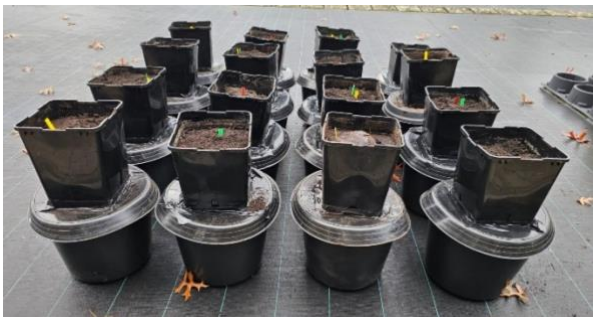
# The effect of continuous mulching on nutrient holding capacity of soil in a non-tilling agricultural practice



Research Report

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# Research Report

Specialisation Applied plant research - Year 4 – Applied biology

HAS green academy, Den Bosch

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# Preface

Presented here is the research report that was produced as part of a project carried out by three Applied Biology students from the HAS green academy. This study was commissioned by Gelukkige Groentes in response to a request for more information on the effect of continuous mulching on the nutrient-holding capacity of the soil in a non-tilling agricultural practice, as applied at Gelukkige Groentes.

We would like to thank our supervisor, Tamara Verhoeven, for her guidance and support throughout this project. She assisted us during this research and provided valuable feedback that enabled us to develop and improve this report. We also want to thank the client, Sam Emons, for his cooperation and for the time he devoted to making this research possible. In addition, we express our gratitude to the staff of HAS green academy for their guidance and support in facilitating this research.

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# Abstract

In recent years, the agricultural sector has faced increasing pressure to adopt more sustainable and environmentally responsible farming practices. Non-tillage farming is one of the proposed solutions; this method reduces soil erosion, loss of organic matter, and maintains soil structure. Not a lot is known about the effects of this kind of farming on the leaching of phosphorus and nitrogen out of the soil of a non-tillage farm. This study has found that the use of non-tillage farming has little effect on the leaching of Nitrogen and Phosphorus in a simulated harvest and winter season. This result was obtained using sandy soil as a control group, sandy soil plus 1 cm of mulch as a fertilizer, soil from "Gelukkige Groentes" (a non-tillage farming practice), and soil from "Gelukkige Groentes" plus 1 cm of mulch. These four treatments were repeated four times, both in a simulated harvest and winter season. The harvest season was simulated in a greenhouse at 20 °C and 70% relative humidity with lettuce plants planted in the soil, and the winter simulation was done outside in a garden with open skies and no plants. Both simulations had 16 pots; these pots were suspended above a bucket to collect the leaching water. The results of this study corroborate the findings of other studies, the CEC (cation exchange capacity), in a soil with more organic material present is marginally higher than in a soil without organic material. This imbalance in ions makes it so that the historical soil retains more nutrients during seasons of heavy rainfall. Moreover, due to the practice of non-tillage, the soil-structure stays intact, and the organic matter can keep building up.

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# 1. Introduction

In recent years, the agricultural sector has faced increasing pressure to adopt more sustainable and environmentally responsible farming practices. Conventional large-scale agriculture, with its focus on monocultures, intensive tillage, and heavy synthetic inputs, has contributed to numerous environmental problems, including soil erosion, declining soil fertility, and water pollution by nutrient loss (Țopa et al., 2025). In recent years, substantial progress has been made by researchers and practitioners in innovating the field of agriculture to achieve more environmentally friendly solutions. One of these practitioners is Gelukkige Groentes, a company located in Malden, the Netherlands (Gelukkige Groentes, 2026). This company aims for sustainability using compost fertilization, non-tillage farming, and the avoidance of chemical fertilizers and plant protection substances (Van Baren, 2023).

Non-tillage farming reduces the risk of soil erosion, conserves soil organic matter, and improves soil structural stability (Soane et al., 2012). Soil type plays a crucial role in this process. Clay soils are generally well suited to non-tillage systems, whereas sandy soils present challenges because their aggregates tend to form angular structures that fit tightly together, restricting air and water movement through the soil profile (Morris et al., 2010). However, other research showed that non-tillage can increase nitrogen stocks in sandy soil (da Silva, 2020). By repeating this process over multiple years, the organic compounds in the soil rise (Reeves, 1997). To create a sustainable and healthy soil, organic matter is of great importance. Organic compounds deliver nutrients, improve the soil structure, and create a Cation Exchange Complex or CEC (Van Iperen, 2019). The CEC is the capability of soil to retain ions; this capability will significantly increase both the water-holding capacity and nutrient-holding capacity. By adding organic compounds to the naturally neutral sandy soil at Gelukkige Groentes, the soil's CEC improved by giant leaps, therefore making the soil more suited for agricultural practices (Murphy, 2015).

One drawback in non-tillage farming is the greater risk of weed pressure (Weber et al., 2017).

Compost mulch provides an ecological alternative to conventional chemical fertilizers. Compost mulch made from organic waste contains, among other nutrients, nitrogen, phosphate, and potassium (Van Iersel, 2025). Compost generally releases nutrients more slowly than chemical fertilizers, because the nutrients must first be mineralized from organic compounds through microbial decomposition before they become available to plants (Sanches et al., 2017). As a result, nutrients from compost are gradually released and retained within the soil organic matter pool, making them available for plant uptake over a longer period, whereas chemical fertilizers contain soluble, readily available nutrients that act more rapidly but are also more prone to depletion or leaching. Gelukkige Groentes uses a combination of both organic waste compost and chicken manure compost. Organic waste compost is added yearly to the field in March, and chicken manure compost is added when needed. Compost also has a second function: by covering the field with a thin layer of compost, less sunlight hits the ground, reducing the number of weeds and therefore reducing the need to spray chemical herbicides (Brown & Tworkoski, 2004). A layer of compost and mulch deters smaller types of pests by acting as a physical barrier that inhibits their movement and access to the soil or plants (Rehman et al., 2019).

