Test of P2L liquid fertilizer in dwarf French bean (Phaseolus Vulgaris L.)

Report of a trial in 2017 on a clay soil in The Netherlands

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business unit Applied Arable and Vegetable Research

This study was carried out by the Wageningen Research Foundation (WR), business unit Applied Arable and Vegetable Research and was commissioned and financed by Agri Advice.

WR is part of Wageningen University & Research, the collaboration of Wageningen University and Wageningen Research Foundation.

Wageningen, October 2017

CONFIDENTIAL

Report WPR-project 37 503 398 00

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Van Geel, W. & M. Vlaswinkel, 2017. Test of P2L liquid fertilizer in dwarf French bean (*Phaseolus Vulgaris* L.). Report of a trial in 2017 on a clay soil in The Netherlands. Wageningen Research, Confidential Report WPR-project 37 503 398 00.

Confidential Report WPR-project 37 503 398 00.

Research commissioned and funded by:

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Belgium

Contents

Summary

The Argentinian company F2L Fertilizantes developed the liquid fertilizers N2L and P2L. N2L can be used as a nitrogen fertilizer and P2L as a phosphorus fertilizer. The advice agency Agri Advice wants to organize the production, sales and distribution of these fertilizers for Fertilizantes F2L in Europe and requested Wageningen University & Research (WUR), business unit Arable Farming and Vegetable Research (AFVR) to execute trials with these products in The Netherlands. Agri Advice expects that with N2L and P2L much lower nitrogen and phosphorus rates will be sufficient in relation to the common nitrogen and phosphate fertilizers that are used in practice, while maintaining crop yield and quality.
Agri Advice insisted to compare the fertilizers at the same fertilizer dosages, based on the idea that:

- a dose of 100 litres N2L (8% and 9% S N) will be equal to a dose of 100 kilogrammes Calcium Ammonia Nitrate (CAN; 27% N);
- a dose of 100 litres P2L (2.8% N, 9% P_2O_5 and 1.3% S) will be equal to a dose of 100 kg triple superphosphate (TSP; 45% P_2O_5) or to 100 litres of ammonium polyphosphate (APP; 10% N and 34% P_2O_5 or 11% N and 37% P_2O_5).

This is an unusual design as besides type of fertilizer, crop growth responds to N rate and P rate. Therefore, different fertilizers are as a rule compared at the same N rate or P rate.
The trials were set up according to the explicit request of Agri Advice. In each trial the fertilizers were compared at three equal fertilizer doses. In this report a trial with dwarf French bean (*Phaseolus Vulgaris* L.) in 2017 is documented.

The trial with dwarf French bean was conducted on a young marine clay soil in the southwest of The Netherlands. P2L was compared to APP at fertilizer doses of 21, 50 and 100 L per ha. Also, an untreated object was included (no phosphate fertilizer). The fertilizers were applied by band application when the beans were sown and injected at both sides of the seed rows. Differences between the treatments for the N-rates applied with P2L and APP were compensated for by additional rates of nitrogen with CAN to insure all treatments got the same amount of nitrogen. The sulphate supply by P2L was negligible and not compensated for at the other treatments.
The beans were sown mid of May and harvested in the first week of August. Crop protection and weed control were carried out according to farmers practice. Irrigation of the crop was not necessary due to ample sufficient rainfall.
The number of plants was counted per plot and crop development was judged five times in June and July. After harvest, gross yield of the beans, tare, nett yield, marketable yield, number of beans and seed percentage of the thickest beans were determined. The data were statistically analysed using the software package Genstat.

The number of plants that emerged was not significantly affected by the fertilizer treatments.
In June the application of APP resulted in a better crop development than the application of P2L. In July this difference disappeared. At 10th July a fertilizer dose of 50 and 100 L/ha led to a better crop development than a dose of 21 L/ha. However, the effect of dosage disappeared later on in July. Finally, the dose of 21 L/ha resulted in the highest yield and highest number of beans. This may be due to the very wet weather circumstances in July, that may have reduced the legume formation of the crop that was initially better developed. P2L should also be examined in a dry growing season to judge the fertilizer.
In this trial P2L performed as well as APP, regarding yield and number of beans, at an almost five times lower P_2O_5-rate. So, P2L looks a promising phosphate fertilizer that can be applied in various crops with a high phosphate demand. Final judgement of P2L must be based upon the result of more trials.

