget window in NPM section 5., N application date/s available in File X will be loaded in NPM section 7. for later selection.

6. Grain and N prices setup

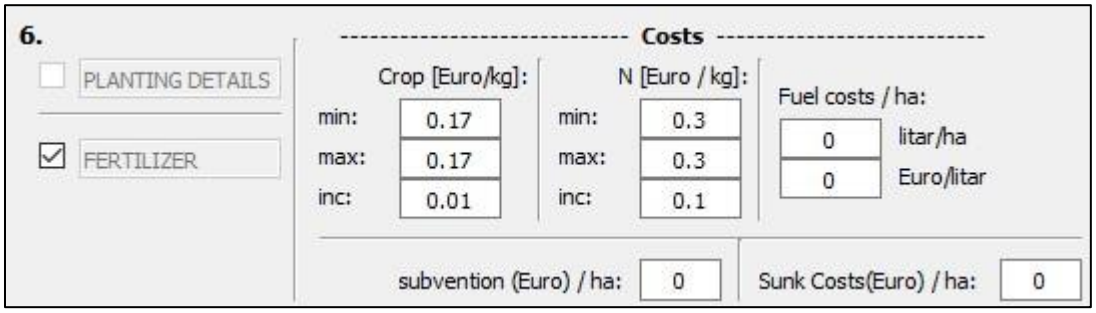

Figure 11 In NPM section 6., price setup can be conducted. It is possible to do grain and N prices sensitivity analysis. If user sets Crop price min and max 0.17, it means that the NPM tool will conduct analysis only based on one price. If a user wants to conduct N prescription sensitivity analysis based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

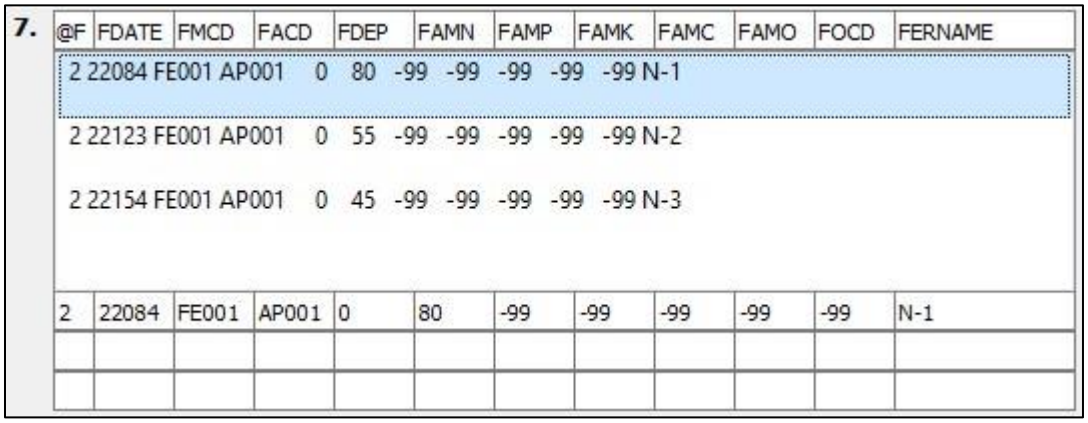

Figure 12 Based on the available N application dates and setup in File X corresponding treatments the user will get options to chose for corresponding sensitivity analysis. The user can select a maximum of 3 application dates with *CTRL + mouse left click* to initialize the dates for potential sensitivity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

