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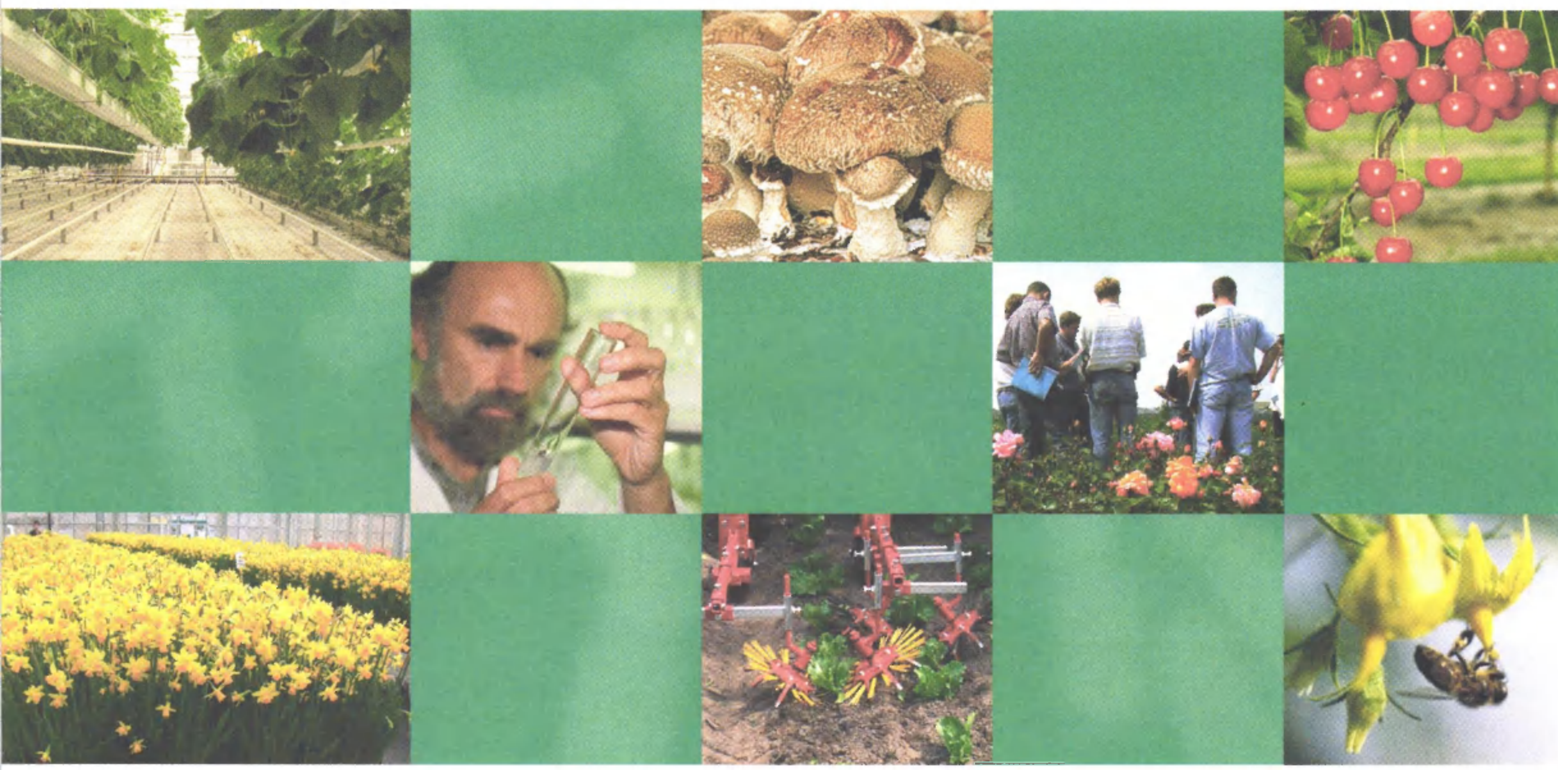
P.J. van Leeuwen, T. Aendekerk and J.P.T. Trompert



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1 Introduction

Bara Mineraler produces several clay products that can be added to potting soil. Addition of these products can have positive effects on plant nutrition. The clay complex absorbs several elements. These minerals can be taken up by the plants during growth. Besides clay granulate for this use, Bara produces Baralith Oxywet, clay powder. Mixing of this clay powder with the peaty potting soil results in an increased capillarity rise.
Aim of this study is to quantify the benefits of Bara clay and Baralith Oxywet compared to other clay products on the growth of Begonia.

2 Materials and methods

Plants were grown on potting soil to which different types of clay were added. During the growing period the plants received fertilizers every time they were watered. Start of the flowering period is indicated as the consumers phase. From that moment on the plants only received water without additional fertilizers. It was expected that the benefits of the Bara clay would show on the growth, flowering and rooting of the plants during the flowering period. The experiment ended at the end of the flowering period.

For this research Begonia Berseba Red is used. Rooted cuttings were planted on August 21st 2007 in several potting soil mixtures.
The potting soil was made by mixing 40 liter Malmbeck peat with 40 liter Storemosse peat. To this mixture 320 gram limestone (calciumcarbonate) and 120 gram PG-mix (12+14+24) were added. To this potting soil several clay products were added (Table 1).

Table 1. Composition of the different potting mixtures

Treatment	Code	Type of product added	Quantity
1	White	Wiemermix	8 kg/ 80 liter
2	Yellow	Hortiklei	8 kg/ 80 liter
3	Blue	Florisol	8 kg/ 80 liter
4	Pink	Bara clay 0-2,8 mm	8 kg/ 80 liter
5	Green	Bara clay buffered*	8 kg/ 80 liter
6	Red	Bara clay + Oxywet	3,2 kg/ 80 liter clay + 0,48 kg / 80 liter oxywet

*) Buffered clay = clay loaded with element before experiment started.
The clay of treatment 5 was loaded by adding 50 ml of fluid A and 10 ml of fluid B to 1 kg of Bara clay.

