Penergetic over winter cabbage growth trial

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Permanent Agriculture and Horticulture Science and Extension

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1. Introduction

This report presents the results of a field experiment that trialled Penergetic 'p' and 'b' products on cabbages grown under New Zealand conditions. It was undertaken under contract for Penergetic New Zealand Limited (hence forth Penergetic NZ) penergeticnewzealand.co.nz.

Penergetic International AG is a Swiss Company who formulate and manufacture ranges of certified organic agriculture products, which are distributed in over 40 countries worldwide. Penergetic NZ provided the following descriptions of their products.

Penergetic b soil uses biostimulating processes to boost soil activity. The sustainable product promotes humus formation and supports soil life. Activating soil life results in a change in the soil structure and soil compaction is reduced in the long term. Improved root growth helps optimize availability of nutrients in the soil for the plants. Penergetic b benefits include: Stimulates soil activity – Reduces harmful organisms – Helps break down crop residues – Promotes healthy root systems – Propagates mycorrhizal fungi – Lowers fertilizer requirements – Optimizes the soil structure – Makes tillage easier – Reduces the need for machinery – Boosts nutrient uptake of plants – Enriches biological quality – Is environmentally friendly and approved for organic agricultural use – Can indirectly help during drought periods since it leads to an improved soil structure and thus a better capacity for storing water – Product is completely harmless to humans, animals and the environment.

Penergetic-p is used as a plant tonic and as described by Penergetic has a stabilizing effect on plant growth and strengthens the immune system of plants. This reduces susceptibility to diseases and pest infestation. An additional benefit is the stimulation on microbiology in the root area and increase of the plant's natural nutrient uptake. Plants become more resistant and through that a better productivity. Penergetic p benefits: Stimulates root growth – Improved assimilation of nutrients – Stimulates plant growth – Increase mycorrhizal fungi – Strengthens plants and increases resistance – Reduction of fertilizer – Cost savings – Accelerate chlorophyll and photosynthesis activity – Improved yield and enhanced crop quality – Better biological quality – Increase stress resistance – Improves nutrient flow – Environmentally friendly – Improve assimilation of nutrients – Activates the symbiosis of soil-root-plant - Stabilisation of the biological optimum for plants – Works synergistically with other agri-inputs .

Penergetic p and b products are designed to be used together, according to application/dosage instructions. The effect of both Penergetic-b & Penergetic-p is optimised. Crop specific versions of Penergetic-p include a vegetable version used in this trial.

2. Methods and design

The experiment was based at the BHU Organics Trust, Lincoln University, in the 'Maples South' field at 43°39'3.42"S 172°27'13.71"E. The BHU is a certified organic property (by Organic Farm NZ[1]), so the trial was managed according to organic regulations. The trial ran over winter, from March 29 to 25 October 2021. Cabbages were chosen as the test crop, as they are suitable for overwinter production (being robust and reliable performers), they are a commonly grown crop, so represent a good 'model crop' on which to test the Penergetic products. The trial was initiated later in the year than optimal due to a desire to gather data on Penergetic products as soon as possible.

A randomised complete block (RCB) design was used with six replicates and two treatments, 1) a null control and 2) Penergetic treatment using both p and b products. Six replicates were used rather than the typical four to increase statistical power, as yield trials often require greater statistical resolution. Six replicates were also used due to the trial being run over-winter when growing conditions are less optimal. However, as discussed below, only five replicates were actually used.

[1] www.organicfarm.org.nz/

The trial used the vegetable bed system on 1.70 m wheel centers, giving a bed top of 1.40 m. The plots consisted of two 37 m long beds, with each plot being 5 m long, with a one meter grassed buffer between plots. There was an additional untreated bed between the two 37 m beds that was grassed, to also act as a buffer. There was a requirement for at least 1 m buffer space as Penergetic NZ stated that the effect of the Penergetic products spread through the soil. To ensure treatment plots had the same vegetation on all sides, two more beds were cultivated on the outsides of the trial beds and also grassed. Each plot therefore had a minimum 1 m grassed and untreated buffer on all four sides (Figures 1 & 2).

