Agronomic dataset on potato growth and yield in the Netherlands

Tamara ten Den[1*], Inge van de Wiel[1], Frits van Evert[2], Martin van Ittersum[1], Allard de Wit[3], Pytrik Reidsma[1†]

[1] Plant Production Systems, Wageningen University and Research, P.O. Box 430, 6700 AK Wageningen, The Netherlands
[2] Agrosystems Research, Wageningen University & Research, P.O. Box 16, 6700 AA Wageningen, The Netherlands
[3] Wageningen Environmental Research, P.O. Box 47, 6700 AA Wageningen, The Netherlands
email: tamara.tenden@wur.nl

Abstract: Data was collected at two field locations in the Netherlands: on the clayey soils in Lelystad and the sandy soils of Vredepeel during 2019 and 2020. The original aim of this dataset was to calibrate and evaluate crop growth models for estimating potential, water-limited and nitrogen-limited yield levels for modern potato cultivars. Therefore, treatments include different cultivars, irrigation regimes, nitrogen fertilization and light interception. During the two seasons extensive data was collected either passively, via non-destructive or via destructive measurements. Passive measurements consisted of weather and soil moisture data and were taken continuously throughout the season. Non-destructive data was collected on photosynthesis, reflection / light intensity, SPAD chlorophyll values, plant height, crop phenology and groundwater level roughly every other week throughout the seasons. Destructive measurements were taken on biomass (leaves, stems and tubers), leaf area, NPK content (leaves) and the number of tubers between five and seven times per season. Additionally, during the final harvest data was collected on the tuber size distribution, marketability and NPK content of the tubers.

Keywords: Potato, the Netherlands, experimental data, crop modelling, model calibration

1 BACKGROUND: In two years at two locations in the Netherlands extensive field data on potato (*Solanum tuberosum* L.) growth has been collected to use in model calibration and evaluation. The data has already been used to recalibrate WOFOST version 7.2 for potential potato yields (ten Den et al. 2022a) to calibrate and evaluate WOFOST and SWAP-WOFOST (version 4.2.6) for water limited yield (ten Den et al. 2022b) as well as water and nitrogen limited yields in WOFOST version 8.1 (Berghuijs et al. in prep) Additionally, the data has been used in Prikaziuk et al. (2022). Lastly the data has been used in multiple MSc theses / MSc internships: a thesis by Brouwer (2020) who focused on potential yield calibration in WOFOST, an internship by Song (2020) who focused on the effects of drought of tuber yield, tuber number and LAI, and lastly an internship by Beurskens (2020) who focused on photosynthesis. The collected data could be of use for further calibration efforts in crop models or for other purposes.

2 MANAGEMENT AND TREATMENTS

The experiment was conducted in the Netherlands during 2019 and 2020, at two locations situated in areas where potato is frequently grown by commercial farmers. The fields were located near Lelystad (latitude 52.54°, longitude 5.55°) and Vredepeel (latitude 51.54°, longitude 5.86°). The two locations differed in soil type, with Vredepeel having sandy soil (clay <1%, silt 9%, sand 87%) and Lelystad having light clayey soil (clay 12-13%, silt 41%, sand 40-41%).

The preceding crops were carrot in Lelystad and spring wheat (*Triticum aestivum* L.) in Vredepeel for the fields used in 2019 and winter wheat followed by fodder radish (*Raphanus sativus* subsp. *Oleiferus* Metzg.) for both locations in 2020. As the fields used in 2019 were located directly bordering those used in 2020, we refer to them as Vredepeel and Lelystad and do not differentiate between the fields used during 2019 and 2020 even though technically we did not use the same fields.

Per location three cultivars were grown, with 'Fontane' as joint cultivar ('Fontane L' – Fontane in Lelystad; 'Fontane V' - Fontane in Vredepeel). Additionally, 'Premiere' and 'Festien' were grown in Vredepeel, and 'Innovator' and 'Markies' in Lelystad. 'Festien' is a starch potato, while the other cultivars are ware processing cultivars. The cultivars differ in the length of their growth duration (earliness) with 'Premiere' being the earliest and 'Festien' being the latest as determined by cultivar earliness values calculated by breeding companies. Additionally, the cultivars differ in the number of tubers per plant, drought tolerance and disease sensitivity. (Table 1)

Due to the differences in number of tubers per plant and plant physiology between the cultivars, cultivar-specific planting distances were used. The cultivars 'Innovator' and 'Festien' were planted at 30 cm distance while for 'Fontane' and 'Markies' a planting distance of 33 cm was used, and for 'Premiere' a planting distance of 35 cm. The row distance could be kept constant and was set at 75 cm which is in line with common practice.