Even though there are several benefits to using compost in farming, covering the soil with a layer of compost mulch could lead to nutrient loss from the compost into the groundwater (Samuelson et al., 2022). . The loss of nutrients into the groundwater is very harmful to the environment due to the

nitrification process, which will slowly turn soil into unworkable soil. The main concern with compost fertilizer is the risk of phosphorus and nitrogen nutrient loss (Hurley et al., 2017). In the case of Gelukkige Groentes, the compost is spread out over the field in March and lies on top of the soil without being removed. This means that even after the growing period, the compost will remain on top of the soil, without crops in the field to absorb the nutrients.

In this study, experiments were performed to measure the risk of nitrogen and phosphorus nutrient leaching in different conditions. Sandy soil will be taken from the agricultural field at Gelukkige Groentes, which has been yearly fertilized with compost for the last six consecutive years, and compared to sandy soil without historical addition of compost to study the effect on the nutrient holding capabilities. Liquid samples will be gathered by capturing the drainage of soil with and without cultivation, and the concentration of phosphate/ phosphorus and nitrogen/ nitrate will be measured using a spectrophotometer. This study aims to gain insight into the possibility of phosphate and nitrogen nutrient leaching in agricultural practices with non-tillage farming using compost as a soil improver and nutrient provider. The aim is also to provide insight into the viability of this agricultural practice, as implemented at Gelukkige Groentes, for potential adoption in the Netherlands or in sandy soil environments.

# 2. Materials & Methods

## 2.1. Experimental design

The two experiments in this research report were conducted in two different locations: inside, simulating a crop-growing cycle, and outside, simulating a late autumn/early winter season. Each experiment had 16 individual pots, which were divided into four treatments: Clean sandy soil provided by the HAS, clean sandy soil provided by the HAS with an added 1cm layer of mulch, historical sandy soil from Gelukkige Groentes (will be referred to as “historical soil”, and historical sandy soil from Gelukkige Groentes with an added 1cm layer of mulch. The mulch was Vigro wood compost and was provided by Van Iersel (Appendix 1: Van Iersel nutrient table wood compost). This mulch is also used to fertilize the historical soil from Gelukkige Groentes yearly. The nutrient content of the historical soil and clean sandy soil from the HAS used in this experiment is shown in Appendix 2. The historical soil from “Gelukkige Groentes” was acquired at one of the plots at their Malden location. To keep the soil structure intact, the pots were manually filled with soil, making sure that the soil wasn't disturbed. Each treatment was replicated four times and placed in square pots (18.5 cm x 18.5 cm x 22.5 cm) and was placed 90 cm apart in a completely random order (Figure 1). These pots were suspended above a bucket, utilizing a plastic lid to make sure that the bottom of the pot didn’t reach the leached water and preventing the drain water from evaporating. To combat algal growth, the pot was sealed off from light using blackout tape.

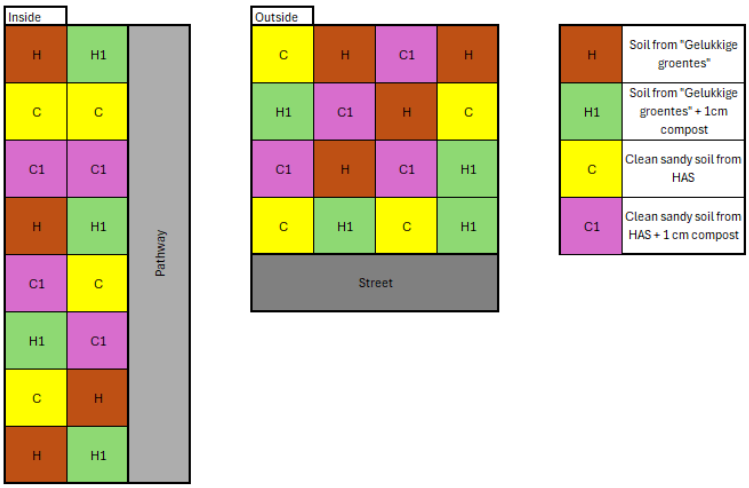


*Figure 1. Experimental design of the trial with treatment indicated with H for historical soil, H1 for the historical soil with a 1 cm fresh layer of mulch, C indicating the control soil, and C1 indicating the control soil with a 1 cm fresh layer of mulch.*

The experiment inside was placed in a greenhouse provided and maintained by the HAS. The greenhouse was set to maintain a temperature of 16 °C and a RH of 70%, and had approximately 10 hours of light per day. For the indoor experiment, a Red Oak Leaf Lettuce (*Lactuca sativa var. NeheRai*) plant was purchased as a seedling from “Brabant Plant” (‘S-Hertogenbosch, The Netherlands). These plants were placed in the centre of the pots approximately 6-7 cm deep.

The outside experiment was placed on a field maintained by the HAS. No plants were placed in the soil for the outside experiment; the pots with containers for drain were placed on a waterproof tarpaulin.

Both experiments were started in late October 2025 and concluded in early January 2026, it ran for approximately 11 weeks.

## 2.2 Plant maintenance and watering

Both inside and outside experiments were closely maintained, de-weeded, and checked for damages/problems. Watering the inside plants was conducted 1 to 2 times per week according to the needs of the plant; every pot received the same amount of water, regardless of the treatment. The water used for the inside experiment was captured rainwater provided by the HAS. Outside, the pots were watered by natural rainfall.

## 2.3 Measurements

### Water samples

The sample collection was done using a bucket below the pots, which captures the drainage water. At week 5, the total water collected in the bucket was recorded, and 10ml of the total water volume was collected and frozen to prevent algae growth. The rest of the water was discarded using the designated disposal sites. The water samples were collected at week 5, and at week 11, after the experiments had concluded, the samples of the same individual were defrosted and homogenized. These mixed samples were measured spectrophotometrically for N and P content using HACH LANGE LatoN LCK138 Nitrogen testing kit and HACH LANGE LCK349 Phosphate testing kit.