Buffer	**1m**	**Pasture**	**Cabbage**	**Pasture**	**Cabbage**	**Pasture**
Rep 1	**5m**		Penergetic		Control	
Buffer	**1m**					
Rep 2	**5m**		Control		Penergetic	
Buffer	**1m**					
Rep 3	**5m**		Penergetic		Control	
Buffer	**1m**					
Rep 4	**5m**		Control		Penergetic	
Buffer	**1m**					
Rep 5	**5m**		Control		Penergetic	
Buffer	**1m**					
Rep 6	**5m**		Penergetic		Control	
Buffer	**1m**	**1.7m**	**1.7m**	**1.7m**	**1.7m**	**1.7m**

Total length 37 m **Total width 8.5m**

Figure 1. Field trial layout and sizes. Rep = replicate

Figure 2. Trial site after cabbages have been planted and grass and clover mixture emerged in buffer zones.

The soil is Wakanui, sib 1a.1, mottled immature pallic, texture is silt with 15 - 35 % topsoil clay, > 1 m diggability depth, stoneless, is imperfectly drained with a moderate over slow permeability profile and with low (23%) topsoil P retention[2]. A full soil test had been done in August 2020 by Hill Laboratories Limited: Soil sample depth 150 mm, pH 6.4, resin P 61 mg/kg, Olsen phosphorus 12 mg/L, anion storage capacity 18%, potassium 0.85 me/100g, calcium 8.4 me/100g, magnesium 1.32 me/100g, sodium 0.16 me/100g, CEC 14 me/100g, total base saturation 75 %, volume weight 0.93 g/mL, sulphate sulphur 5 mg/kg, extractable organic sulphur 6 mg/kg , aluminium ($CaCl_2$ extractable) 0.3 mg/kg, reserve potassium (TBK) 7.2 me/100g, reserve magnesium 23.2 me/100g, potentially available nitrogen 128 kg/ha 15cm depth, anaerobically mineralisable N 92 µg/g, organic matter 4.9%, total carbon 2.8%, total nitrogen 0.26%, C/N ratio 11.1%, anaerobically mineralisable N/total N Ratio 3.6%, phosphorus (Mehlich 3) 97 mg/L, potassium (Mehlich 3) 320 mg/L, calcium (Mehlich 3) 1,641 mg/L, magnesium (Mehlich 3) 157.5 mg/L, sodium (Mehlich 3) 36 mg/L, sulphur (Mehlich 3) 17 mg/L, iron (Mehlich 3) 182 mg/L, manganese (Mehlich 3) 23.7 mg/L, zinc (Mehlich 3) 4.7 mg/L , Copper (Mehlich 3) 0.7 mg/L , boron (Mehlich 3) 1.13 mg/L , cobalt (Mehlich 3) 0.3 mg/L, aluminium (Mehlich 3) 986 mg/L, 'total' phosphorus 596 mg/kg, 'total' sulphur 241 mg/kg, 'total' calcium 3,190 mg/kg, 'total' copper 5 mg/kg, 'total' molybdenum 0.3 mg/kg, 'total' cobalt 7.7 mg/kg, 'total' selenium 0.3 mg/kg, 'total' cadmium 0.12 mg/kg, base saturation K 6.0%, Ca 59%, Mg 9.3 %, Na 1.1%.

In September 2020, 500 $kg \cdot ha^{-1}$ of Balance granulated reactive rock phosphate (RPR) supplying 61 $kg \cdot ha^{-1}$ P and plus 55 $kg \cdot ha^{-1}$ of Sulphurgain Pure supplying 50 $kg \cdot ha^{-1}$ S was applied based on the above soil test. No soil test has been taken post fertiliser application.

On 29 March the trial area was prepared. The area had been in a green manure for the previous six months consisting of triticale (× *Triticosecale*)@ 40 kg/ha, vetch (*Vicia sativa*) @10 kg/ha, oats (*Avena sativa*) @ 40 kg ha, and mustard (*Brassica juncea*) @ 5 kg/ha. The cover crop was mulch mowed close to the ground, then rotary hoed approximately 5 cm deep to kill the plants, the beds were then put in by ripping the ground using a Ransomes' ridged leg cultivator, in two passes to a depth of 30 to 40 cm, then finally rotary hoed at approximately 15 cm, to create a planting tilth.