Table 1: General information per cultivar

Cultivar	**Earli-ness**	**Tubers per plant**	**Drought**	**Sensitive to which diseases**	**More information**
Premiere	very early (8)	8-10	Sensitive	*Phytophthora infestans* in haulm and tubers	*https://www.europotato.org/varieties/view/Premiere*
Innovator	mid-early (7)	7-8	Sensitive	*Phytophthora infestans* in tubers	*https://www.europotato.org/varieties/view/Innovator*
Fontane	mid-late (5.5)	10-12	medium	*Phytophthora infestans* in haulm and tubers	*https://www.europotato.org/varieties/view/Fontane*
Markies	late (4)	8-10	Very tolerant	Powdery scab and *Alternaria solani*	*https://www.europotato.org/varieties/view/Markies*
Festien	late (3)	8-10	Tolerant	Some sensiti-vity for common scab	*https://www.averis.nl/friksbeheer/wp-content/uploads/2023/02/FestienNLRassen2023.pdf*

Preparing the soil for planting in both locations was done by ploughing with subsoilers and a packer. In Lelystad a power harrow was used additionally. Just before planting, P, K, N and Mg fertilization was applied (Table 2). All the seed tubers planted were 35/45 mm class E, irrespective of cultivar and planting dates were late April in both years (Table 3).

Nitrogen fertilization differed between treatments and was applied as mineral fertilizer (Table 2). The nitrogen fertilization was based on recommended rates, depending on cultivar specific characteristics such as earliness; the estimated quantity released by the location-specific nitrogen mineralization was subtracted. For the N1 treatment 30% of this rate was applied, while for the N2 treatment 130% was applied. For the N0 treatment no nitrogen fertilization was applied. Nitrogen fertilization was split up over up to three applications: the first application was before the planting, the second before building the ridges and the third right after tuber initiation (Table 3 and 4).

Both fields were irrigated using drip irrigation. The irrigation schedule was based on continuously measured soil pF values at depths of 15 and 30 cm (2019) or 30 and 50 cm (2020) using Teros 21 soil water potential sensors. Two treatments were included in the experiment, an optimal (W2) treatment that aimed at a constant pF of 2.4 and a limited irrigation / drought treatment (W1) that aimed for a pF of 3.2.

Table 2: Fertilization amounts

Fertilization	**Type used**	**Lelystad**		**Vredepeel**	
		2019	**2020**	**2019**	**2020**
Nitrogen	calcium ammonium nitrate: 27%N, 13.5% NO_3, 13.5% NH_4, 27% PGS-7	See table 3	See table 3	See table 3	See table 3
P_2O_5	triple superphosphate	170 kg ha^{-1}	170 kg ha^{-1}	45 kg ha^{-1}	45 kg ha^{-1}
K_2O	K-50	275 kg ha^{-1}	275 kg ha^{-1}	275 kg ha^{-1}	275 kg ha^{-1}
MgO	kieserite $MgSO_4H_2O$,	60kg ha^{-1}	60 kg ha^{-1}	-	-

Table 3: Important dates per year and location

	Lelystad		**Vredepeel**	
	2019	**2020**	**2019**	**2020**
Planting date	25 April	20 April	18 April	21 April
Emergence dates	Innovator: 28 May Fontane: 29 May Markies: 30 May	Innovator: 21 May Fontane: 22-23 May Markies: 22-23 May	Premiere: 23 May Fontane: 25 May Festien: 21 May	Premiere: 20 May Fontane: 22 May Festien: 19 May
Tuber initiation dates	Innovator: 17 June Fontane: 17 June Markies: 17 June	Innovator: 4 – 8 June Fontane: 8 June Markies: 11 June	Premiere: 12 June Fontane: 10 June Festien: 12 June	Premiere: 2 –3 June Fontane: 4 - 5 June Festien: 12 – 13 June
Haulm killing	2 and 7 October	23 September	25 September	24 September
Nitrogen fertilization	1st: 25 April 2nd: 1 May 3rd: 21 June	1st: 9 April 2nd: 1 May 3rd: 15 June	1st: 9 April 2nd: 19 April 3rd: 18 June	1st: 14 April 2nd: 6 May 3rd: 19 June

Table 4: Nitrogen application for all cultivar and nitrogen treatments. The nitrogen application was the same in 2019 and 2020.

Cultivar	Nitrogen treatment	1st N application (kg N ha^{-1})	2nd N application (kg N ha^{-1})	3rd N application (kg N ha^{-1})	Total N applied (kg N ha^{-1})
Innovator	N0	-	-	-	0
Innovator	N1	85	-	-	85
Innovator	N2	125	125	125	375
Fontane L	N0	-	-	-	0
Fontane L	N1	85	-	-	85
Fontane L	N2*	125	115	120	360
Markies	N0	-	-	-	0
Markies	N1	85	-	-	85
Markies	N2	125	85	110	320
Premiere	N0	-	-	-	0
Premiere	N1	75	-	-	75
Premiere	N2	125	85	110	320
Fontane V	N0	-	-	-	0
Fontane V	N1	75	-	-	75
Fontane V	N2	125	85	110	320
Festien	N0	-	-	-	0
Festien	N1	75	-	-	75
Festien	N2	125	50	90	265

*The shadow treatment (N2S) received 125 kg N/ha for the first application, 115 kg/ha for the second and 120 kg/ha for the third application giving a total of 360 kg/ha.