Each treatment was placed on an ebb and flood table. Per table 12 pots were used for measurement. More pots were used to fill the tables. The experiment was executed in two-fold. A map of the treatments in the greenhouse is shown in Appendix 1.

The plants were watered as needed, which was generally two times per week. Plants were watered during 15 minutes of flood. During flood the water stands 2,5 cm high. The pots are 12 cm high.
From planting August 21st until August 26th the plants did not receive any additional nutrition. From August 26th until October 11th the plants were watered with solution nr 1 (Appendix 2) and from October 11th until the start of the consumers phase (November 9th) they were watered with solution nr 2 (Appendix 2).
From the start of the consumers phase all plants were watered with plain rainwater with EC of 0,44 mS/cm.

The plants were given a natural day length from planting August 21st until October 8th. From October 8th until beginning of flowering (November 9th) the plants were given additional assimilation light from 17.00 to 20.00 h.
The greenhouse was heated to 18°C and windows started to open at 20°C. The shading screen was closed when more than 250 W/m^2 light was received in order to prevent sun burn.

Measurements

1. Nutrient solution in week 33, 40, 42 and 45. Week 33 and 40 were the beginning and end of the first nutrient solution. Week 42 and 45 were the beginning and end of the second nutrient solution before the consumers phase.
2. Nutrients in potting soil in week 35 (start of growth), 40 (end of first nutrient solution), 45 (start of flowering) and 9 (end of flowering).
3. CEC (cation exchange capacity) September 14th and November 11th.
4. Moisture content and EC of the pots.
5. Date of beginning of flowering and length and diameter of plant at beginning of flowering.
6. Condition of roots at beginning of consumers phase and at the end of the experiment.
7. Flower index during flowering.
8. Number of flower branches and number of flower branches with flowers, at the end of the experiment.

Experimental data were statistically analyzed with variance analysis using the GENSTAT program (10th edition). When results are presented in tables the Least Significant Difference (LSD) is indicated. When the difference between two numbers is bigger than the LSD then the difference is significant (95%).

3 Results

3.1 Beginning of flowering, date, length and diameter of plant

Beginning of flowering is defined when five open flowers per plant are present. This is the normal stage in which the plants are ready to be sold to consumers. The beginning of flowering marks the end of watering with fertilizers and the beginning of watering with plain rainwater.
On October 29th 10% of the plants had five open flowers. On November 1st is was 55% and November 5th already 81%. On November 9th it was almost 100%. This day was marked as the start of the consumers phase. One replicate of treatment 1, 2 and 3 flowered one to two days later than all the other treatments and replicates.

When the consumers phase started the length and diameter of the plant was recorded (table 2). There was no influence of the treatments on the length or diameter of the plants.

Table 2. Average length (cm) and diameter (cm) of plants at beginning of flowering.

Treatment	Length plant	Diameter plant
1 Wiemermix	26.7	31.4
2 Hortiklei	27.0	31.9
3 Florisol	27.2	31.0
4 Bara clay 0-2,8 mm	28.2	30.8
5 Bara clay buffered	28.0	31.1
6 Bara clay + Oxywet	28.3	32.4
LSD	ns*	ns*

* ns = not significant

3.2 Rooting of the plants

At two times during the experiment the quality and quantity of the roots was recorded by giving a root index (table 3). At the beginning of the flowering a root index was given from 1 to 5 (1= no/poor rooting and 5 = excellent rooting). At the end of the experiment a root index was given from 1 to 10 (1= no/poor rooting and 10= excellent rooting).

Root index at beginning of flowering

The roots of treatment 5 (Bara clay buffered) were not as good as the roots of most other treatments. There were mainly roots in the bottom part of the pot whereas the other pots had roots almost to the top of the pot. Treatment 2 had also a lower root index as some other treatments. The reason for this lower root index is that a substantial part of the roots at the bottom of the pot were rotten.

Table 3. Root index at beginning of flowering (5=excellent) and at the end of the flowering (10=excellent) as average per treatment.

Treatment	Root index beginning	Root index end
1 Wiemermix	4.0	6.6
2 Hortiklei	3.5	5.0
3 Florisol	4.5	6.0
4 Bara clay 0-2,8 mm	3.9	7.3
5 Bara clay buffered	3.0	6.8
6 Bara clay + Oxywet	4.5	7.3
LSD	0.72	0.47

Root index at the end of flowering
At the end of the flowering there were more differences in root quality and quantity.
The roots of treatment 4 and 6 (Bara and Oxywet) were looking the best. In these pots were the most and healthy looking roots. The root index of treatment 1 (Wiemermix) and 5 (Bara buffered) was significant lower than the index of treatment 4 and 6.
The roots in treatment 2 (Hortiklei) had the lowest index. They were partially rotten, especially visible from the bottom of the pot but also from the side of the pot. The same was observed with treatment 3 (Florisol) but to a lesser extent.
The pots of treatment 5 (Bara buffered) looked dry at the top part of the pot from half way the experiment until the end. There were no roots at the top part of the pot.

3.3 Flowering

On January 18th the flowering was examined by giving a flower index (table 4). The plants were at that moment already flowering for more than two months. There was no difference in flowering of the plants visible between treatments at January 18th.
At the end of the flowering the number of flowering branches of each pot was counted. The number of flowering branches indicates if there has been a difference in the number of flowers. At the same time the number of flowering branches with still good flowers was counted. This gives an indication of the number of flowers at the end of the experiment.
The plants of treatment 4 and 6 had more flowering branches than the plants of the other treatments. Although no differences during flowering were visible these two treatments have given more flowers than treatment 2 and 5.
There were no differences in the number of flowering flower branches.

Table 4. Average flowering index at January 18th (1=no flowers/end of flowering, 5=in full bloom), number of flower braches and number of flowering flower branches at the end of the experiment.