1 Introduction

The Argentinian company F2L Fertilizantes developed the liquid fertilizers N2L and P2L. N2L can be used as a nitrogen fertilizer and P2L as a phosphorus fertilizer. According to the F2L Fertilizantes considerable nutrient savings can be achieved (50% or more) by application of these fertilizers in relation to the current, most common N and P fertilizers. On its website[1] F2L Fertilizantes cites various results of tests that are performed by the Argentinian Instituto Nacional de Tecnologia Agropecuaria (INTA).
The advice agency Agri Advice wants to organize the production, sales and distribution of these fertilizers for Fertilizantes F2L in Europe. For that, Agri Advice first want to test the products in agronomic field trials with different crops in The Netherlands, Belgium and France. Agri Advice requested Wageningen University & Research (WUR), business unit Arable Farming and Vegetable Research (AFVR) to execute the trials in The Netherlands.

Agri Advice expects that also in Europe with N2L and P2L much lower nitrogen and phosphorus rates will be sufficient in relation to the common nitrogen and phosphate fertilizers that are used in practice, while maintaining crop yield and quality. The idea is that:

- a dose of 100 litres N2L (8% and 9% S N) will be equal to a dose of 100 kilogrammes Calcium Ammonia Nitrate (CAN; 27% N);
- a dose of 100 litres P2L (2.8% N, 9% P_2O_5 and 1.3% S) will be equal to a dose of 100 kg triple superphosphate (TSP; 45% P_2O_5) or to 100 litres of ammonium polyphosphate (APP; 10% N and 34% P_2O_5 or 11% N and 37% P_2O_5).

The research question of Agri Advice is to examine this expectation in field trials under the Dutch growing conditions and to compare N2L and P2L to standard fertilizers. The standard N fertilizer in Netherlands is CAN. The value of other nitrogen fertilizers is expressed relatively to CAN. Triple superphosphate (TSP) is the most common P fertilizer. In case of band application of phosphate often NP-fertilizers are used. There are several products on the market for this and there is not really a standard fertilizer. However, worldwide APP is a commonly used fertilizer.

Agri Advice insisted to compare the fertilizers at the same fertilizer dose, which is unusual. As, besides type of fertilizer, crop growth responds to N rate and P rate, different fertilizers are as a rule compared at the same N rate or P rate. To examine the replacement value of one fertilizer to another a range of equal N or P rates for both fertilizers is used in trials.
AFVR carried out four field trials in 2017 in which N2L and P2L were tested in potato and besides P2L was tested in dwarf French bean (*Phaseolus Vulgaris* L.). The trials were set up according to the explicit request of Agri Advice. In each trial the fertilizers were compared at three equal fertilizer doses.

The implementation and results of the 2017 trial with dwarf French bean is documented in this report. Dwarf French bean has a high phosphate need. Phosphate stimulates root development and flowering. More flowers can result in more legumes and a higher yield.
The treatments, experimental design and implementation or the trial are described in chapter two. The results are presented in chapter three and they are discussed in chapter four.

[1] http://f2lfertilizantes.com

2 Materials and methods

The trial with dwarf French bean was conducted on a young marine clay soil at the research site Westmaas of AFVR in the southwest of The Netherlands. A soil fertility analyses of the trial field is presented in Annex 1.

2.1 Treatments

P2L was compared to APP 10-34. The composition of both fertilizers is presented in Table 1. Also, an untreated object was included as control (no phosphate fertilizer). The fertilizers were applied by band application when the beans were sown and injected at both sides of the seed rows at a distance of 5-6 centimeters beside the row and 4 centimeters deeper than sowing depth. Dwarf French bean responds better to band application than to broadcast application of phosphate fertilizer.
The applied rates of the fertilizers are mentioned in table 2. Differences between the treatments for the N-rates applied with P2L and APP, were compensated for by additional rates of nitrogen, broadcast applied with CAN just after sowing, to insure all treatments got the same amount of nitrogen.
According to the official Dutch recommendation 120 kg N per ha should be applied.
As the plant available amount of sulphur in the soil was high, sulphate fertilization was not necessary. The sulphate supply by P2L was negligible and not compensated for at the other treatments.
The trials were set up as a randomized block design with four replicates.