Due to the drip irrigation, we were restricted in our experimental design on both locations as the strips were connected to the pump on one side of the experimental field, all laid out parallel over the fields. This resulted in rows of irrigation treatments, thus not allowing for a completely randomized design.

For both locations, treatments were replicated three times excluding those containing N0, which was only replicated once. In Vredepeel a partial randomized design was applied (Figure 1). The design in Lelystad was more complex (strip block design) as in addition to restrictions due to the drip irrigation, the number of times the planting equipment drove over the fields had to be reduced to prevent soil compaction. Therefore, the field was split up into three blocks separated by a turning lane. Each block consisted of two or three plots in a row. Each row in a block consisted of only one cultivar. The block with two plots in a row contained only N1 and N2 treatments while block with three plots in a row also contained the N0 treatments (Figure 2).

Three additional plots were placed at the side of the field in Lelystad. These plots were subjected to a shade treatment that reduced 50% of the light intensity (N2S). The shade was achieved via shade covers. The plots were located at the side of the field to prevent the shade covers from affecting nearby plots. The shade covers were placed a few days after tuber initiation on the 17th of June in 2019 and the 15th of June in 2020.

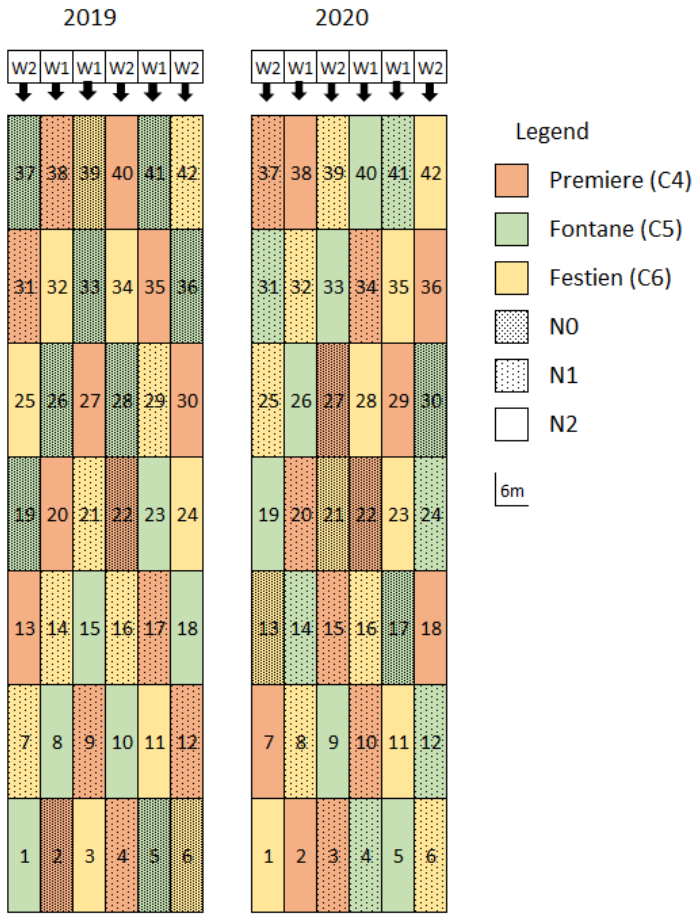

Figure 1: The experimental set-up in Vredepeel in 2019 (left) and 2020 (right).