### Measurements for nitrogen and phosphate content with a spectrophotometer

The sample analysis was done using the DR3900 Spectrophotometer from HACH LANGE (United States of America). The instrument has a wavelength range of 320 to 1100 nm and an accuracy of 1.5 nm (between 340-900 nm). Using these wavelengths can measure both total phosphorus (400-470 nm) and total nitrogen oxides (350-400 nm) (Vandaele et al., 2002).

### Soil samples

#### *Historical measurements*

The soil analysis of the historical soil in December 2024 was conducted by Van Iersel; the method used for both total P and N content is unknown. Only nitrate and ammonium concentrations, no total nitrogen was reported; for the P content, the total phosphate content was stated in the report.

#### *New samples*

The content of the control sandy soil was tested by Eurofins. The method used for nitrogen was Em: NIRS. For the total phosphate content, the amount of $P_2O_5$ in mg/kg was converted to kg/ha. The method used for the measurement of $P_2O_5$ was PAL1: Gw NEN 5793.

The soil analysis of Inside H, H1, C1, and outside H, H1, C1 was performed at the end of the experiment by removing the soil from the pots and having it analysed by Eurofins. The nitrogen content was tested using the method Em: CNE3, and the results were noted in mg/kg. The phosphate content was tested using the method PAL1: Gw NEN 5793, and the results were noted in mg $P_2O_5$ / 100 g. With the given bulk density, these results were converted to kg/ha.

## 2.4 Data analysis

The independent variable of these experiments is the soil treatments that were used. The response variables are the amount of phosphate and nitrogen that leach out ($L \cdot mol^{-1} \cdot cm^{-1}$).

The program R (RStudio-2025.09.0-387) will be used for the data analysis. First, a test was conducted to determine if the variables follow a normal distribution. If so, analysis of covariance and comparison of means (Tukey HSD, $\alpha < 0.05$) was performed. Moreover, a Kirk-Wallis test and a following post-hoc Dunns test with Bonferroni correction were performed ($\alpha < 0.05$).

Outliers were removed when a valid reason was found.

# 3. Results

## 3.1 Difference in nutrient drain off for cultivated soil

Based on the results obtained from the indoor experiment with cultivation, several clear outliers were identified. Statistical analyses were performed using either an analysis of variance (ANOVA) or a Kruskal–Wallis test, depending on the normality of the data. In both cases, appropriate post hoc tests were conducted, and the analyses were performed both with and without the identified outliers. The outliers were subsequently removed based on valid and justified reasoning.

For the indoor experiment with cultivation, the control treatment showed a significantly higher average nitrogen concentration in the drain off compared to all other treatments (P = 0.0038) (Figure 2).

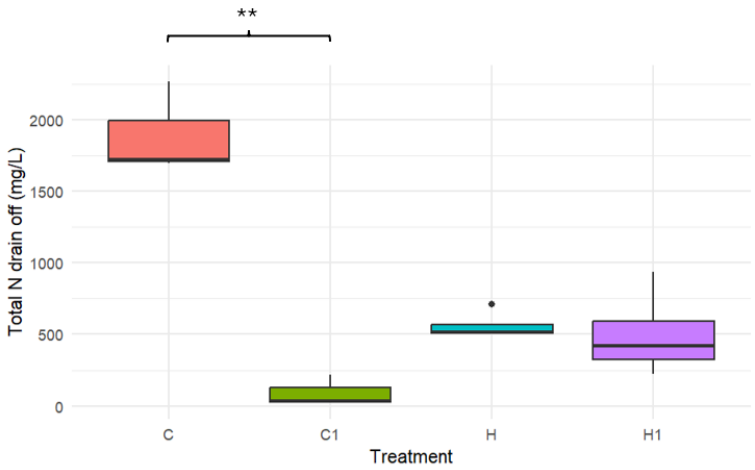


*Figure 2. Boxplot showing total N drain off per treatment in the inside experiment, with H standing for historical soil, H1 for the historical soil with a 1 cm fresh layer of mulch, C indicating the control soil, and C1 indicating the control soil with a 1 cm fresh layer of mulch. Here, the outliers are removed. A Kruskal-Wallis test was conducted, followed by a post-hoc Dunns test with Bonferroni correction. A significant difference between C and C1 was observed (P = 0.0038). ''**'' Represents a p-value between 0.001 and 0.01. No significant differences between the other treatments were observed (P > 0.05).*

For all soil treatments with crop cultivation, no significant difference in total phosphorus concentration was found in the drain off (P = 0.241) (Figure 3). Although not significant, the control with added mulch showed a lower mean value than the other treatments.

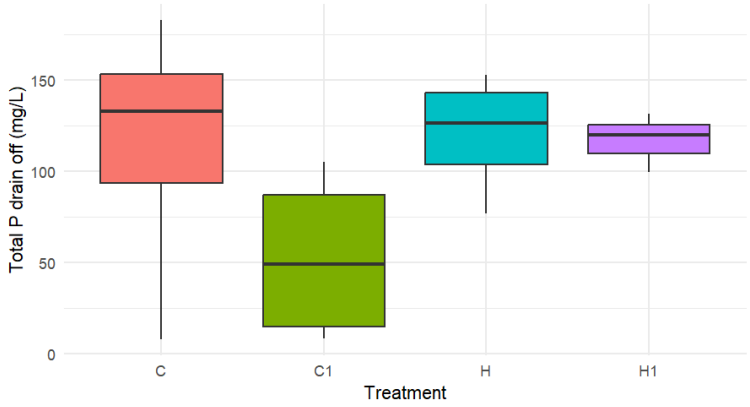


*Figure 2. Boxplot showing P drain off per treatment in the indoor experiment with H standing for historical soil, H1 for the historical soil with a 1 cm fresh layer of mulch, C indicating the control soil, and C1 indicating the control soil with a 1 cm fresh layer of mulch. Here, the outlier is removed. An Analysis of variance test followed by a post-hoc Tukey HSD test was conducted. No significant differences were observed (P = 0.241).*

## 3.2 Difference in nutrient drain off for soil without cultivation

Based on the results obtained from the outdoor experiment without cultivation, several clear outliers were identified. For both phosphorus and nitrogen leaching data, an Analysis of variance test followed by a post-hoc Tukey HSD test was conducted. The outliers were again removed based on valid and justified reasoning.