Table 1 *Composition of the fertilizers*

Element	P2L	APP
N	2.9%	10%
P_2O_5	9%	34%
SO_3	1.3%	-
Density (kg/litre)	1.1	1.37

Table 2 *Treatments*

Code	Fertilizer	Dose (L/ha)	P_2O_5-rate (kg/ha)	N-rate (kg/ha)	Additional N-rate with CAN (kg/ha)
A	None	0	0	0	120
B	P2L	21	2	1	119
C	P2L	50	5	2	118
D	P2L	100	10	3	117
E	APP 10-34	21	10	3	117
F	APP 10-34	50	23	7	113
G	APP 10-34	100	47	14	106

2.2 Implementation of the trial

Previous crop in 2016:	winter wheat followed by white mustard as a green manure
Soil mineral N before sowing:	31 kg N ha^{-1} in soil layer 0-30 cm measured on 1-5-2017
Soil tillage and sowing:	seed bed preparation with a rotary tiller and sowing of the beans on 15-5-2017
Row distance:	50 cm
Sowing depth:	2-3 cm
Variety:	Faraday
Emergence:	23th May
Weed control:	spraying herbcides on 17th May and 31th May hand weeding on 16th June
Crop protection:	spraying fungicides on 4th July and 18th July
Harvest:	on 7-8-2017 with a bean harvester
Plot size (m)	
- gross size:	10 m x 6 m
- net size (harvested area):	7 m x 1.5 m

Crop protection and weed control were carried out according to farmers practice. Irrigation of the crop was not necessary due to ample sufficient rainfall.

The intention was to harvest when the thickest beans had reached a seed percentage of 12-15% (seed weight/total legume weight). The seed percentage is a criterion for ripeness of the beans, that is used to determine the moment of harvest. An earlier harvest (<12% seed weight) gives a somewhat better bean quality but a lower yield.
At 31th July the seed weight amounted to 9%. Harvest could take place within a few days. However due to rainfall in that period the moment of harvest was delayed. At 4th August the seed weight amounted to 15%. At 7th August the weather circumstances were favourable for harvest.

The weather data of 2017 at the trial site are presented in Annex 2. The growing season was characterized by a wet summer. Especially July was a very wet month.

2.3 Observations and measurements

The numbers of plants were counted in the net plots after emergence. The crop development was judged five times in June and July by a report mark (0-10).
After harvest, gross yield of beans per plot was weighed. Samples of 1 kg per plot were taken to determine tare and the amount of marketable and non-marketable beans. The samples were cleaned by removing leaf and stem parts and other pollutions (tare), after which net weight was determined. The number of beans was calculated from the net yield and the average bean weight. The non-marketable beans were separated: rotten beans, broken beans, too crooked beans and too small beans (<5 mm of diameter). Of the marketable yield 20 thick beans per plot were taken to determine the seed percentage.

The data were statistically analysed using the software package Genstat. Analysis of variance (ANOVA) was performed on the data. The next effects were distinguished: the effect of P-fertilization average for all treatments versus no P-fertilization (control) and within P-fertilization the main effect of fertilizer type, the main effect of dosage and the interaction effect between fertilizer and dosage. The probabilities of the F-test (F pr.) are represented if F pr.<0.10. Otherwise it is indicated as n.s. (not significant).
Object means are presented supplied with letters that indicate significant differences according to the Students t-test at probability 0.05. Means without a common letter are significantly different according to the t-test (P<0.05).

3 Results

3.1 Crop development

The number of plants that emerged was not significantly affected by the fertilizer treatments. At average there were 33 plants per m^2 at the trial field.
The judgement of the crop development is presented in the Tables 3 to 7. Plots were rated higher when the crop was better developed and the plants were taller.