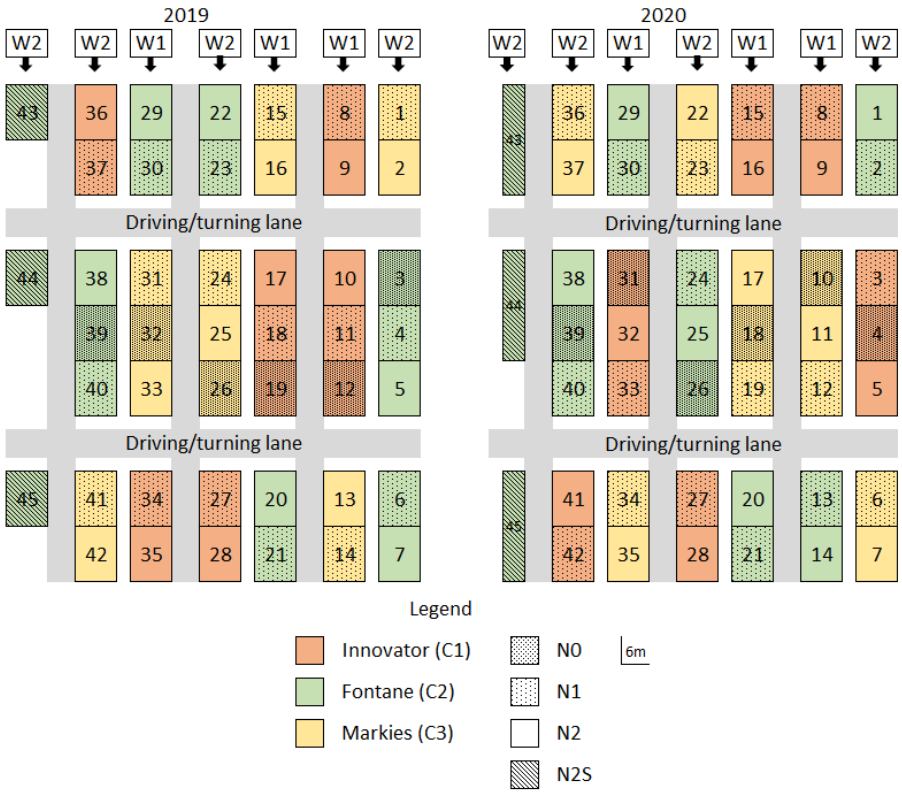

Figure 2: The experimental set-up in Lelystad in 2019 (left) and 2020 (right).

The width and length of the shadow treatment plot differed between the years. In 2019 the plots were 9 by 12m and in 2020 4.5 by 24 m. This was due to the width of the individual covers (4.5 by 4.5 m). Having plots of 9 m wide meant that people had to step through the plot to remove the shade cover for spraying and fertilization. This proved to be impractical as people tripped over the ridges while removing the covers. Therefore, we adjusted the size of these plots during the 2020 to the width of one shade cover. This way, the covers could be removed while standing on the flat ground of the driving lanes.

At the end of the season, any remaining haulm was killed using 2 l ha^{-1} Reglone (see Table 3 for dates). Prior to this date some of the treatments had already reached maturity. These were all treatments with the cultivars 'Innovator' and 'Premiere' as well as the N2 treatments with the cultivar 'Fontane' and 'Markies' during the 2020 season. For the other plots the plants had to be haulm killed.

Combined, the different cultivars, nitrogen, irrigation and shade cover options resulted in 19 treatments in Lelystad and 18 treatments in Vredepeel.

Crop protection, growth regulation and weeding were performed according to conventional farming practices in the Netherlands. Diseases and weeds were managed using a variety of crop protection products. Prior to planting, seed tubers were treated with Moncereen to prevent diseases Rhizoctonia (*Rhizoctonia* sp.) and silver scurf (*Helminthosporium solani*). To prevent weeds, a mix of the herbicides Boxer (3 l ha^{-1}), Challenge (1.5 l ha^{-1}) and Proman (2 l ha^{-1}) were used to treat weeds just after planting. Throughout the season weeds were removed either by hand or mechanically.

Diseases forming the highest risk for the potatoes in these experiments were Phytophthora (*Phytophthora infestans*) and early blight disease (*Alternaria solani*). The cultivar 'Markies' was particularly sensitive to early blight (Table 1), therefore 0.5 l ha^{-1} Narita was sprayed in Lelystad to prevent further development of early blight disease by first sightings of the disease on leaves, in both years mainly end of June until the end of July. Additionally, fungicides were sprayed throughout the season to prevent infestations of Phytophthora when the risk was highest with high humidity and high temperatures. This was from the end of June till mid-July These fungicides were either a mix of 0.4 l ha^{-1} Revus, 0.5 l ha^{-1} Wetcit and 0.25 l ha^{-1} Gazelle, or a mix of 0.5 l ha^{-1} Zorvec Enicade and 0.3 l ha^{-1} Gachink or 0.5 l ha^{-1} Ranman Top.

3 MEASUREMENTS

A multitude of measurements were taken through the season, which can be divided into three groups: non-destructive, destructive and passive measurements. Dedicated areas were set up in each plot for the destructive and non-destructive measurements in order to prevent border effects, see appendix A for the exact layouts. Unless stated otherwise, measurements were taken on all plots.

3.1 NON-DESTRUCTIVE MEASUREMENTS

As the name implies, the non-destructive group contains all measurements taken that were non-destructive. These were Soil Plant Analysis Development (SPAD), plant height, groundwater level, soil penetration resistance and photosynthesis. See Table 5 for the timing of these measurements.