Treatment	Index January 18th	Flower branches	Flowering flower branches
1 Wiemermix	2.9	31.0	10.3
2 Hortiklei	2.9	30.2	9.1
3 Florisol	3.3	31.5	11.1
4 Bara clay 0-2,8 mm	3.1	34.3	11.5
5 Bara clay buffered*	3.3	28.0	8.9
6 Bara clay + Oxywet	3.2	33.8	11.6
LSD	ns	2.97	ns

3.4 Moisture content and EC of potting soil

During the growth of the plants the moisture content and EC of the potting soil were measured.
The main reason for measuring the moisture content was to maintain the necessary water content of the pots.
In week 37 the moisture content varied from 40 to 60 with an average of 48%. The EC had an average of 2,4 mS/cm. The situation was the same in week 39 with a moisture content of 46% and an EC of 2,3 mS/cm.
In week 41 the moisture content was a little lower with 39%. The EC was also lower with 1,8 mS/cm.
In week 44 the moisture content was much lower with 27% while the EC was much higher with 4,3 mS/cm. The reason for the low moisture content and high EC is the fact that the measurements were done just before watering the plants. The plants needed to be watered and therefore the EC was higher.
In week 41 the moisture content of two treatments were not only measured from the top of the pot but also 2 cm from the bottom of the pot. In the treatment with Oxywet the moisture content in de top of the pot was just as high as in the bottom of the pot (figure 1). This confirms the claim of Bara on the qualities of this product.

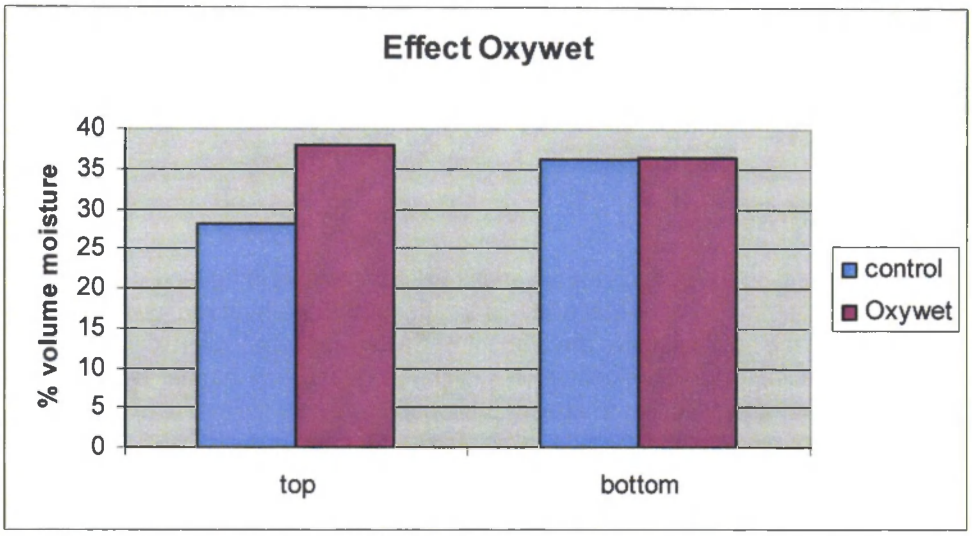


Figure 1. Moisture content of two treatments measured from the top of the pot or at 2 cm from the bottom of the pot.

In week 44, just before watering, the moisture content was measured in all treatments from the top and 2 cm from the bottom. It is shown in table 5 that the positive effect of Oxywet was not clearly in week 44. In some treatments the moisture at the bottom of the pot was higher than at the top of the pot (treatment 2 and 5).

Table 5. Average moisture content in volume % measured from the top of the pot or 2 cm from the bottom of the pot.

Treatment	top	bottom
1 Wiemermix	30.5	28.2
2 Hortiklei	28.5	35.3
3 Florisol	31.6	32.7
4 Bara clay 0-2,8 mm	24.7	25.4
5 Bara clay buffered*	21.4	24.1
6 Bara clay + Oxywet	27.4	27.7

When the roots were examined at the end of the experiment the pots of treatment 6 (Oxywet) were the only ones that were moist at the top of the pot. The moisture content was not measured at that moment.

3.5 Nutrient solution

During the growing period the Begonia plants were watered with two different nutrient solutions. The contents of the solutions is presented in Appendix 2. In Appendix 3 the results of the solutions that were used are presented.
The results shown in row W33 and W40 are from the solution given from August 26th to October 11th. The results from week 33 shows the solution as it was prepared and from week 40 how the solution was after being applied in ebb and flood during 7 weeks. The contents of most elements is lower because of uptake from week 33 to week 40.
The results shown in row W42 and W45 are from the solution given from October 11th to November 9th. The solution in week 42 had changed a little compared to the solution of week 33. For the last part of the growing period it was decided to give more K and raise the pH. The content of the solution in week 45 shows that much uptake has taken place during those four weeks.
From November 9th the plants were watered with plain rainwater. The EC of the water was 0,45 mS/cm. In

November the water has been changed every week to prevent that nutrients from the pots would come into the water and could be used by other plants again. From December until week 7 the water has not been changed. The EC in week 7 had raised to 0,5 mS/cm indicating that only a small amount of nutrients leached out of the potting soil.

3.6 Nutrients in potting soil

All the data of the amounts of elements in the potting soil in various weeks is shown in Appendix 4. At the beginning of the experiment the amount of NH_4 and NO_3 in treatment 5 (Bara buffered) was higher than in other treatments because of the buffered clay. The amount of Ca in treatment 2 (Hortiklei) was higher than in other treatments because the calcium content in this clay is higher than in other types of clay. Treatment 1 (Wiemermix) was high in Fe and Mn and treatment 3 (Florisol) was high in Fe.

In week 40, before the nutrient solution was changed, the amount of NH_4 in the pots was much lower than in week 35. Treatment 5 (Bara buffered) had still the highest amount of NH_4. The differences in the amounts of the other elements in all treatments were small.