At mid-June and the end of June the APP-applications resulted in a better crop development than the P2-applications (Tables 3 and 4). De crop development at the P2L-applications was hardly (and not significant) better than that of the control (no P-fertilization).
From end of June onwards, the crop started flowering. No differences between the treatments in earliness of flowering were obeserved.
On 10th July the backlog of the P2L-fertilized crop had disappeared and crop development at P2L and APP remained equal till harvest (Table 5). There was also an effect of dosage: a better crop development at 50 and 100 L/ha than at 21 L/ha.
However on 21th and 31th July, the effect of dosage had dissapeared (Tables 6 and 7). The crop development on 21th July and 31th July of all P-fertilized treatment was on average (rate 8.0 on both dates) significant better than that of the control (rate 7.5 at 21th July and 6.8 at 31th July).

Table 3 *Judgement of the crop development at 16th June*

Dose	**Fertilizer**			**Dose on**
(L/ha)	**None**	**P2L**	**APP**	**average**
0	7.4 a b			7.4 a
21		7.5 a b	7.6 a b c	7.6 a
50		7.8 a b c	8.0 b c	7.9 a
100		7.3 a	8.3 c	7.8 a
Fertilizer on average	7.4 a	7.5 a	8.0 b	

F pr.	
Effect of P-fertilization average versus control	n.s.
Effect of fertilizer type within P-fertilization	0.034
Effect of dosage within P-fertilization	n.s.
Interaction effect fertilizer * dosage	n.s.

Table 4 *Judgement of the crop development at 26th June*

Dose (L/ha)	Fertilizer None	P2L	APP	Dose on average
0	6.8 a			6.8 a
21		7.0 a	7.8 a b	7.4 a
50		7.0 a	8.3 b	7.6 a
100		7.5 a b	8.1 b	7.8 a
Fertilizer on average	6.8 a	7.2 a	8.0 b	

F pr.	
Effect of P-fertilization average versus control	0.044
Effect of fertilizer type within P-fertilization	0.009
Effect of dosage within P-fertilization	n.s.
Interaction effect fertilizer * dosage	n.s.

Table 5 *Judgement of the crop development at 10th July*

Dose (L/ha)	Fertilizer None	P2L	APP	Dose on average
0	6.8 a			6.8 a
21		7.5 a b c	7.3 a b	7.4 a
50		7.8 b c	8.3 c	8.0 b
100		8.3 c	8.0 b c	8.1 b
Fertilizer on average	6.8 a	7.8 b	7.8 b	

F pr.	
Effect of P-fertilization average versus control	0.002
Effect of fertilizer type within P-fertilization	n.s.
Effect of dosage within P-fertilization	0.036
Interaction effect fertilizer * dosage	n.s.

Table 6 *Judgement of the crop development at 21th July*

Dose (L/ha)	Fertilizer None	P2L	APP	Dose on average
0	7.5 a			7.5 a
21		8.0 a	8.0 a	8.0 a
50		8.0 a	8.0 a	8.0 a
100		8.1 a	8.1 a	8.1 a
Fertilizer on average	7.5 a	8.0 a	8.0 a	

F pr.	
Effect of P-fertilization average versus control	0.049
Effect of fertilizer type within P-fertilization	n.s.
Effect of dosage within P-fertilization	n.s.
Interaction effect fertilizer * dosage	n.s.

Table 7 *Judgement of the crop development at 31th July*

Dose (L/ha)	Fertilizer None	P2L	APP	Dose on average
0	6,8 a			6,8 a
21		8,3 b	8,3 b	8,3 c
50		7,8 b	7,6 b	7,7 b
100		7,9 b	8,3 b	8,1 bc
Fertilizer on average	6,8 a	8,0 b	8,0 b	

F pr.	
Effect of P-fertilization average versus control	<0.001
Effect of fertilizer type within P-fertilization	n.s.
Effect of dosage within P-fertilization	n.s.
Interaction effect fertilizer * dosage	n.s.

3.2 Yield

The highest yield was obtained at the lowest dosage of both fertilizers (Tables 8 and 9). Although yield at APP was on average somewhat higher than yield at P2L, this difference was not significant.
The percentage of tare did not differ significant between the treatments. On average it amounted 1.5% of the gross yield. Also, the percentage of non-marketable beans did not differ significant between the treatments and amounted 21% of the nett yield on average in the trial.
The number of beans also did not differ significantly between P2L and APP and the highest number of beans was obtained at the lowest dosage (Table 10).
Due to the delayed harvest the seed percentage was high. There was no significant difference between P2L and APP for seed percentage. The seed percentage was lowest at the fertilizer dosage of 21 L/ha. This points to a somewhat later ripening of the beans. The effect of dosage was weakly significant.