On the 30 March, Penergetic-b was applied to the Penergetic plots at the recommended rate of $0.3 \cdot g \cdot m^2$ / 3 $kg \cdot ha^{-1}$. It was applied using a 40 L sprayer tank with a Shurflo 8000-543-136 12 volt DC pump operating at 4 bar, supplying a hand held spray bar with three DG TeeJet 110 94 VP nozzles, spaced 50 cm apart, with a flow rate of 0.75 L per minute each giving a total flow rate of 2.25 L/m for the three nozzles. The sprayer was filled with approximately 7 L of water, 27.9 g of Penergetic-b

[2] smap.landcareresearch.co.nz/

added to the water and then the water toped up to 15 L, to provide sufficient extra volume of spray liquid for losses in pipes etc. The spay mixture was circulated when transporting to the site and between spray applications. Each plot was then sprayed for 30 seconds with four passes to ensure even coverage, with the spray bar held approximately 30 cm above the soil surface so that there was a small amount of overlap of the spray fans. The spay bar was held diagonally across the bed so to only spray the bed top.

On 31 March, ten 60 cell 30 x 50 cm cell trays were filled with the standard Lincoln University Nursery 3-4 month plant raising mix, made of 400 L composted bark, 100 L pumice, Osmocote exact 3-4 month 1.5 kg, horticultural lime 500g, hydraflo 500g, per 500 L finished mix. Half the trays were then emptied of the plant raising mix, which was then mixed with Penergetic-b at the rate of 0.3 g/m2 of tray surface. The plant raising mix was spread out on a clean flat surface, then the pile was turned four times to thoroughly mix the Penergetic-b into the plant raising mix. The five empty trays were then refilled with the Penergetic-b treated plant raising mix. Cabbage seeds, McGregor's brand cv. "Golden Acre" were then sown one seed per cell, covered with a thin layer of sieved plant raising mix, and placed in a propagation glass house, and kept lightly watered. On 9 April due to poor seedling emergence, the seedlings that had emerged were removed with the minimum compost disturbance possible, and then resown with a new batch of McGregor's "Golden Acre" batch number DFD15, covered with a thin layer of sieved horticultural peat, and returned to the potting house.

On 20 April false seedbed cultivation was undertaken using a 'roller undercutter' (Merfield, 2015) to kill the weed flush with the control plots cultivated first and the Penergetic plots afterwards to avoid transferring Penergetic treated soil to the control plots. The areas around the plots were sown with a mix of creeping red fescue (*Festuca rubra*) and small leaved white clover (*Trifolium repens*). On 4 May the trial plots were roller undercut again to kill further weed flush, again with control plots treated first and Penergetic plots afterwards.

On 17 May cabbages were transplanted. Before planting the Penergetic transplants were watered in their trays with 5·g Penergetic-p in one litre of water immediately before planting out. Control plots were planted first then Penergetic to again minimise the chance of cross-contamination. Each 5 × 1.4 m plot was marked out with four rows 30 C apart, with 50 cm spacing down the row, planted on diagonals to give a square planting pattern / equidistant spacing. This gave a total of 42 cabbages per plot. To avoid edge effects, and to further increase treatment separation, only cabbages from the center two rows will be used for measurements, and the first and last cabbages at the ends of the plots will also be excluded further extending the buffer size between plots closer to 1.5 m. This gives 17 cabbages per plot to be used for measurements.

The whole trial area was covered with a 0.6 mm hole size mesh crop cover (Figure 3, Merfield, 2017b) for pest control, principally rabbits, hares and pukekos, but also late season caterpillars, with the additional benefit of improving the microclimate and protecting the crop from wind to help compensate for the late planting (Merfield, 2017a).

Figure 3. Mesh crop cover on trial area post planting.

On 3 June the Penergetic plots were sprayed with 0.2 $g \cdot m^2$ / 2 $kg \cdot ha^{-1}$ Penergetic-p using the same method for applying Penergetic-b to the soil (see above) and (Figure 4).