For the outdoor experiment without cultivation, no significant difference in average nitrogen concentration in the drain off was found (P = 0.433) (Figure 4). This effect was also observed for the total phosphorus concentration in the drain off (P = 0.746) (Figure 5).

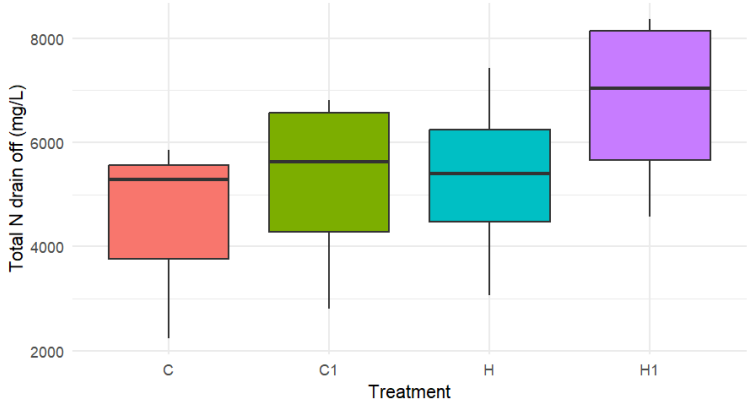


*Figure 4. Boxplot showing the total N drain off per treatment in the outside experiment, with H standing for historical soil, H1 for the historical soil with a 1 cm fresh layer of mulch, C indicating the control soil, and C1 indicating the control soil with a 1 cm fresh layer of mulch. Here, the outlier is removed. An Analysis of variance test followed by a post-hoc Tukey HSD test was conducted. No significant differences were observed (P = 0.433).*

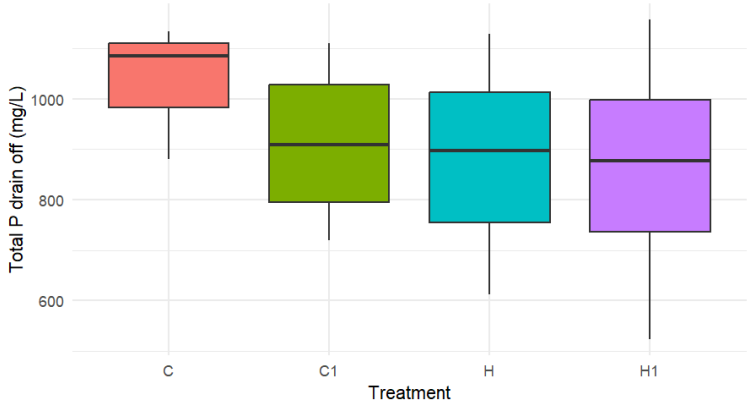


*Figure 5. Boxplot showing total P drain off per treatment in the outside experiment, with H standing for historical soil, H1 for the historical soil with a 1 cm fresh layer of mulch, C indicating the control soil, and C1 indicating the control soil with a 1 cm fresh layer of mulch. Here, the outliers are removed. An Analysis of variance test followed by a post-hoc Tukey HSD test was conducted. No significant differences were observed (P = 0.746).*

## 3.3 Soil samples

Start and finish measurements of total nitrogen and phosphorus were used to compare nutrient composition of the treatments. This was done to support the interpretation of the leaching results.

The soil analyses show that the historical soil treatments had the highest nitrogen concentration compared to the control soil (Table 2). In contrast, the total phosphorus content is lower in the historical soil treatments and higher in the control soil.

*Table 1. Total phosphorus and nitrogen content per soil treatment, with H standing for historical soil, H1 for the historical soil with a 1 cm fresh layer of mulch, C indicating the control soil, and C1 indicating the control soil with a 1 cm fresh layer of mulch. The phosphorus and nitrogen content of the historical soil at Gelukkige Groentes in 2024 was also included, along with the 2023 control soil.*

| **Soil sample** | **Total P content (kg/ha)** | **Total N content (kg/ha)** |
|---|---|---|
| Historical soil December 2024 | 811 | 13 |
| Control sandy soil December 2023 | 818 | 3570 |
| Inside H | 1050 | 10231 |
| Inside H1 | 1102 | 9105 |
| Inside C1 | 2032 | 3315 |
| Outside H | 1148 | 8364 |
| Outside H1 | 1102 | 7010 |
| Outside C1 | 2094 | 3110 |

## 3.4 Visual observations on cultivated lettuce

Even though the focus of the experiment was on leaching and nutrient content of different soil treatments, differences in crop performance between treatments were observed. The control soil with added mulch showed better growth of the plants compared to the control soil without added mulch (Figures 6 & 7). The crops on both historical soil treatments appear to similarly good growth (Figures 8 & 9).