In week 45 at the beginning of the consumers phase there was hardly any NH_4 left except for treatment 5 and 6 (Bara buffered and Oxywet). Just like in week 40 the differences in the amounts of other elements between the treatments were small.

At the end of the experiment (week 9) after watering with plain water the pH had raised whereas the content of most elements had decreased because of uptake by the plants and a little drainage by the ebb and flood water. The amount of several elements was of treatment 5 (Bara buffered) slightly higher than in other treatments.

3.7 CEC and elements in clay

The main expected benefit of Bara clay is the cation exchange capacity (CEC) is increased. The clay complex can absorb a lot of elements which can be used by the plant at a later stage during the growing season. This may result in a better growth or a longer and better growing/flowering period when the plant is sold to consumers.
The results of a CEC determination are obtained by washing the material with $BaCl_2$. In this way all elements are removed from the clay complex and replaced by Ba^{2+}. By washing the potting soil (including clay) with water a part of the elements will stay in the clay complex. The difference between these two determinations is the quantity absorbed by the clay complex.

In table 6 the amounts of Ca^{2+} (mg/kg) in the potting soil are show from the CEC and water extraction. In table 6 is shown that Hortiklei contains the highest and Florisol the lowest amount of calcium. At the beginning of the flowering period (week 45) the calcium content was higher than at the start. Because of the use of fertilisers during growing the amount of calcium in the clay and potting soil has increased. The increase in the treatment with Oxywet can be explained by the higher water uptake because of Oxywet.

Table 6. Amount of Ca^{2+} (mg/kg) from CEC or water extraction in week 37 and week 45 per treatment and the percentage of Ca soluble in water.

Treatment	CEC w37	CEC w45	Water w37	Water w45	% in w w37	% in w w45
1 Wiemermix	11120	13960	455	654	4.1	4.7
2 Hortiklei	15520	20160	645	807	4.2	4.0
3 Florisol	8000	10560	386	678	4.8	6.4
4 Bara clay 0-2,8 mm	10720	13400	453	650	4.2	4.9
5 Bara clay buffered*	11280	14200	420	678	3.7	4.8
6 Bara clay + Oxywet	11760	16880	517	1207	4.4	7.2

The situation for Mg is comparable with Ca. Approximately 90% of the Mg is absorbed by the clay complex and 10% is in soluble in water.

In table 7 is presented that the amount of K has increased during growing the Begonia because of the nutrition given. The amount K in Florisol measured by CEC is the lowest of all treatments. The amount of K in Oxywet measured by water extraction at the beginning of the flowering is the highest. Approximately 65% of the available K is soluble in water and 35% is in the clay complex. At the beginning of the experiment the percentage K in the clay complex was lower than at the beginning of the flowering period. The amount of K in the complex was higher in Bara clay and Hortiklei compared to Wiemermix and Florisol and Oxywet. The lower amount of K in the complex in the Oxywet treatment can be explained by the fact that this treatment has a smaller amount of clay in the potting soil compared to the other treatments.

Table 7. Amount of K (mg/kg) from CEC or water extraction in week 37 and week 45 per treatment.

Treatment	CEC w37	CEC w45	Water w37	Water w45	% in Complex w37	% in Water w37	% in Complex W45	% in Water W45
1 Wiemermix	1485	1778	1077	1133	27	73	36	64
2 Hortiklei	1298	1493	837	858	36	64	43	57
3 Florisol	1017	1294	841	930	17	83	28	72
4 Bara clay 0-2,8 mm	1185	1314	718	659	39	61	50	50
5 Bara clay buffered*	1501	1712	964	994	36	64	42	58
6 Bara clay + Oxywet	1513	2316	1086	1552	28	72	37	67

4 Conclusion and discussion

The growing conditions in this experiment were good as all plants grew and flowered very well. The plants flowered for four months. The differences between the treatments were small.