SPAD, plant height and groundwater level measurement were taken throughout the season from emergence till maturity or haulm killing, whichever came first. The plant height of the plants was measured compared to the field level (which lies in the middle between top and bottom of the ridge). SPAD values were measured with a SPAD-520 on all leaves of the fifth newest leaf of the plant. Per plot at least four plants were measured.

Table 5: Timing of non-destructive measurements.

Measurement	**Lelystad**		**Vredepeel**	
	2019	**2020**	**2019**	**2020**
Height, SPAD, groundwater and groundcover*	7 May 12 June 20 June 8 July 22 July 5 August 18 August 2 September 17 September 30 September	8 June 21 June 13 July 3 August 17 August 7 September 14 September 22 September	23 May 29 June 4 June 17 June 1 July 15 July 29 July 12 August 26 August 10 September 23 September	2 June 15 June 29 June 6 July 20 July 27 July 24 August 31 August 10 September
Photosynthesis	17 July 18 July	23 July 10 August	3 August 10 August	22 July 11 August
Reflection	14 June 25 June 9 July 23 July 6 August 20 August 3 September	10 June 24 June 22 July 5 August 1 September 17 September	23 May 20 June 3 July 17 July 13 August 27 August	3 June 17 June 1 July 29 July 12 August 25 August 8 September
Soil penetration resistance	-	6 May	-	29 April

* Groundcover in 2019 only

Groundwater levels were measured relative to field level at four locations in the field using groundwater monitoring wells with a depth of 2 m. During the 2019 season estimations of groundcover were done visually throughout the season. During 2020 these groundcover measurements were discarded in favour of using reflection data to estimate groundcover. Reflection measurements during 2020 were done with a Tec 5 sensor. Measurements were taken during both years with a frequency of every other week. Measurements were taken on ten plants per plot.

Soil penetration resistance was measured using a penetrologger from Eijkelkamp. The penetrologger measures the force needed to penetrate the soil from topsoil to a depth of 80 cm and includes GPS coordinates of the measurements. It was measured for three points in every plot following a zig-zag pattern throughout the field. Soil penetration resistance was measured only in 2020, both in Vredepeel and in Lelystad.

Lastly, non-destructive photosynthesis measurements were taken by making light response curves with a LICOR 6400 at ambient CO_2 concentrations. PAR intensities used were 0, 50, 100, 150, 200, 250, 500, 100, 1500, 2000 and 2300/2500 W m^{-2}. Between three and seven plants per plot were measured. Photosynthesis measurements were taken infrequently (Table 5) and only for limited treatments. During the 2019 season measurements were only done for two of the N2W2 plots per cultivar. Additionally, during the 2019 night-time measurements were at a PAR intensity of 0. During 2020 measurement were only done on Fontane, but in both a W1 and a W2 plot per location.

3.2 DESTRUCTIVE MEASUREMENTS

Destructive measurements were done by harvesting plots which in turn were divided up into four to six intermediate harvests, during which above and belowground parts were harvested and one final harvest during which only belowground parts were harvested. For the timing of these measurements see table 6.

Table 6: Dates of the destructive harvests

Harvest	Lelystad		Vredepeel	
	2019	2020	2019	2020
Intermediate	6 June	8 June	4 June	2 June
	20 June	21 June	17 June	15 June
	8 July	13 July	1 July	29 June[b]
	22 July	3 August	15 July	6 July
	5 August	17 August[a]	29 July	20 July[b]
	19 September	7 September	12 August	27 July[c]
				24 August[c]
Final	31 October	17 October	10 October	19 October

a Only the aboveground parts of cv. Innovator were harvested due to severe rainfall. Other cultivars were not harvested
b Only Premiere was harvested
c Premiere was not harvested

During each intermediate harvest 12 plants were removed and the area that they occupied was measured. The fresh weight of the aboveground biomass was determined and for a subsample of aboveground biomass (between 0.5 kg and 2.5 kg of fresh weight being a minimum of 15% of the full sample) the sample was separated per plant organ (stems, leaves and reproductive parts). Both the fresh weight and the dry weight (dried for 48+ hours in a 70 °C oven) of the plant organs were determined. Prior to drying the leaf area of 200g fresh weight of leaves were measured using a LICOR 3100 area meter. These leaves were dried separately (48+ hours in a 70°C oven) to determine the specific leaf area. On the dried leaf sample, pooled per treatment, NPK analysis were performed. For this they were grounded to 1 mm size particles. The NPK samples were digested with a mixture of H_2SO_4–Se, H_2O_2 and salicylic acid. In these digests total N and P was measured spectrophotometrically with a segmented-flow system (Skalar San++ System) using the Berthelot and molybdenum blue reactions, respectively. In the same digests, K was measured with a Varian AA240FS fast sequential atomic absorption spectrometer.