8. NPM gradient increase of N applied and Assemble Presriptions

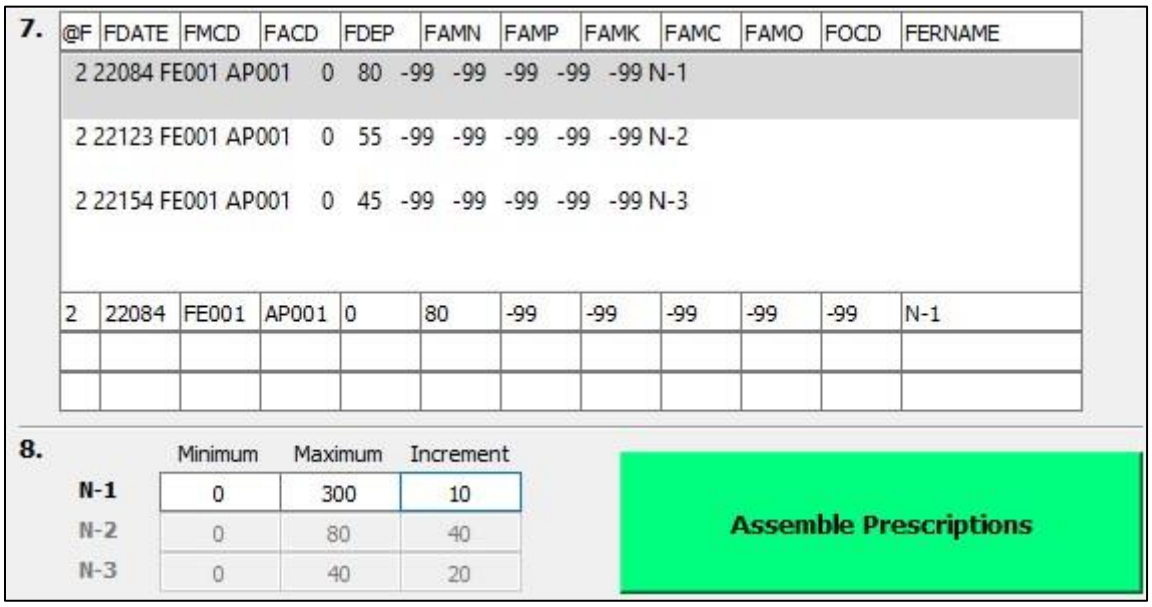

Figure 13 In NPM section 8., the user can set NPM marginal return sensitivity analysis by defining min, max and inc. steps. If user sets min=0, max=300 and inc.=10, the NPM algorithm will execute crop model by conducting marginal return analysis with one-unit inputs of 10 kg N (inc.=10) and at each step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

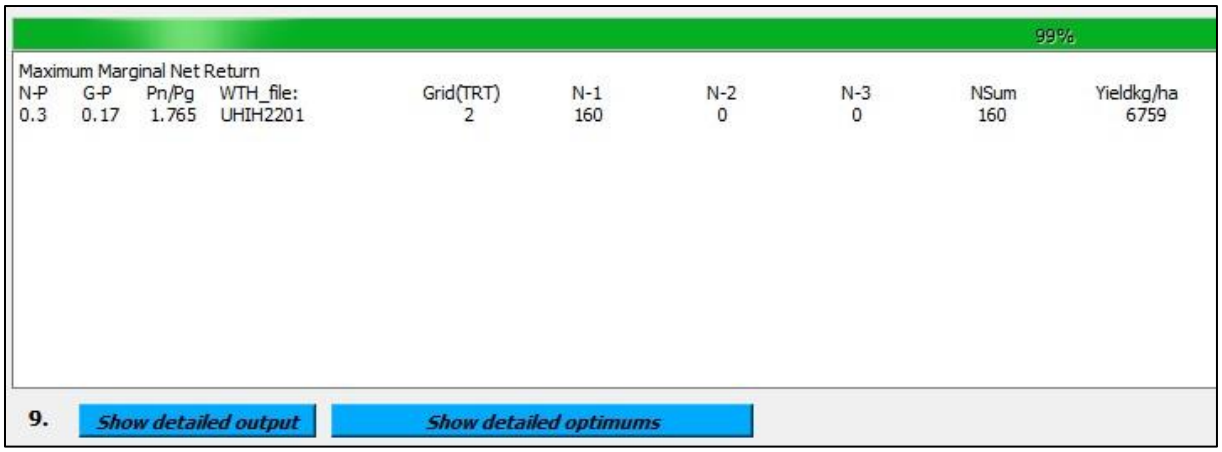

Figure 14 After NPM setup and Assemble Prescriptions push button is clicked (Figure 13) the NPM algorithm will conduct sensitivity analysis and show MNR maximizing N application rate in text browser window. In case if multiple N applications result in same MNR, all of them will be shown in text browser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