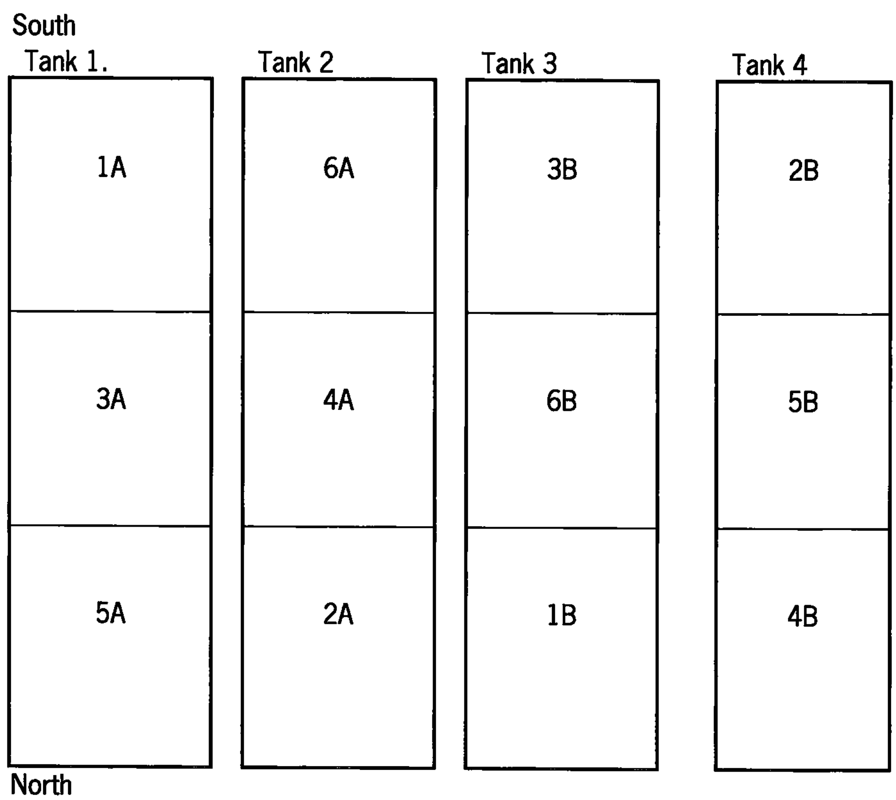
A few significant differences have been observed during the experiment. The roots of treatment 5 (Bara buffered) had the lowest root index of all treatments at the beginning of the flowering. There were less roots compared to the other treatments and there were no roots in the top of the pot. The root index of treatment 2 (Hortiklei) was at the beginning of the flowering also lower than of most other treatments. The reason for the lower index was the presence of rotten roots at the bottom of the pot. At the end of the flowering period the root index of treatment 4 and 6 (Bara and Oxywet) was higher than those of the other treatments. These treatments had most healthy roots, also at the bottom of the pots. The root index of treatment 1 (Wiemermix) and 5 (Bara buffered) was lower because in some pots the roots were looking less good. The root index of treatment 3 (Florisol) was significant lower because most of the roots at the bottom of the pot were rotten. The lowest index was given to treatment 2 (Hortiklei) which had poor looking roots and rotten roots at the bottom of the pot in all pots. Although the differences were clearly visible it did not lead to visible differences in plant growth and flowering.
Two months after the start of the flowering a flower index was given. At that time there were no visible differences in flowering. During the rest of the flowering period no visual differences between the treatments has been observed. When at the end of the flowering period the number of flower branches were counted it showed that treatment 4 and 6 (Bara and Oxywet) had more flower branches, and therefore a higher number of flowers, than treatment 2 (Hortiklei) and 5 (Bara buffered). Although the differences were significantly they could not be seen during the flowering.
For the moisture of the pots two differences has been observed. The treatment with Oxywet had until the end of the experiment pots that were humid to the top of the pot. The even distribution of water in the pot has been measured. On an other occasion, just before watering with ebb and flood, the top of the pot was just as dry as other treatments. However, after watering the pots with Oxywet always became moisture again at the top of the pot.
Another observation was that the top of the pots from treatment 5 (Bara buffered) became dry in upper most 20% of the pot. As the pots were all watered by ebb and flood during the same time there is no explanation why the water did not came to the top of the pot in this treatment after some time.

From the analysis of the potting soil it was clear that there were differences between the treatments because of the different types of clay used.
The Hortiklei contains high amounts of Ca and Mg. Florisol contains low amounts of Ca, Mg and K.
The levels of elements in Bara clay and Wiemermix were in between those of the other products.
Buffering Bara clay with minerals (loading with minerals) before the experiment started was an attempt to give extra nutrients that the plants can use later during their growing and flowering period. In this experiment no favourable effects of this buffered clay were observed. It is not clear why the growth of the plants in this treatment was not so good. Although this treatment had very often the highest levels of elements the EC of the pot was not higher than the EC of the other treatments.

The plants received fertilizers from the moment the cuttings were planted until the beginning of flowering every time they were watered. It is normal horticultural practice to grow Begonia this way. It can be concluded that by growing Begonia this way there is enough nutrition in the potting soil for the Begonia to flower very nice during the consumers phase. When the consumers phase started all leaves are developed and all flowers are formed. The flowers only have to develop.
In other research in which Bara clay proved to be beneficiary for growth during consumers phase the situation was different. In that study perennials were grown outdoors. With rainfall nutrients were washed out of the pot and the elements in the clay complex were used by the plants. In this greenhouse experiment the nutrients in the pot were not washed out.

Appendix 1

Map of treatments in the greenhouse. There is one water tank per three tables.



Appendix 2

Nutrient solution during growing period.
Period 1: August 21st until October 11th.
Period 2: October 11th until November 15th.

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Nutrient solution in mmol per liter			
Solution during period:		**1**	**2**
Main elements Mmol/l			
NO_3		9	9
NH_4		1,25	1,50
H_2PO_4		**0,75**	**0,75**
SO_4		1,75	1,0
K		4,0	4,25
Mg		1,5	1,0
Ca		1,5	2,5
Fertilisers in mmol per liter			
Solution during period:		**1**	**2**
Main elements Mmol/l			
$Ca(NO_3)2$		2,50	2,50
KH_2PO_4		**0,75**	**0,75**
$MgSO_4$		1,5	1,0
NH_4/NO_3 vl.		1,25	1,5
KNO_3		2,75	**2,5**
K_2SO_4		0,25	1,0
gram fertiliser per 1000 liter			
Solution during period:		**1**	**2**
Pertilisers in gram/1000 liter			
$Ca(NO_3)2$		450	450
KH_2PO_4		**102**	**102**
$MgSO_4$		370	247
NH_4/NO_3 vl.		**169**	**203**
KNO_3		278	253
K_2SO_4		44	126
Libremix B		20	20

Appendix 3

Content nutrient solution per week number.

1:1, 5 volume extract			**mmol per liter**										
Nr.	**EC**	**pH**	**NH_4**	**K**	**Na**	**Ca**	**Mg**	**NO_3**	**Cl**	**SO_4**	**HCO_3**	**P**	**Si**
W33	1.6	6.9	2	3.5	1.1	2.4	1.4	8.8	1	1.4	0.8	0.83	0.08
w40	1.3	5.8	0.7	2.6	1	2.4	1.1	7.4	0.9	1.2	<0.1	0.53	0.09
w42	1.6	7.7	1.6	4.8	1.8	2.6	1.2	7.9	1.5	1.2	2	0.73	0.15
w45	1.3	6.8	<0.1	3.8	2	2.1	1	6.7	1.6	1	0.2	0.54	0.17

Nr.	**um per liter**					
W33	**Fe**	**Mn**	**Zn**	**B**	**Cu**	**Mo**
	15	5.4	3	16	4.6	5.3
w40						
	12	4.7	3	12	3.3	3.4
w42						
	14	5.3	2.8	18	5.4	5.5
w45						
	10	4.1	2.8	13	4.8	4.5

Appendix 4

Nutrients in potting soil at the start (potting soil was made week 33), week 35, week 40 (before flowering) and week 45 (beginning of flowering). Per treatment (1 to 6) and replicate (A and B).