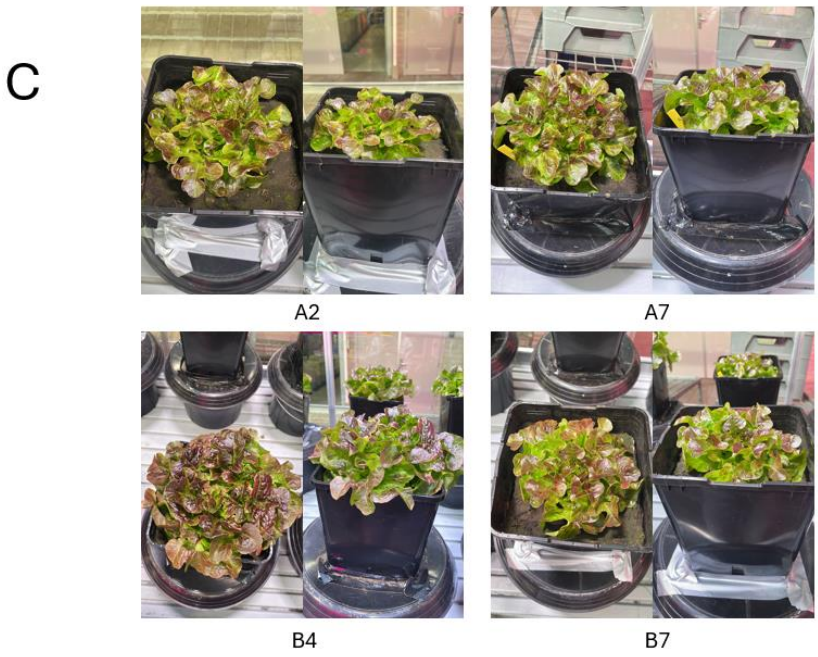


*Figure 6. Growth of the lettuce plants in the pots in the indoor experiment. These are the plants that belonged to treatment C.*

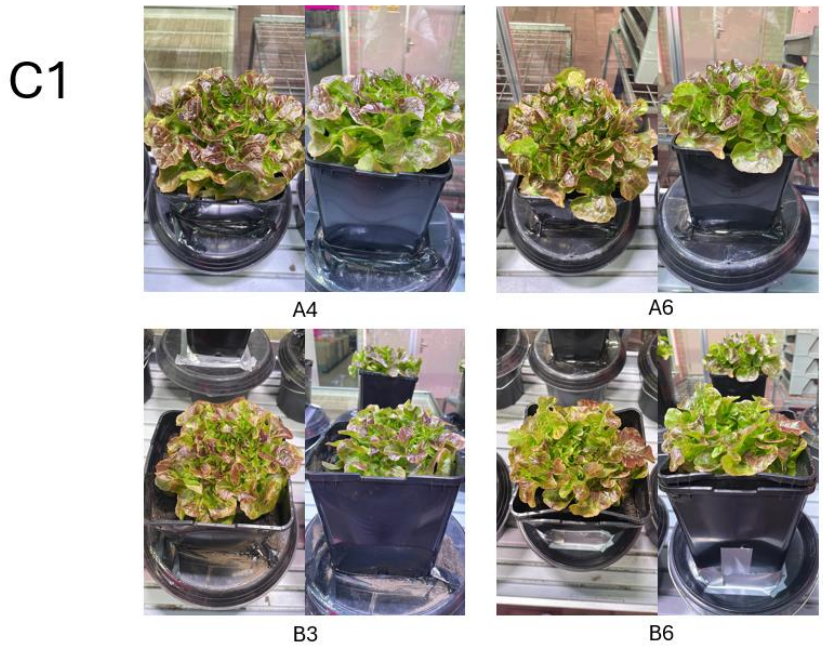


*Figure 7. Growth of the lettuce plants in the pots in the indoor experiment. These are the plants that belonged to treatment C1.*

H

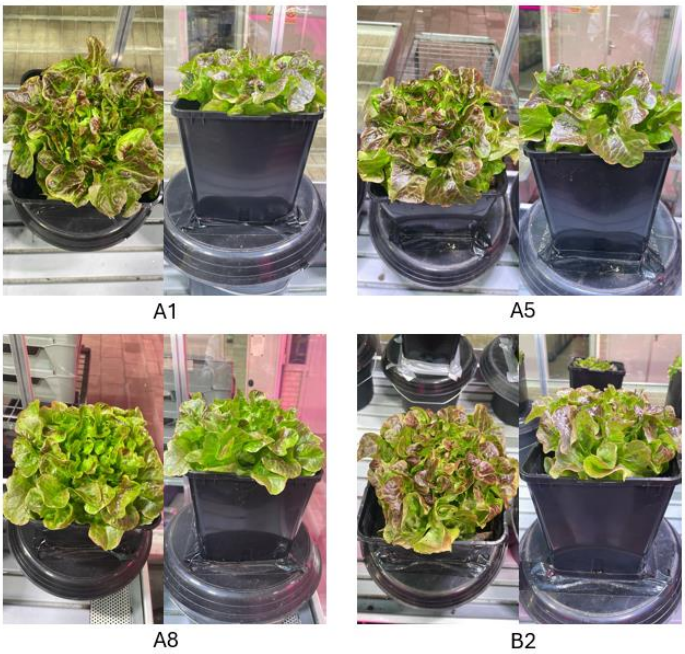


*Figure 8. Growth of the lettuce plants in the pots in the indoor experiment. These are the plants that belonged to treatment H.*