For the intermediate harvests all harvested tubers were removed from the roots and were weighed. The total amount of tubers was counted. If the total weight per sample was below 5 kg then the tubers were dried in an oven (48+ hours in a 70°C oven). Otherwise, the UnderWater Weight (UWW) method (Veerman 2001) was used on a subsample of between five to eight kg fresh weight, the exact fresh weight of these tubers were recorded. Once, on the 20th of June 2019, the roots were cleaned, and their fresh and dry weight determined (via 48+ hours in a 70°C oven).

The final harvests were taken from an area of 13.5 m^2 in Vredepeel and 15 m^2 in Lelystad. During the final harvest the measurements taken on the tubers were extended, as the tubers were sorted per size (0-35, 35-45, 45-50, 50-60, 60+ mm), and the amount of non-marketable tubers (as green tubers, rotten tubers, or growth cracks) were determined, counted and weighted (fresh weight only). Tuber dry weight was measured both by oven drying (35-60 mm sized tubers at 70°C for 48+ hours) as well as via the UWW method. Lastly, an NPK analysis was performed on the tubers using the same methodology as for the leaves. Like the leaves, the tuber NPK analysis was done a pooled sample per treatment.

3.3. PASSIVE MEASUREMENTS

The passive measurements were taken by sensors. These were weather data and soil moisture data.

The weather data were obtained from local DACOM weather stations at <1 km from the experimental fields. Available data were daily minimum and maximum air temperature

(°C), windspeed (m s^{-1}), rainfall (mm) and ETo/Etref via Makkink (mm day^{-1}). For further weather information (irradiation (kJ m^{-1} day^{-1}) and humidity (%)), the nearest KNMI weather stations to the field were used. These were the Volkel KNMI weather station for the Vredepeel field and Lelystad airport for the Lelystad field.

Soil sensors were used to collect data on soil temperature (°C) and soil water potential (pF and kPa). The soil moisture and temperature data were obtained from CaTeC Soil water potential sensors which were placed in six plots per field. The six sensors were split up among the treatments as much as possible. In Lelystad they were placed in plots 7, 13, 20, 22, 30 and 36 during 2019 and 1, 9, 17, 28, 35 and 41 during 2020. In Vredepeel they were placed in plots 10, 11, 18, 25, 27 and 32 during 2019 and 2, 7, 9, 35, 40 and 42 during 2020. During the 2019 season the sensors were placed at a depth of 15 and 30 cm and during the 2020 season at a depth of 30 and 50 cm.

4 DATABASE STRUCTURE AND AVAILABILITY

Attached to the report are a set of folders. These are data, figures and scripts.

The folder 'data' contains the data described in the previous measurements section and is divided up into several files (Table 7). Where applicable, data was combined into one file. Most measurements on plot level (from the destructive and non-destructive harvests) were combined in one file. The data for photosynthesis, irrigation, reflection, soil water potential, groundwater level, NPK content and soil penetration resistance are all in separate files.

Meta data for all these files is provided in the first Excel tab called 'meta'. Meta data includes general information, a list of the treatments (i.e. irrigation level, nitrogen fertilization and cultivar) as well as an explanation of the headers used for the data itself. The second tab (called 'data') contain the data itself. The 'reflection' file contains two tabs of data called 'Data1' and 'Data2'. The 'soil water potential' file contains four tabs of data, one for each location-year combination. Through all the datafiles the same identifiers for the location of the field etc. were used. In addition to the abovementioned data files, we also included two files with weather data, one for the Lelystad location and one for the Vredepeel location. These files contain meta information on the top six rows while the rest of the file is the actual data.

The plot specific measurement taken are in units such as grams DW per sample. For convenience we have included an R script (called Plotspecific.R made in R version 4.0.3 (Team 2020) to convert these measurements in more commonly used units such as kg/ha. This script is placed in the folder 'scripts' and is the only script included. The file resulting from running this script is called 'plots_specific_processed.xlsx' and is already included in the subfolder 'processed data' within the data folder itself. The meta information for the 'plots_specific_processed.xlsx' is added as a separate file in the same location.

Lastly, the folder 'figures' contains the figures used in the publication.

Table 7: Overview of the files of the dataset.