1:1, 5 volume extract			**mmol per liter**											**um per liter**					
Nr.	**EC**	**pH**	**NH_4**	**K**	**Na**	**Ca**	**Mg**	**NO_3**	**Cl**	**SO_4**	**HCO_3**	**P**	**Si**	**Fe**	**Mn**	**Zn**	**B**	**Cu**	**Mo**
W33-3kgCa	0.8	5	1.7	2.3	0.5	0.6	0.7	3.2	0.2	1	0.1	1	0	7.8	2.3	0.5	4.6	0.2	0.1
W33-4kgCa	0.7	5.2	1.6	2.1	0.5	0.6	0.6	3	0.3	0.9	0.1	1	0	8.4	2	0.6	3.8	0.3	0.1
1. w35	1	5.2	1.8	2.2	0.7	1.2	1	4	0.5	1.5	0.1	0.9	0.3	15	13	1.1	6.4	0.5	0.1
2.w35	1	5.8	1.8	1.9	0.7	1.6	0.7	3.9	0.3	1.6	0.2	0.5	0.2	7.1	4.6	0.7	5.8	0.3	0.3
3.w35	1	5	1.9	1.8	0.8	1.1	1	3.9	0.4	1.5	0.1	1	0.2	15	5.2	0.5	5.8	0.4	0.1
4. w35	1	5	1.9	1.6	0.8	1.2	1	3.9	0.4	1.6	0.1	0.5	0.2	9.3	6.9	0.3	6	0.3	0.1
5. w35	1.2	5.2	3	2.2	0.9*	1.2	1	4.4	0.5	1.7	0.1	1.6	0.5	9.2	6.6	0.5	5.4	0.4	0.1
6. w35	0.6	5	1	2.2	0.4	0.6	0.2	2.8	0.2	0.7	0.1	0.3	0.1	4.6	1	0.2	4.2	0.1	0.1
1Aw40	1.1	5.4	0.3	2.2	1.4	2	1.8	4.8	0.5	1.9	<0.1	0.9	0.3	14	7	1.9	8.9	0.4	0.2
1bw40	1.2	5.3	0.3	2.4	1.2	2.1	1.9	5.1	0.4	2.1	<0.1	0.9	0.3	14	7.4	1.4	5.8	0.3	<0.1
2aw40	0.9	6.1	0.2	1.7	1.1	2	1.2	3.8	0.4	1.9	<0.1	0.3	0.2	6.1	2.5	1.7	4.4	0.2	0.2
2bw40	0.8	6.1	0.1	1.5	1	1.6	1	2.9	0.5	1.6	<0.1	0.3	0.2	5.5	1.9	1.3	3.3	0.2	0.1
3aw40	0.8	5.4	0.1	1.6	1.1	1.4	1.4	3	0.4	1.6	<0.1	0.9	0.2	12	2.4	1.4	4.1	0.3	<0.1
3bw40	1.1	5.3	0.2	2	1.2	1.9	1.9	4.1	0.4	2.2	<0.1	1.1	0.2	13	4.4	1.5	5.3	0.3	<0.1
4aw40	0.8	5.3	0.2	1.4	1.1	1.3	1.2	3	0.4	1.5	<0.1	0.4	0.3	12	3.9	0.8	4.4	0.3	<0.1
4bw40	0.9	5.2	0.3	1.7	1.1	1.7	1.5	3.7	0.5	1.8	<0.1	0.5	0.3	13	5	0.9	4.3	0.3	<0.1
5aw40	1.1	5.4	0.9	2.2	1.2	1.6	1.5	4.6	0.4	1.5	<0.1	1.5	0.3	11	5	0.9	4.1	0.3	<0.1
5bw40	1	5.4	0.9	2.1	1.2	1.4	1.3	4.2	0.4	1.2	<0.1	1.3	0.4	9.4	4.9	0.8	4.2	0.3	<0.1
6aw40	0.9	5.4	0.2	1.8	1.6	1.4	1.4	3.3	0.5	1.7	<0.1	0.8	0.2	10	2.7	1.2	4.7	0.3	<0.1
6bw40	0.9	5.3	0.3	2	1.1	1.6	1.5	4.1	0.6	1.7	<0.1	0.6	0.3	23	4	1.1	4.9	0.3	<0.1
1Aw45	1.1	5.7	<0.1	2.3	1.5	1.6	1.6	4.5	0.7	1.9	<0.1	0.7	0.2	14	4.7	1.4	4.8	0.5	<0.1
1bw45	1.1	5.8	<0.1	2.3	1.5	1.5	1.5	3.9	0.7	1.9	<0.1	0.7	0.3	11	3.1	1.1	4.8	0.5	<0.1
2aw45	1	6.4	<0.1	2.1	1.6	1.9	1.2	3.6	0.7	2.2	<0.1	0.3	0.2	4.4	1.7	1	4.6	0.5	0.2
2bw45	0.9	6.5	<0.1	1.9	1.6	1.5	1	2.7	0.9	2	<0.1	0.2	0.1	4.3	1.3	1.2	3.7	0.4	0.2
3aw45	0.9	5.9	<0.1	1.9	1.5	1.2	1.2	2.6	0.8	1.7	<0.1	0.7	0.2	11	2	1.1	4.7	0.5	<0.1
3bw45	1.2	5.7	<0.1	2.4	1.8	1.8	1.8	4.6	0.8	2.2	<0.1	0.8	0.2	12	3.6	1.4	4.6	0.6	<0.1
4aw45	1.2	5.6	0.4	2.2	1.9	1.9	1.6	3.9	1.3	2.6	<0.1	0.4	0.2	18	4.5	1.1	4.7	0.7	<0.1
4bw45	0.7	5.9	<0.1	1.4	1.4	1	1	2	0.9	1.8	<0.1	0.3	0.2	13	2.1	0.8	3.4	0.6	<0.1
5aw45	1	5.7	0.3	2.1	1.4	1.3	1.2	4.4	0.6	1.3	<0.1	0.9	0.3	14	3	0.8	4.4	0.5	<0.1
5bw45	1.1	5.7	0.7	2	1.7	1.5	1.4	3.9	1.1	1.9	<0.1	1	0.2	16	4.9	0.8	3.9	0.6	<0.1
6aw45	1	5.7	0.2	2.2	1.7	1.4	1.4	4.2	0.8	1.9	<0.1	0.6	0.2	12	2.5	1.4	4.3	0.7	<0.1
6bw45	1	5.6	0.1	2.1	1.7	1.6	1.5	4.7	0.5	2.1	<0.1	0.5	0.2	13	3.2	1	4.1	0.5	<0.1
mean	1	5.9	0.3	2.1	1.6	1.5	1.4	3.8	0.8	2		0.6	0.2	12	3.1	1.1	4.3	0.6	0.2