H1

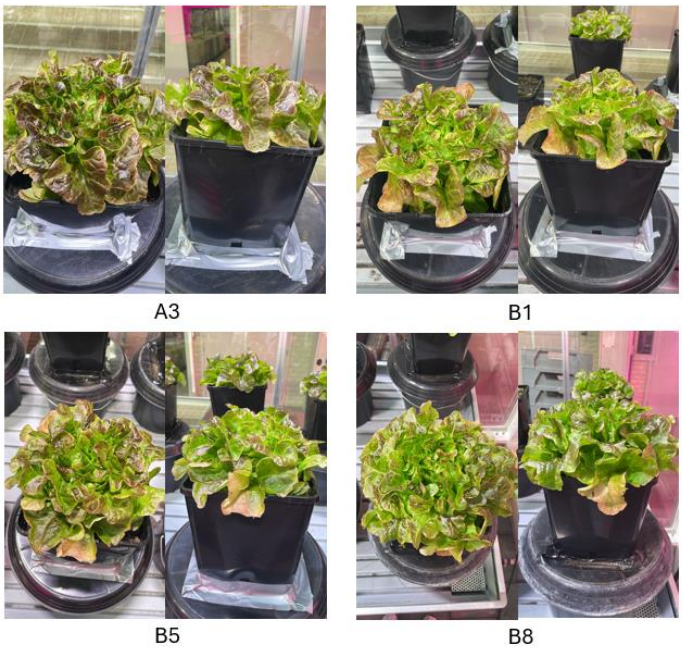


*Figure 9. Growth of the lettuce plants in the pots in the indoor experiment. These are the plants that belonged to treatment H1.*

# 4. Discussion & conclusion

This research shows that under non-tillage management, the historical soil from Gelukkige Groentes, which has yearly been fertilized with compost for the last six consecutive years, exhibits similar levels of phosphate and nitrogen leaching regardless of mulch application during the growing season. This is a result that was not expected, because the expectation of this trial was that adding mulch to the soil would increase nitrogen and phosphorus leaching. However, during the greenhouse trial, the sandy soil control group without mulch showed significantly higher nitrogen leaching compared to the sandy soil control group with added mulch after removing the outliers. A similar difference has been observed in the case of phosphorus nutrient loss during the greenhouse trial between these control groups. This indicates that the addition of mulch leads to an increase in nutrient retention capacity. Previous research has shown that non-tillage and reduced tillage systems enhance topsoil structure stability compared with conventional deep ploughing, enabling the soil to retain nutrients more effectively (Steponaviciene et al., 2023). Because of this increased soil stability, adding a nutrient-rich layer of mulch should not result in a sudden increase in nutrient leaching. Other research showed that because of these soils' high nutrient-retention capacity, plants can absorb nutrients more efficiently, resulting in improved yields under non-tillage systems for sorghum and wheat (Toliver et al., 2012). The improvement of growth has also been observed during this research; the plants grown on the historical soil of Gelukkige Groentes appeared to have a higher yield than those grown in the control sandy soil.

The results of the open-air trial show no differences in nutrient leaching for both nitrogen and phosphorus between all treatments. This would suggest that there is no difference in nutrient leaching in the period after harvest and before the start of the next growing cycle, when comparing the soil types with and without an added mulch layer. This result differed from expectations because the expectations were that the open-air trial would show an increase in nutrient leaching after adding mulch. Another expectation was that the historical soil would show more leaching than the control sandy soil; this is not the case. It seems that the addition of mulch directly and over time increased the nutrient retention capabilities of the soil. This is probably because of the increase in organic matter in the soil. Organic matter in soil leads to the retention of nutrients (Bhadha et al., 2017). This could explain why no difference was found in the open-air trial.

The results of the soil analysis are also very noteworthy. The soil analyses of the treatments were performed after the conclusion of the drain experiments. However, there is a problem in comparing these results; the analyses were done by different companies and using different methods, it is difficult to compare the values and reach conclusions with high certainty, not all results were given in the same unit. To give an example, the analysis of the historical soil used in the field shows a concentration of P in the form of phosphate instead of total P. The method of testing is unknown for this analysis (table 5). To stay replicable and reliable, a decision is made to compare the analyses of the treatments done in this study among themselves and to the phosphorus concentration of the control sandy soil, since these were done using the same company and method of testing (Phosphorus acetic acid and ammonium lactate dissolving, also: PAL). In this study, the positive effects of non-tillage and the addition of mulch are also supported by comparing the soil analyses. These results showed that the historical soil from Gelukkige Groentes, when compared to the same soil with added mulch, contained nearly the same concentration of nitrogen and phosphorus at the end of the experiment. This was unanticipated because the expectation was that the addition of mulch would increase the nitrogen nutrient content. This again indicates that the historical soil has increased in stability and nutrient-holding capacity. Evidently, in the historical soil to which mulch was added, a decrease in nitrogen content was observed in the soil samples. At the same time, the level of leaching was comparable to that of the soil without mulch. This may indicate the previously discussed effect that mulch enhances

the nutrient uptake capacity of plants. In this soil, a greater amount of nitrogen was likely absorbed by the plants, even though the mulch simultaneously contributed additional nitrogen to the system. When this increased input and enhanced uptake are considered together, the result is a comparable amount of nitrogen leaching to the amount observed in this historical soil without mulch, as reflected in the leaching results. This is supported by the visual representation of the plants. It is evident that the plants cultivated on the historical soil have shown more growth than the plants grown on the control of sandy soil. It is also clear that the treatments with added mulch have shown more growth than the treatments without added mulch. The efficient uptake of nitrogen from the soil can be attributed to the fact that leafy plants have a high nitrogen-absorbing capacity (Taha et al., 2017). This can vary among other crop species. For example, legumes require less nitrogen from the soil because they can fixate nitrogen from the air (Day et al., 2001). To conclude, nitrogen leaching can differ during the cultivation of different crop species.