Folder	File name	Description
Data	Groundwaterlevel.xlsx	The measured groundwater levels in cm as compared to field level.
Data	NPK.xlsx	The results for the nitrogen potassium and kalium measurements in ppm and % for the samples pooled per treatment.
Data	Penetrologger.xlsx	The data for the soil penetration resistance measurement. Measurements were taken every 2 cm.
Data	Irrigation.xlsx	The daily irrigation amount per treatment plus the daily rainfall.
Data	Photosynthesis.xlsx	The data from the photosynthesis measurements.
Data	Reflection.xlsx	All the reflection data as well as light interception data for 2020. It also contains some light interception data on the effect of the shade covering. The tab Data1 contains the reflection data and the tab Data2 contains the light interception data.
Data	Waterpotential.xlsx	The data generated by the soil potential sensors. Only 12 sensors per location could be used. Meta information is in the first tab and the other tabs contain the data separated by year and location.
Data	Weatherfile_lelystad.xlsx	The weather data for the Lelystad field. Meta information is in the top nine rows of the datafile instead as a separate tab.
Data	Weatherfile_vredepeel.xlsx	The weather data for the Vredepeel field. Meta information is in the top nine rows of the datafile instead as a separate tab.
Data	Plotspecific_raw.xlsx	Data for most of the plot specific measurements. The file contains three tabs, one containing meta data, one containing data from 2019 and one containing data from 2020.
Data > Processed Data	Plotspecific_processed.cvs	Processed data from the Plotspecific_raw.xlsx as achieved with Plotspecific.R. Meta data is not included in the file but can be found in the separate file 'Plotspecific_processed_meta.xlsx'.
Scripts	Plotspecific_processed_meta .xlsx	The meta data for the 'plotspecific_processed.cvs' File. This file is in in the folder 'processed data'.
Figures	Plotlayout.xlsx	Excel file consisting of the figures included in this report.

AUTHOR CONTRIBUTIONS

All authors contributed to the design and execution of the research as well as editing of the manuscript. T.t.D. and I.v.d.W. contributed to writing the manuscript.

ACKNOWLEDGEMENTS

We wish to thank Bert Rijk his assistance in setting up the experiments and data collection. We also thank Willem van Geel and Johannes Schra from WUR Open Teelten Lelystad for their help with the Lelystad field and Marc Kroonen, Harry Verstegen, and Jos van Meijel from WPR Open Teelten Vredepeel for their help with the Vredepeel field. Additionally, we wish to thank Bert Meurs and Frank Hollewand for collecting the reflection and light

interception data, and Wilma Jans and Bart Kruijt for the use of the LICOR-6400. We also wish to thank Suzanne Brouwer, Reneé Beurskens and Yongbo Song for their help during their thesis / internship. Lastly we wish to thank our co-workers at PPS for their help with the field work. This publication is part of the project Potato Gap NL (project number 16891) of the research programme Holland Innovative Potato which is (partly) financed by the Dutch Research Council (NWO). In addition, it received direct funding from Holland Innovative Potato, the Netherlands.

REFERENCES

Berghuijs, H.N.C., Ten Den, T., Ravensbergen, A.P.P., Van der Wiel, I, Van Evert, F.K., De Wit, A.J.W., Van Ittersum, M.K. and Reidsma, P. in prep., Strategies to Reduce Nitrogen Surpluses in Potato Crops in the Netherlands; a Modeling Approach.

Beurskens, R., 2020, Explaining Variation in Photosynthesis Rate in Potato, MSc Internship, Plant Production Systems, Wageningen University and Research.

Brouwer, S., 2020, Calibration of Wofost by Using Experimental Data to Simulate Potential Production of Five Dutch Potato Cultivars, Msc thesis, Plant Production Systems, Wageningen University & Research.

handboekbodemenbemesting.nl, 2019, Aardappel". url: (https://www.handboekbodemenbemesting.nl/nl/handboekbodemenbemesting/handeling/bemesting/stikstof/aardappel.htm).

Prikaziuk, E., Ntakos, G., Ten Den, T., Reidsma, P., van der Wal, T. and van der Tol, C., 2022, Using the Scope Model for Potato Growth, Productivity and Yield Monitoring under Different Levels of Nitrogen Fertilization, International Journal of Applied Earth Observation and Geoinformation 114:102997. doi: https://doi.org/10.1016/j.jag.2022.102997.

Song, Y., 2020, The Varying Drought Response of Ware Potato Cultivars in the Netherlands: How Cultivar and Level of Irrigation Affect the Physiological Traits of Potato Plants, MSc Internship, Plant Production Systems, Wageningen University & Research.

R Core Team, 2020, R: A Language and Environment for Statistical Computing, Vienna, Austria: R Foundation for Statistical Computing. url: https://www.R-project.org/

ten Den, T., van de Wiel, I., De Wit, A.J.W., van Evert, F.K., van Ittersum, M.K. and Reidsma, P., 2022a, Modelling Potential Potato Yields: Accounting for Experimental Differences in Modern Cultivars, European journal of agronomy 137:126510. doi: https://doi.org/10.1016/j.eja.2022.126510.

ten Den, T., van de Wiel, I., van Ittersum, M.K., de Wit, A.J.W., van Evert, F.K. and Reidsma, P., 2022b, Capturing Cultivar Differences in Water-Limited Yield Potential of Potato in the Netherlands Via Experimentation and Modelling, Pp. 288-88 in XVII Congress of the European Society for Agronomy (ESA 2022): ESA European Society for Agronomy. url: https://edepot.wur.nl/586348.