Nutrients in potting soil at the end of the experiment (week 9) per treatment (1 to 6) and replicate (A and B).

1:1, 5 volume extract			**mmol per liter**											**um per liter**					
Nr.	**EC**	**pH**	**NH_4**	**K**	**Na**	**Ca**	**Mg**	**NO_3**	**Cl**	**SO_4**	**HCO_3**	**P**	**Si**	**Fe**	**Mn**	**Zn**	**B**	**Cu**	**Mo**
1Aw9	1	6.1	<0.1	1.7	3	1.6	1.3	2.9	3.1	1.6	<0.1	0.4	0.2	9.7	1.7	2.5	<0.1	0.5	0.1
1Bw9	0.6	6.5	<0.1	1.3	2	0.6	0.4	1.2	2.1	0.7	<0.1	0.2	0.2	24	0.8	1.5	<0.1	0.4	0.2
2Aw9	1.1	6.7	<0.1	1.7	3.5	1.9	1.1	1.8	4.2	1.9	<0.1	0.2	0.2	5.5	1.1	1.3	<0.1	0.4	0.3
2Bw9	0.7	7	<0.1	1.2	2.7	1.1	0.6	0.3	3.1	1.3	<0.1	0.1	0.2	4.8	0.3	0.7	<0.1	0.2	0.5
3Aw9	0.8	6.4	<0.1	1.1	2.9	0.9	0.8	0.4	3.2	1.2	<0.1	0.3	0.2	9.7	0.5	1.6	<0.1	0.3	0.2
3Bw9	0.8	6.5	<0.1	1.3	2.7	1	0.9	0.9	2.8	1.5	<0.1	0.4	0.2	8.1	0.6	2	<0.1	0.4	0.2
4Aw9	0.8	6.4	<0.1	1.1	2.9	1	0.7	0.9	3.3	1.1	<0.1	0.2	0.2	13	0.7	1.8	<0.1	0.4	0.3
4Bw9	0.6	6.4	<0.1	0.8	2.3	0.8	0.5	0.7	2.3	1	<0.1	0.1	0.2	16	0.6	1.4	<0.1	0.5	0.2
5Aw9	1.4	5.9	0.2	2.2	3.6	2	1.7	5.9	3.7	1.7	<0.1	0.7	0.2	12	3.2	2.2	<0.1	0.6	<0.1
5Bw9	0.9	6.1	0.2	1.4	2.7	1.3	1.1	2.4	2.8	1.3	<0.1	0.6	0.2	13	2.2	2	<0.1	0.5	0.1
6Aw9	1.1	6.2	<0.1	1.5	3.2	1.8	1.6	2.9	3.1	2.1	<0.1	0.5	0.2	10	1.6	3.6	<0.1	0.8	0.1
6Bw9	0.5	6.6	<0.1	0.8	1.8	0.5	0.3	0.5	1.9	0.5	<0.1	0.1	0.2	19	0.5	1.1	<0.1	0.4	0.5
mean	0.9	6.4	0.2	1.3	2.8	1.2	0.9	1.7	3	1.3		0.3	0.2	12	1.2	1.8		0.5	0.2

Appendix 5

CEC of potting soil including clay additives. Samples from the start of the experiment (before planting Begonia) w37 and samples from the beginning of the consumers fase, w45 per treatment in **cmol/kg**.

		CEC ongebufferd ICP-AES Varian						CEC ongebufferd ICP-AES Varian	
Lab	**Monster**	**Al(3+)**	**Ca**	**CEC**	**Fe(3+)**	**K**	**Mg**	**Mn**	**Na**
code	**nr.**	**[cmol(+)/kg]**	**[cmol(+)/kg]**	**[cmol(+)/kg]**	**[cmol(+)/kg]**	**[cmol(+)/kg]**	**[cmol(+)/kg]**	**[cmol(+)/kg]**	**[cmol(+)/kg]**
1	Treat. 1 w45	0.18	34.9	46.2	0.00	4.56	17.8	0.14	1.72
2	Treat. 2 w45	0.04	50.4	53.2	-0.02	3.83	16.8	0.06	2.04
3	Treat. 3 w45	0.15	26.4	34.0	0.00	3.32	14.7	0.07	1.72
4	Treat. 4 w45	0.07	33.5	44.2	0.02	3.37	17.7	0.13	2.16
5	Treat. 5 w45	0.14	35.5	47.8	0.02	4.39	17.3	0.14	1.82
6	Treat. 6 w45	0.12	42.2	47.3	0.02	5.94	23.1	0.14	2.42
7	Treat. 1 w37	-0.11	27.8	14.3	-0.01	3.81	14.3	0.26	0.77
8	Treat. 2 w37	-0.04	38.8	23.6	-0.02	3.33	11.4	0.14	0.68
9	Treat. 3 w37	-0.04	20.0	17.1	-0.01	2.61	11.3	0.11	0.70
10	Treat. 4 w37	0.00	26.8	19.3	-0.01	3.04	13.7	0.17	0.75
11	Treat. 5 w37	0.11	28.2	15.8	-0.01	3.85	14.5	0.18	0.95
12	Treat. 6 w37	0.04	29.4	14.9	0.01	3.88	16.3	0.16	0.98
13	Treat. Contr w37	-0.03	36.7	8.98	-0.01	6.60	23.5	0.13	1.00

CEC of potting soil including clay additives. Samples from the start of the experiment (before planting Begonia) w37 and samples from the beginning of the consumers fase, w45 per treatment in **mg/kg**.