Table 8 *Nett yield of beans (tons per ha)*

Dose (L/ha)	Fertilizer			Dose on average
	None	P2L	APP	
0	15.1 a			15.1 a
21		18.0 cd	18.7 d	18.4 c
50		17.0 bc	16.7 bc	16.8 b
100		16.3 ab	17.4 bcd	16.8 b
Fertilizer on average	15,1 a	17,1 b	17,6 b	

F pr.	
Effect of P-fertilization average versus control	0.001
Effect of fertilizer type within P-fertilization	n.s.
Effect of dosage within P-fertilization	0.016
Interaction effect fertilizer * dosage	n.s.

Table 9 *Marketable yield of beans (tons per ha)*

Dose (L/ha)	Fertilizer			Dose on average
	None	P2L	APP	
0	11,7 a			11,7 a
21		14,6 bc	15,4 c	15,0 c
50		13,6 abc	13,3 ab	13,4 b
100		12,7 ab	14,1 bc	13,4 b
Fertilizer on average	11,7 a	13,6 b	14,2 b	

F pr.	
Effect of P-fertilization average versus control	0.009
Effect of fertilizer type within P-fertilization	n.s.
Effect of dosage within P-fertilization	0.043
Interaction effect fertilizer * dosage	n.s.

Table 10 *Number of beans per m^2*

Dose (L/ha)	Fertilizer			Dose on average
	None	P2L	APP	
0	518 a			518 a
21		617 c	615 bc	616 b
50		542 a	558 ab	550 a
100		560 abc	567 abc	563 a
Fertilizer on average	518 a	573 b	580 b	

F pr.	
Effect of P-fertilization average versus control	0.013
Effect of fertilizer type within P-fertilization	n.s.
Effect of dosage within P-fertilization	0.009
Interaction effect fertilizer * dosage	n.s.

Table 11 *Seed percentage of the thickest beans*

Dose (L/ha)	Fertilizer			Dose on average
	None	P2L	APP	
0	26% ab			26% ab
21		23% a	25% ab	24% a
50		29% b	26% ab	27% b
100		26% ab	26% ab	26% ab
Fertilizer on average	26% a	26% a	26% a	

F pr.	
Effect of P-fertilization average versus control	n.s.
Effect of fertilizer type within P-fertilization	n.s.
Effect of dosage within P-fertilization	0.076
Interaction effect fertilizer * dosage	n.s.

4 Discussion

In June the application of APP resulted in a better crop development than the application of P2L. In July this difference disappeared. It is unknown why crop development at P2L initially lagged behind, but it is an aspect to examine in next trials.
At 10th July a fertilizer dose of 50 and 100 L/ha led to a better crop development than a dose of 21 L/ha. However, the effect of dosage disappeared later on in July. Finally, the dose of 21 L/ha resulted in the highest yield and highest number of beans. This may be due to the very wet weather circumstances in July, causing a high pressure of fungous diseases, especially of grey mould (*Botrytis cinerea*). A high humidity and a luxuriant crop development stimulates grey mould. Maybe this had a negative effect on the legume formation of the crop that was initially better developed. This would mean than in a dry growing season another result can be expected.
In general, the performance of fertilizers is affected by growth circumstances such as weather conditions and soil type. Therefore, fertilizers must be examined in different years and on different soil types to judge them.
The delayed harvest will have increased the yield but decreased the quality of the beans. The seed percentage was high and a part of the beans will have been overripe.

P2L performed as well as APP, regarding the harvest result, at an almost five times lower P_2O_5-rate. The lowest fertilizer dose gave the best result in this trial and this was only 2 kg P_2O_5 per ha for P2L. In a next trial APP could be included at rates of 2 and 5 kg P_2O_5 per ha as well, to compare the performance of the fertilizers at the same P_2O_5-rates for determining the value of P2L compared to APP.
So, P2L looks a promising phosphate fertilizer that can be applied in various crops with a high phosphate demand. Final judgement of P2L can be done based upon the results of more trials.