Veerman, A., 2001, Variatie in Knolkwaliteit Tussen En Binnen Partijen Van Consumptie-aardappelrassen. url: https://edepot.wur.nl/121260.

APPENDIX A

Figure A1: Layout of the measurements per plot in Lelystad. On the right the layout for the shadow plots during 2020 and on the left the layout for all other plots during both 2019 and 2020. T1 till T6 stand for intermediate harvests while final indicates the final harvest.

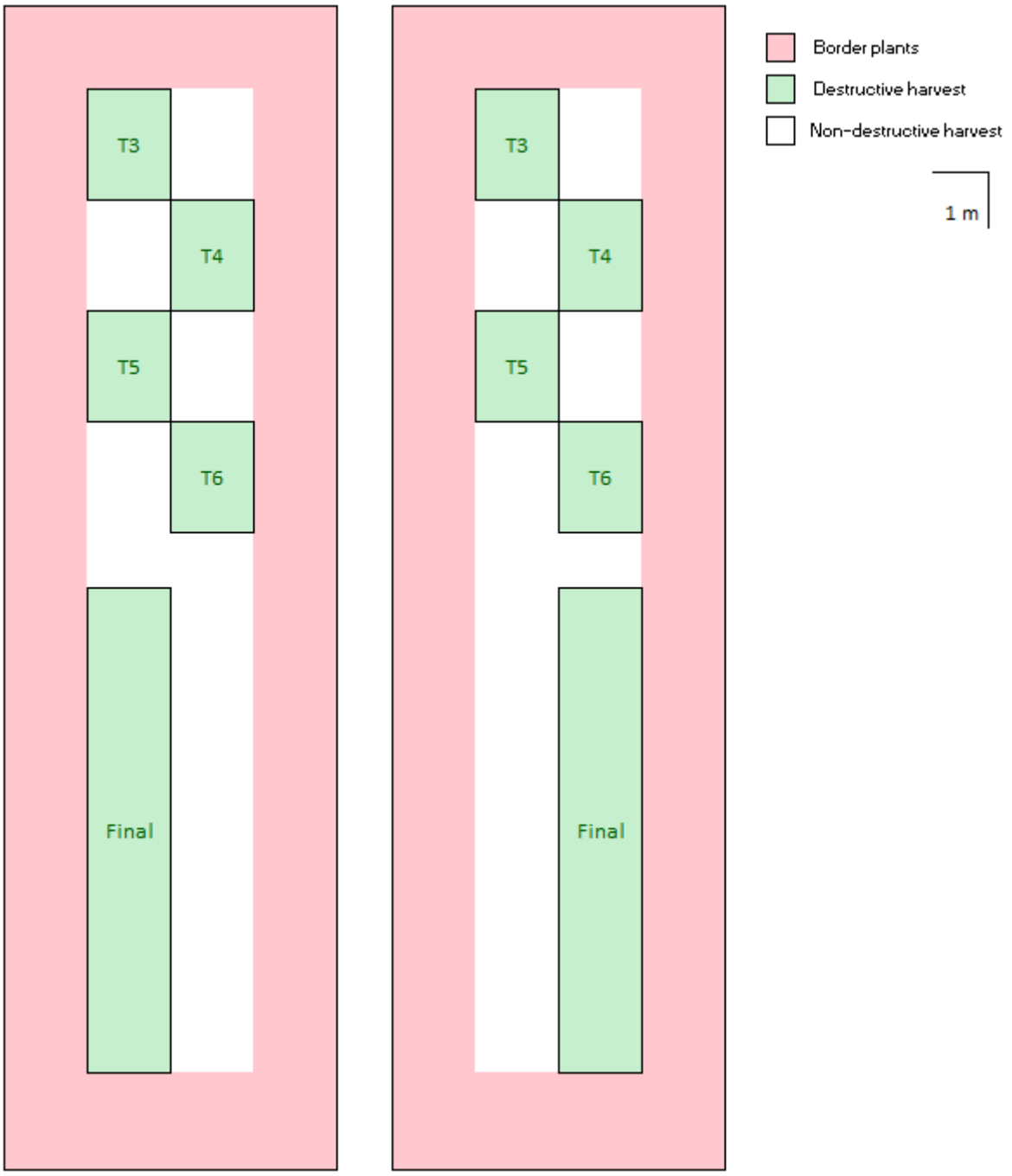

Figure A2: Layout of the measurements per plot in Vredepeel in both 2019 and 2020. T1 till T6 stand for intermediate harvests while final indicates the final harvest. The difference in plots is due to tractor tracks: if a track is on the left of a plot, then the right layout is used (plots 2, 6, 8, 12, 14, 18, 20, 24, 26, 30, 32, 36, 38, 42), otherwise the standard layout is used (on the left).