		CEC ongebufferd ICP-AES Varian						CEC ongebufferd ICP-AES Varian	
Lab	**Monster**	**Al(3+)**	**Ca**	**CEC**	**Fe(3+)**	**K**	**Mg**	**Mn**	**Na**
code	**nr.**	**(mg/kg)**	**(mg/kg)**	**[cmol(+)/kg]**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
1	Treat. 1 w45	48.6	13960.0		0.0	1778.4	4272.0	77.0	395.6
2	Treat. 2 w45	10.8	20160.0		-11.2	1493.7	4032.0	33.0	469.2
3	Treat. 3 w45	40.5	10560.0		0.0	1294.8	3528.0	38.5	395.6
4	Treat. 4 w45	18.9	13400.0		11.2	1314.3	4248.0	71.5	496.8
5	Treat. 5 w45	37.8	14200.0		11.2	1712.1	4152.0	77.0	418.6
6	Treat. 6 w45	32.4	16880.0		11.2	2316.6	5544.0	77.0	556.6
7	Treat. 1 w37	-29.7	11120.0		-5.6	1485.9	3432.0	143.0	177.1
8	Treat. 2 w37	-10.8	15520.0		-11.2	1298.7	2736.0	77.0	156.4
9	Treat. 3 w37	-10.8	8000.0		-5.6	1017.9	2712.0	60.5	161.0
10	Treat. 4 w37	0.0	10720.0		-5.6	1185.6	3288.0	93.5	172.5
11	Treat. 5 w37	29.7	11280.0		-5.6	1501.5	3480.0	99.0	218.5
12	Treat. 6 w37	10.8	11760.0		5.6	1513.2	3912.0	88.0	225.4
13	Treat. Contr w37	-8.1	14680.0		-5.6	2574.0	5640.0	71.5	230.0

Amount of elements received by **water extraction**. Samples from the start of the experiment (before planting Begonia) w37 and samples from the beginning of the consumers fase, w45 per treatment in **mg/kg**.

		Water-extractie (SFA)		ICP-Vista							Chlor-o-counter
Lab	**Monster**	**N-NO3+N-NO2**	**N-NH4**	**Al**	**Ca**	**Fe**	**K**	**Mg**	**Mn**	**Na**	**Cl**
code	**nr.**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
1	Treat. 1 w45	694	57.2	24.8	654	23.2	1133	414	4.09	422	166
2	Treat. 2 w45	377	19.5	33.0	807	16.9	858	314	1.14	411	151
3	Treat. 3 w45	699	18.4	5.57	678	11.5	930	451	1.99	385	226
4	Treat. 4 w45	484	25.9	5.16	650	9.77	659	384	3.32	421	420
5	Treat. 5 w45	698	71.7	2.92	678	9.73	994	404	3.50	413	265
6	Treat. 6 w45	1215	31.5	4.33	1207	11.4	1552	736	4.72	556	483
7	Treat. 1 w37	692	252	4.53	455	7.49	1077	289	6.11	177	150
8	Treat. 2 w37	524	156	4.15	645	5.14	837	224	2.77	155	87.9
9	Treat. 3 w37	557	187	5.13	386	14.1	841	273	3.04	184	140
10	Treat. 4 w37	549	184	2.73	453	5.46	718	266	4.09	175	140
11	Treat. 5 w37	600	336	3.32	420	5.28	964	254	3.71	202	153
12	Treat. 6 w37	718	294	8.25	517	10.8	1086	351	4.13	223	199
13	Treat. Contr w37	1113	495	2.78	566	8.72	2027	471	2.97	214	236

Results of **CEC** minus **water extraction** in mg/kg.

Lab code	Monster nr.	Al(3+) (mg/kg)	Ca (mg/kg)	CEC [cmol(+)/kg]	Fe(3+) (mg/kg)	K (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Na (mg/kg)
1	Treat. 1 w45	23.8	13306.0		-23.2	645.3	3858.0	72.9	-26.2
2	Treat. 2 w45	-22.2	19353.2		-28.1	636.1	3717.6	31.9	58.2
3	Treat. 3 w45	34.9	9882.1		-11.5	364.4	3077.3	36.5	10.5
4	Treat. 4 w45	13.7	12749.7		1.4	655.5	3863.6	68.2	75.7
5	Treat. 5 w45	34.9	13522.0		1.5	718.3	3748.5	73.5	5.2
6	Treat. 6 w45	28.1	15672.7		-0.2	764.7	4807.6	72.3	0.6
7	Treat. 1 w37	-34.2	10664.7		-13.1	408.5	3143.0	136.9	-0.1
8	Treat. 2 w37	-15.0	14874.7		-16.3	462.2	2511.7	74.2	1.0
9	Treat. 3 w37	-15.9	7613.8		-19.7	176.8	2439.3	57.5	-22.8
10	Treat. 4 w37	-2.7	10267.0		-11.1	468.1	3021.9	89.4	-2.4
11	Treat. 5 w37	26.4	10860.2		-10.9	537.4	3225.9	95.3	16.0
12	Treat. 6 w37	2.5	11243.1		-5.2	427.5	3560.5	83.9	2.0
13	Treat. Contr w37	-10.9	14113.7		-14.3	546.6	5168.7	68.5	15.9