Annex 1 Soil fertility of the trial field

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Fertilization Manager
Arable land
2B ZW 5192

Your client number is: 6025935

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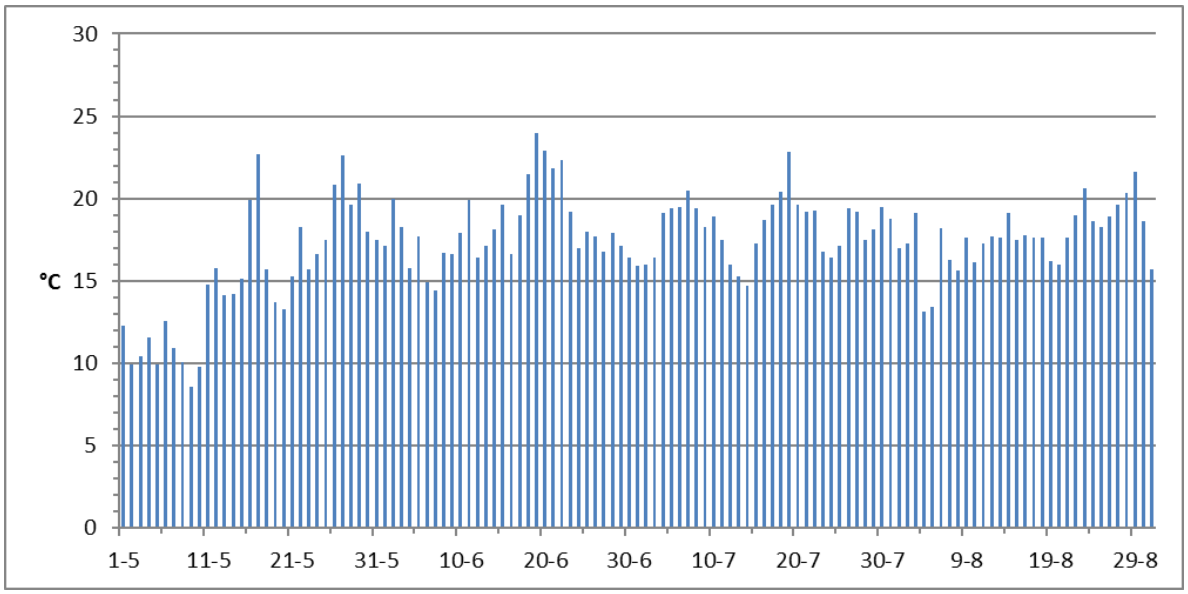
Copy

Analysis	Investigation/ordernr:	Date sampling:	Date report:	Grant issued by:
	757587/004076685	01-05-2017	13-10-2017	Eurofins Agro, Kortingsregeling Postbus 170, 6700 AD WAGENINGEN

Results		Unit	Result	Avg.*	Target value	low	rath.low	good	rath.high	high
macro nutrient	Nitrogen	mg N/kg	1360							
	C/N ratio		10	12	13 - 17					
	N-supplying capacity	kg N/ha	73	72	93 - 147					
	S-available	kg S/ha	17		5 - 9					
	Sulphur	mg S/kg	240							
	C/S ratio		55		50 - 75					
	S-supplying capacity	kg S/ha	13	44	20 - 30					
	P-available (P-PAE)	mg P/kg	1,8	1,7	1,0 - 2,4					
	P-stock (P-Al)	mg P_2O_5/100 g	73	54	27 - 47					
	Pw	mg P_2O_5/l	41							
	K-available (K-PAE)	mg K/kg	109		70 - 110					
	K-stock	mmol+/kg	4,2		3,5 - 4,8					
	Ca-available	kg Ca/ha	321		222 - 519					
	Total Ca stock	kg Ca/ha	9390		7655 - 11485					
	Mg-available	mg Mg/kg	51	65	50 - 85					
	Mg-stock	mmol+/kg	7,2		8,1 - 16,1					
	Na-available	mg Na/kg	8	20	35 - 50					
	Na-stock	mmol+/kg	0,6							
physical	Acidity (pH)		7,3	7,4	> 6,4					
	C-organic	%	1,3							
	Organic matter	%	2,6	3,4						
	C-inorganic	%	0,99							
	Carbonate lime	%	7,4	6,1	2,0 - 3,0					
	Clay	%	18	17						
	Silt	%	33							
	Sand	%	39							
	Clay-humus (CEC)	mmol+/kg	164	165	> 123					
	CEC-saturation	%	100	89	> 95					
biological	Soil life	mg N/kg	31		60 - 80					