9. Show detailed outputs

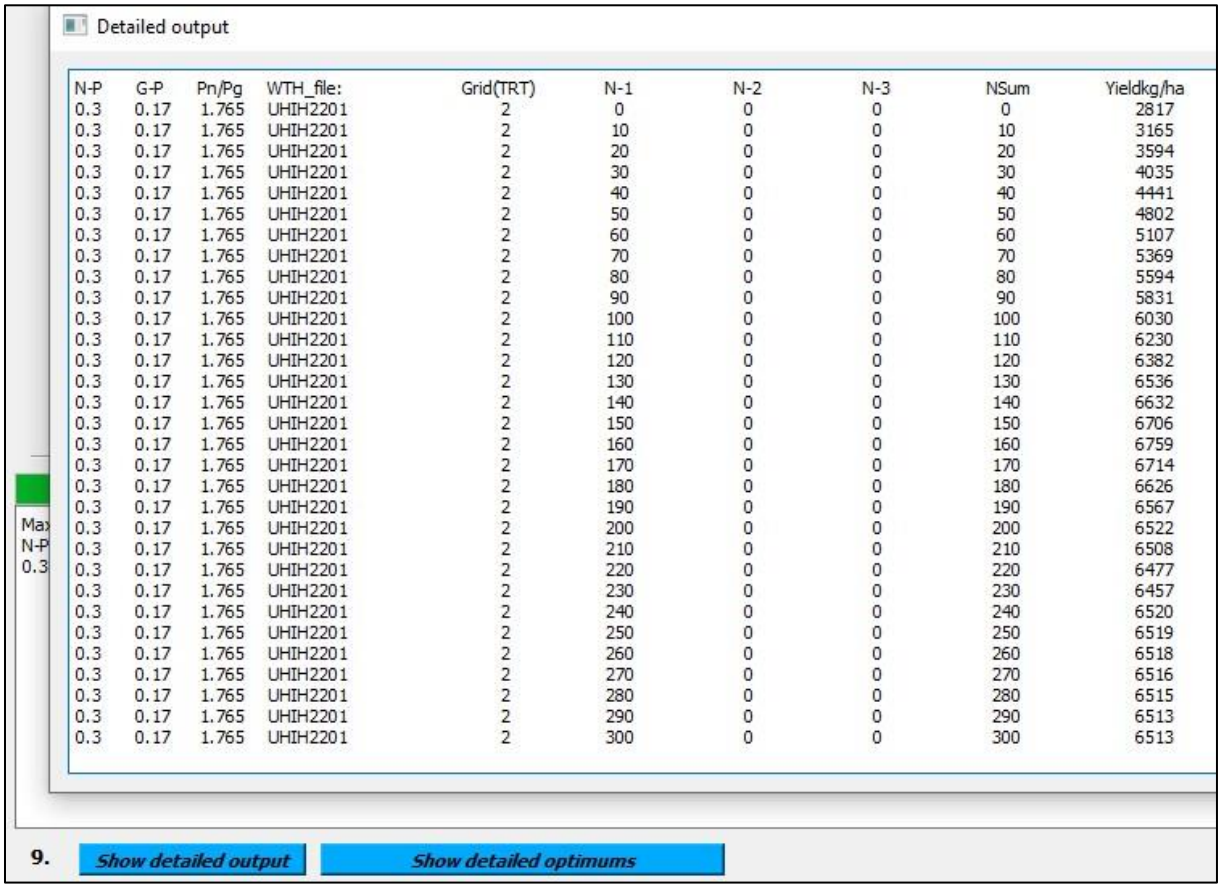

Figure 15 Based on the setup in Figure 13, detailed outputs can be displayed in additional popout window as shown in this figure, with N-P (nitrogen price), G-P (grain price), Pn/Pg (price ratio) etc.