Figure 4. Control plot (left) Penergetic plot (right) on 3 June prior to being sprayed.

On 10 June, due to concerns about the 3 June spray beading up and running off the cabbages (due to their waxy leaves) and therefore leaving little Penergetic-p on the plants, another application was made, this time using the Penergetic-p designed specifically for vegetables as well as soap to act as a surfactant. New World supermarket 'Value' brand bar soap 'Beauty Soap' containing sodium palmate, petrolatum, palm kernelate, water, sodium chloride, titanium dioxide, glycerine, tetrasodium EDTA, sodium stearate, fragrance, sodium lauryl glutamate and cetyl alcohol was used, being the purest form of soap, i.e., with the least amount of additives, that could be obtained at short notice. 40 g of soap was finely grated and then mixed with 1L of boiling water and shaken to dissolve. The sprayer was filled with 40 L of water, the soap mixture added and then mixed by circulating with the pump, giving a rate of 1g soap·L water. The control plots were then sprayed with the soap mixture. Then the spray tank was drained to 20 L and 16.8 g Penergetic-p for vegetables added and mixed in via pump circulation and the Penergetic plots were then sprayed. The mesh crop

covered was removed at 11:30 am to allow the plants time to dry out, the plants were sprayed at 1:00 pm, then left to dry until 4:00 pm when the mesh cover was put back on the trial area.

On 15 June the plots were weeded with a 4 Wheel Hoe pedestrian weeder, though due to the large amount of rain that had fallen at the end of May (see Appendix) this was not fully effective. Weed levels were still low enough to not cause any impact on cabbage growth.

On 20 July, the plots were sprayed again with 0.2 $g \cdot m^2$ / 2 $kg \cdot ha^{-1}$ Penergetic-p for vegetables using the same method as the 10th June including the use of soap. Covers were removed at 9:30 am when still frosted, plants were sprayed at 12:30 pm, covers were replaced at 3:00 pm.

On 27 September, when the trial area had dried out sufficiently after winter, plots were hand weeded (Figure 5).

Figure 5. Control plot (left) Penergetic plot (right) on 27 September after being hand weeded.

On the 25 Oct, due to the cabbages starting to go to flower, despite not reaching full size, the trial was harvested. Due to the large rainfall that fell during the trial (a total of 454 mm, see Appendix) not all cabbages survived, so the full 17 cabbages per plots that had been planned to be harvested (see above) was reduced to 15 cabbages per plot. Even with the reduction in the number of cabbages that were harvested for, there were still insufficient cabbages in the sixth replicate to harvest. Rather than further reduce the number of cabbages harvested per plot, which could increase variability, it was decided to harvest only the first five reps, as five replicates is still more than the typical four reps of a field trial. The cabbages were then weighed en mass per plot. After weighing they were put in polytunnel to dry, before being put in research drying ovens at Lincoln University from 11 to 15 November, when then were removed and the dry weight taken.

Results were analysed by general ANOVA using Fisher's unprotected LSD.

3. Results

For the fresh harvest weight, the total plot weight of the control cabbages was 3.72 kg and the Penergetic cabbages was 4.79 kg (p=0.011, $LSD^{5\%}$=0.671), being a 29% weight increase due to Penergetic treatment. Dry weights were control 511 g and Penergetic 651 g (p=0.005 $LSD^{5\%}$=69.6) being a 27% weight increase due to Penergetic treatment. See the Appendix for the raw data.

The 'p' value is a measure of probability in statistical tests such as ANOVA, and is a way of determining that the results did not occur by chance. The smaller the number the more robust the result is. The standard p value used to decide if a result is a real effect is 5% (0.05), i.e., a p value larger than 5% is consider non-significant, i.e., the results occurred by chance, while less than 5% the results are significant, i.e., not due to chance. In agricultural and biological sciences, a <0.1% (0.001) p value is considered highly significant, i.e., it is highly unlikely that the result occurred by chance. Both the p values for these results are well under the 0.05 significance threshold and the dry weight is close to the 0.001 highly significant p value, indicating both are robust results and that the increased weight due to Penergetic treatment is statistically robust.