The results of this study are better explained by placing them in a broader scientific spectrum. Cultivating on sandy soil poses more risk to nutrient leaching than clay and loam soils; this is because the sandy soil does not contain a natural cation exchange complex (CEC). Soil particles are, in most cases, negatively charged, which means that soil particles can capture and temporarily hold positively charged nutrients (Cations) in soils that have a high CEC (Mengel, 1993). Sandy soil hardly contains this ability because of its particle size. The ability to capture and temporarily hold a larger amount of nutrients is based on the surface area of these particles combined. The particle size of sand is between 0,075 – 4,75mm dependent on the type, and is considered big compared to clay at a particle size of <0,002mm (Sophie, 2025). The larger particle size leads to a smaller surface area and decreases its cation exchange abilities. By adding a layer of mulch each year, the organic matter content in the soil rises. This organic matter, after being added to the soil, starts to decay and gets broken down by microbiological processes, after which humus is created. This hummus contains a lot of negatively charged particles like carboxyl and phenol groups. During this decay process, the organic matter is broken down into a lot of small particles. These small particles combined create a big surface area in the soil, which is negatively electrostatically charged, in effect, adding cation exchange capacity to the soil. Cations like ammonium, potassium, and magnesium can be captured and temporarily held until absorbed by the plant root by this CEC (Ross & Ketterings, 2009). The plant root absorbs these cations by excreting positively charged hydrogen ions, which take the place of the positively charged particles in the soil. This process leads to releasing these nutrients in the soil, after which the plant can uptake these nutrients. With the addition of mulch, the soil's ability to capture and temporarily hold these nutrients is improved. It is believed that a part of this process occurred during this experiment. By increasing the organic matter in the soil, a decrease in nitrogen leaching was observed, while the nitrogen content in the soil remained the same. It is possible that the nitrogen introduced to the system by adding compost was in the form of ammonium, which was captured and held temporarily until it was taken up by the plant root.

The results of this study are based on a relatively small number of data points, as the number of tests available to measure leaching was limited. Additionally, several outliers were removed from the dataset because it was certain that these values were incorrect. Two samples were swapped, and for a few samples that later turned out to be outliers, the dilutions were not performed correctly, resulting in inaccurate final measurements. Consequently, for some treatments, only three samples were included in the data analysis. Using a larger number of data points could lead to more reliable results (Blainey et al., 2014). If the number of tests is not a limiting factor, increasing the size of the experiment could improve reliability.

To gain a better understanding of leaching, leaching over time can also be considered. This would provide insight into leaching during the cultivation period of, for example, young versus fully grown plants. Additionally, leaching into deeper soil layers can be examined, which helps determine when leaching could actually result in nutrients being no longer available for plant uptake and instead being lost, potentially contaminating the groundwater. In a future study, groundwater samples could be taken and analysed to compare them to the allowed maximum nitrate concentration of 50mg/l (CLO, 2012), to allow for a more definitive statement on whether this non-tillage compost fertilizing agricultural setup is contributing to a positive change in the agricultural field. Furthermore, a recommendation is made to include a soil analysis of the field soil and control soil before the start of the experiment in a future study. This could be done to more clearly follow the path taken by the nutrients during the trials. Also, the CEC could be measured in the field and compared to a soil sample of the surrounding area to prove the increase in soil fertility and stability.

This study shows that practicing non-tillage farming and compost fertilization methods allows the soil to develop a strong and stable nutrient retention capacity, which promotes better plant growth. This research also demonstrates that in the cultivation of lettuce, the application of a layer of mulch reduces the leaching of phosphate and nitrogen. However, this level of leaching differs for other crops, which could be researched in follow-up studies. To further support the findings and increase reliability, the experiment could be scaled up. This would allow for the assessment of additional factors, such as the effects of cultivating other crops, leaching into deeper soil layers, and leaching over time. In this study, phosphor and nitrogen leaching in the outdoor experiment without cultivation did not lead to observable results. Increasing the scale of the experiment could help reveal such effects in future studies. Until further research is conducted, this study has shown that the effects of non-tillage farming and compost fertilizing do not lead to an increase in nutrient leaching when compared to the control groups.

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# 6. Appendix

## Appendix 1. Van Iersel nutrient table wood compost

*Table 2. Average composition of Vigro wood compost (Van Iersel, 2025).*

| | |
|---|---|
| Nitrogen (N) | 4.8 kg/ton product |
| Phosphate (P2O5) | 2.2 kg/ton product |
| Potassium (K2O) | 4.3 kg/ton product |
| Magnesium (MgO) | 1.7 kg/ton product |
| Calcium carbonate (CaCO3) | 7.5 kg/ton product |
| Sulfur (SO3) | 2.0 kg/ton product |
| Organic matter | 22.1% (from dry matter) |
| Dry matter | 63.7% |
| pH-KCl | 7.3 |
| Salinity (EC) | < 2.0 mS/cm |
| Stability | < 10.0 mmol O2/kg o.m./hour |
| Appearance | Brown/black crumb product |

## Appendix 2. Nutrient content of Historical soil from Gelukkige Groentes and clean sandy soil from HAS

| Mineraal | Huidig Niveau | Ideaal Niveau | Mineralen balans laag / gemiddeld / hoog |
|---|---|---|---|
| CEC | 11,23 | | |
| TEC | 11,39 | | |
| | | | |
| | | | |
| pH water | 6,9 | 6,3 | |
| stabiele organische stof | 3,5 % | 2,8 - 10,0 % | |
| Cal/Mag-verhouding | 6,15 :1 | 5,67 :1 | |
| Nitraat stikstof | 9 kg/ha | | |
| Ammonium stikstof | 4 kg/ha | | |
| Fosfaat | 811 kg/ha | 250 - 750 kg/ha | |
| Calcium | 4157 kg/ha | 3470 kg/ha | |
| Magnesium | 405 kg/ha | 367 kg/ha | |
| Kalium | 298 kg/ha | 299 - 597 kg/ha | |
| Natrium | 47 kg/ha | 29 - 88 kg/ha | |
| Aluminium | 1 kg/ha | 0 < 11,48 kg/ha | |
| Zwavel | 42 kg/ha | 67 - 112 kg/ha | |
| Borium | 1,7 kg/ha | 2,2 - 6,7 kg/ha | |
| IJzer | 842 kg/ha | 90 - 448 kg/ha | |
| Mangaan | 78 kg/ha | 67 - 224 kg/ha | |
| Koper | 10,4 kg/ha | 4,5 - 15,7 kg/ha | |
| Zink | 46,5 kg/ha | 11,2 - 22,4 kg/ha | |
| Molybdeen | 0,11 kg/ha | 0,90 - 1,57 kg/ha | |
| Kobalt | 0,11 kg/ha | 0,22 - 1,12 kg/ha | |
| Silicium | 114 kg/ha | 100 - 350 kg/ha | |
| | | | |
| **BASE SATURATION** | | | |
| Calcium | 81,47 % | 68,00 % | |
| Magnesium | 13,24 % | 12,00 % | |
| Kalium | 2,99 % | 3,00 - 6,00 % | |
| Natrium | 0,80 % | 0,50 - 1,50 % | |
| Aluminium | 0,00 % | 0,50 % | |
| Waterstof | 1,50 % | 10,00 % | |