Detailed output

N-P	G-P	Pn/Pg	WTH_file:	Grid(TRT)	N-1	N-2	N-3	NSum	Yieldkg/ha	profit(Gkg*P)	Subvention	Cost(Nkg*P)	Fuel(lit*P)	SunkCost	MNR
0.3	0.17	1.765	UHIH2201	2	0	0	0	0	2817	478.89	0.0	0.0	0.0	0.0	478.89
0.3	0.17	1.765	UHIH2201	2	10	0	0	10	3165	538.05	0.0	3.0	0.0	0.0	535.05
0.3	0.17	1.765	UHIH2201	2	20	0	0	20	3594	610.98	0.0	6.0	0.0	0.0	604.98
0.3	0.17	1.765	UHIH2201	2	30	0	0	30	4035	685.95	0.0	9.0	0.0	0.0	676.95
0.3	0.17	1.765	UHIH2201	2	40	0	0	40	4441	754.97	0.0	12.0	0.0	0.0	742.97
0.3	0.17	1.765	UHIH2201	2	50	0	0	50	4802	816.34	0.0	15.0	0.0	0.0	801.34
0.3	0.17	1.765	UHIH2201	2	60	0	0	60	5107	868.19	0.0	18.0	0.0	0.0	850.19
0.3	0.17	1.765	UHIH2201	2	70	0	0	70	5369	912.73	0.0	21.0	0.0	0.0	891.73
0.3	0.17	1.765	UHIH2201	2	80	0	0	80	5594	950.98	0.0	24.0	0.0	0.0	926.98
0.3	0.17	1.765	UHIH2201	2	90	0	0	90	5831	991.27	0.0	27.0	0.0	0.0	964.27
0.3	0.17	1.765	UHIH2201	2	100	0	0	100	6030	1025.1	0.0	30.0	0.0	0.0	995.1
0.3	0.17	1.765	UHIH2201	2	110	0	0	110	6230	1059.1	0.0	33.0	0.0	0.0	1026.1
0.3	0.17	1.765	UHIH2201	2	120	0	0	120	6382	1084.94	0.0	36.0	0.0	0.0	1048.94
0.3	0.17	1.765	UHIH2201	2	130	0	0	130	6536	1111.12	0.0	39.0	0.0	0.0	1072.12
0.3	0.17	1.765	UHIH2201	2	140	0	0	140	6632	1127.44	0.0	42.0	0.0	0.0	1085.44
0.3	0.17	1.765	UHIH2201	2	150	0	0	150	6706	1140.02	0.0	45.0	0.0	0.0	1095.02
0.3	0.17	1.765	UHIH2201	2	160	0	0	160	6759	1149.03	0.0	48.0	0.0	0.0	1101.03
0.3	0.17	1.765	UHIH2201	2	170	0	0	170	6714	1141.38	0.0	51.0	0.0	0.0	1090.38
0.3	0.17	1.765	UHIH2201	2	180	0	0	180	6626	1126.42	0.0	54.0	0.0	0.0	1072.42
0.3	0.17	1.765	UHIH2201	2	190	0	0	190	6567	1116.39	0.0	57.0	0.0	0.0	1059.39
0.3	0.17	1.765	UHIH2201	2	200	0	0	200	6522	1108.74	0.0	60.0	0.0	0.0	1048.74
0.3	0.17	1.765	UHIH2201	2	210	0	0	210	6508	1106.36	0.0	63.0	0.0	0.0	1043.36
0.3	0.17	1.765	UHIH2201	2	220	0	0	220	6477	1101.09	0.0	66.0	0.0	0.0	1035.09
0.3	0.17	1.765	UHIH2201	2	230	0	0	230	6457	1097.69	0.0	69.0	0.0	0.0	1028.69
0.3	0.17	1.765	UHIH2201	2	240	0	0	240	6520	1108.4	0.0	72.0	0.0	0.0	1036.4
0.3	0.17	1.765	UHIH2201	2	250	0	0	250	6519	1108.23	0.0	75.0	0.0	0.0	1033.23
0.3	0.17	1.765	UHIH2201	2	260	0	0	260	6518	1108.06	0.0	78.0	0.0	0.0	1030.06
0.3	0.17	1.765	UHIH2201	2	270	0	0	270	6516	1107.72	0.0	81.0	0.0	0.0	1026.72
0.3	0.17	1.765	UHIH2201	2	280	0	0	280	6515	1107.55	0.0	84.0	0.0	0.0	1023.55
0.3	0.17	1.765	UHIH2201	2	290	0	0	290	6513	1107.21	0.0	87.0	0.0	0.0	1020.21
0.3	0.17	1.765	UHIH2201	2	300	0	0	300	6513	1107.21	0.0	90.0	0.0	0.0	1017.21

Figure 16

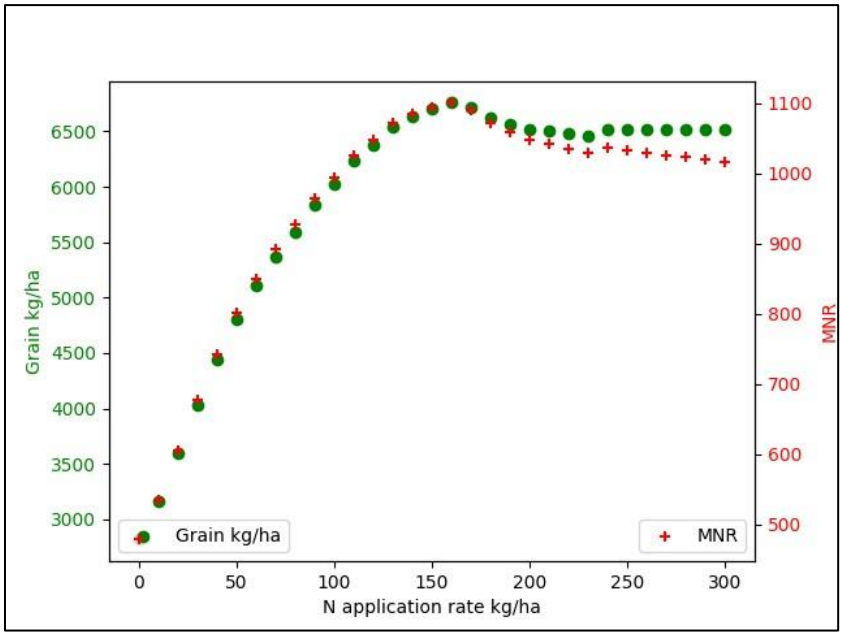

Figure 17 This is graphic depiction of the corresponding agronomic yield and MNR.

References

Interface:
The NPM_v2 user interface was created in Qt Designer 5
(https://doc.qt.io/qtcreator/index.html)

Programming language:
The NPM_v2 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 was compiled into windows runnable with Pyinstaller
(https://www.pyinstaller.org/)

NPM_v2 algorithm and interface development/setup by Emir Memic.