Annex 2 Weather data

Average daily temperatures at the research site Westmaas

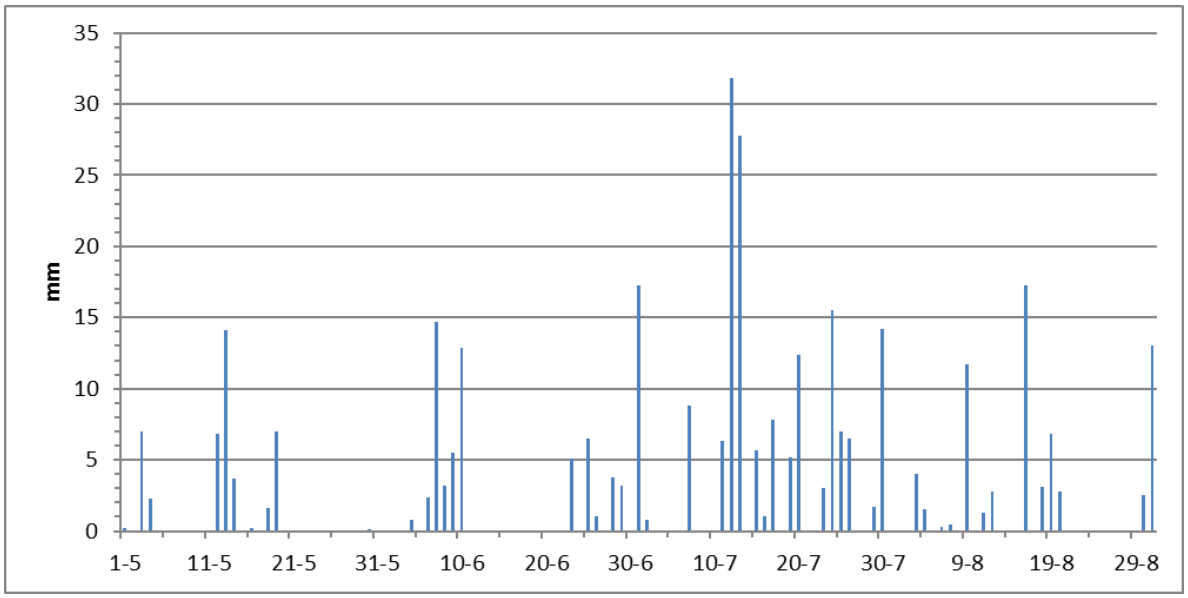


Average temperature (°C) per decade of days and normal temperatures[1]

Decade	May		June		July		August	
1	10.6	(11.7)	16.9	(15.1)	18.3	(17.4)	16.4	(18.3)
2	15.9	(13.2)	19.5	(15.2)	18.2	(17.7)	17.4	(17.9)
3	18.4	(13.7)	18.4	(16.2)	18.3	(18.3)	19.0	(16.7)

[1] Normal temperatures (average of 1981-2010) are displayed between brackets

Daily sum of precipitation at the research site Westmaas



Sum of precipitation (millimeters) per decade of days and normal precipitation[1]

Decade	May		June		July		August	
1	9.5	(17.8)	39.5	(26.4)	26.9	(26.7)	18.0	(22.3)
2	33.4	(16.4)	0.0	(19.6)	98.0	(25.0)	34.1	(22.4)
3	0.1	(21.7)	19.6	(21.4)	47.9	(26.9)	15.5	(34.4)

[1] Normal precipitation (average of 1981-2010) are displayed between brackets

To explore the potential of nature to improve the quality of life

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Rapport 37 503 398 00

The mission of Wageningen University and Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 5,000 employees and 10,000 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.