*Figure 2. Nutrient contents of historical soil at ''Gelukkige Groentes'' in Malden*

| Resultaat | | Eenheid | Resultaat | Streeftraject |
|---|---|---|---|---|
| Chemisch | N-totale bodemvoorraad | kg N/ha | 3570 | 3570 - 5350 |
| | C/N-ratio | | 16 | 13 - 17 |
| | N-leverend vermogen | kg N/ha | 45 | 95 - 145 |
| | S-plantbeschikbaar | kg S/ha | 19 | 20 - 30 |
| | S-totale bodemvoorraad | kg S/ha | 630 | 780 - 1450 |
| | C/S-ratio | | 93 | 50 - 75 |
| | S-leverend vermogen | kg S/ha | 6 | 20 - 30 |
| | P-plantbeschikbaar | kg P/ha | 6,3 | 6,7 - 11,2 |
| | P-bodemvoorraad | kg P/ha | 810 | 570 - 730 |
| | K-plantbeschikbaar | kg K/ha | 225 | 260 - 410 |
| | K-bodemvoorraad | kg K/ha | 305 | 260 - 425 |
| | Ca-plantbeschikbaar | kg Ca/ha | 210 | 270 - 625 |
| | Ca-bodemvoorraad | kg Ca/ha | 2735 | 2930 - 3730 |
| | Mg-plantbeschikbaar | kg Mg/ha | 210 | 260 - 410 |
| | Mg-bodemvoorraad | kg Mg/ha | 210 | 260 - 410 |
| | Na-plantbeschikbaar | kg Na/ha | < 30 | 56 - 112 |
| | Na-bodemvoorraad | kg Na/ha | 51 | 56 - 112 |
| | Si-plantbeschikbaar | g Si/ha | 65130 | 22310 - 96660 |
| | Fe-plantbeschikbaar | g Fe/ha | 12600 | 9290 - 16730 |
| | Zn-plantbeschikbaar | g Zn/ha | 2900 | 1860 - 2790 |
| | Mn-plantbeschikbaar | g Mn/ha | 37840 | 11900 - 18590 |
| | Cu-plantbeschikbaar | g Cu/ha | 135 | 150 - 240 |
| | Co-plantbeschikbaar | g Co/ha | 70 | 15 - 30 |
| | B-plantbeschikbaar | g B/ha | 340 | 595 - 820 |
| | Mo-plantbeschikbaar | g Mo/ha | < 10 | 370 - 18590 |
| | Se-plantbeschikbaar | g Se/ha | 8,6 | 13 - 17 |
| Fysisch | Zuurgraad (pH) | | 5,7 | 5,2 - 5,8 |
| | C-organisch | % | 1,58 | |
| | Organische stof | % | 3,0 | |
| | C/OS-ratio | | 0,53 | 0,45 - 0,55 |
| | Koolzure kalk | % | 0,4 | 2,0 - 3,0 |
| | Klei (<2 µm) | % | 1 | |
| | Silt (2-50 µm) | % | 13 | |
| | Zand (>50 µm) | % | 83 | |
| | Klei-humus (CEC) | mmol+/kg | 44 | > 44 |
| | CEC-bezetting | % | 99 | > 95 |
| | Ca-bezetting | % | 83 | 80 - 90 |
| | Mg-bezetting | % | 10 | 6,0 - 10 |
| | K-bezetting | % | 4,8 | 2,0 - 4,0 |
| | Na-bezetting | % | 1,4 | 1,0 - 1,5 |
| | H-bezetting | % | < 0,1 | < 1,0 |
| | Al-bezetting | % | < 0,1 | < 1,0 |

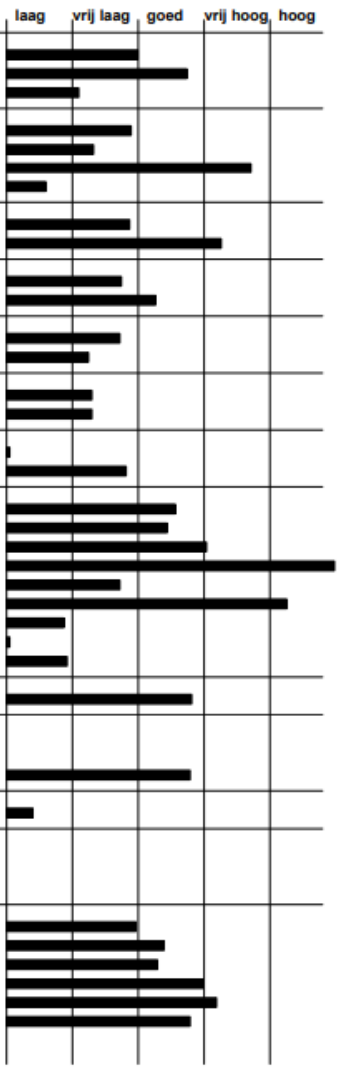


*Figure 3. Nutrient contents clean sandy soil from HAS*