$LSD^{5\%}$ stands for the **L**east **S**ignificant **D**ifference at a 5% p value. If the difference between measurements is larger than the LSD then the difference between them is statistically significant at the 5% p level. It is presented to allow readers to compare the actual difference among the measurements with the LSD. In the case of the cabbage wet weights of 4.79 kg - 3.72 kg = 1.07 kg which is considerably larger than the $LSD^{5\%}$ of 0.671 kg, which is reflected in the small p values.

4. Discussion

The results show a clear statistically and biological significant increase in weight due to Penergetic treatment.

It was disappointing that the cabbages could not be grown to full size due to going to flower in spring but, this was a known risk with a late planting. The additional delay caused by the poor emergence of the first batch of seeds further exacerbated this issue.

5. References

Merfield, C. N. (2015). False and Stale Seedbeds: The most effective non-chemical weed management tools for cropping and pasture establishment. The FFC Bulletin, 2015(V4), 25. http://www.bhu.org.nz/future-farming-centre/information/bulletin/2015-v4/false-and-stale-seedbeds-the-most-effective-non-chemical-weed-management-tools-for-cropping-and-pasture-establishment

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6. Appendix

6.1. Rainfall data

Date	Rainfall mm	Date	Rainfall mm	Date	Rainfall mm
2021-03-28	0.4	2021-06-22	1.0	2021-09-30	1.4
2021-03-29	0.2	2021-06-23	0.2	2021-10-04	17.4
2021-04-02	1.2	2021-06-28	2.2	2021-10-05	1.0
2021-04-03	0.2	2021-06-29	8.0	2021-10-06	0.2
2021-04-10	3.2	2021-06-30	0.4	2021-10-07	0.4
2021-04-14	0.6	2021-07-01	0.2	2021-10-08	0.2
2021-04-16	0.6	2021-07-04	0.2	2021-10-09	2.0
2021-04-17	11.6	2021-07-06	0.2	2021-10-10	0.2
2021-04-24	13.8	2021-07-07	1.6	2021-10-11	1.8
2021-04-25	0.2	2021-07-10	0.2	2021-10-12	11.6
2021-04-26	0.2	2021-07-16	0.2	2021-10-13	16.0
2021-04-27	1.8	2021-07-17	3.4	2021-10-14	1.4
2021-04-30	0.2	2021-07-18	1.2	2021-10-18	2.4
2021-05-02	0.2	2021-07-19	4.0	2021-10-19	0.6
2021-05-08	0.2	2021-07-20	0.2	2021-10-20	0.2
2021-05-10	0.2	2021-07-22	3.8	**Total**	**453.90**
2021-05-11	1.2	2021-07-27	8.6		
2021-05-12	23.0	2021-08-02	1.0		
2021-05-14	0.2	2021-08-03	35.8		
2021-05-18	4.6	2021-08-04	0.2		
2021-05-22	0.2	2021-08-05	0.2		
2021-05-24	2.2	2021-08-06	9.0		
2021-05-25	1.0	2021-08-07	0.2		
2021-05-28	0.6	2021-08-08	13.2		
2021-05-29	19.6	2021-08-09	7.8		
2021-05-30	68.0	2021-08-13	0.8		
2021-05-31	53.8	2021-08-14	3.8		
2021-06-01	2.2	2021-08-18	1.2		
2021-06-03	0.2	2021-08-20	1.4		
2021-06-05	0.2	2021-08-27	1.8		
2021-06-06	1.2	2021-08-28	3.5		
2021-06-07	4.6	2021-08-29	0.4		
2021-06-08	0.2	2021-08-30	1.0		
2021-06-10	0.4	2021-09-02	0.4		
2021-06-13	1.0	2021-09-08	5.6		
2021-06-14	0.2	2021-09-10	0.8		
2021-06-15	0.2	2021-09-13	10.6		
2021-06-16	0.2	2021-09-14	10.0		
2021-06-17	14.2	2021-09-15	0.4		
2021-06-18	7.2	2021-09-23	0.2		
2021-06-19	1.6	2021-09-26	0.2		
2021-06-20	8.2	2021-09-27	0.2		
2021-06-21	0.6	2021-09-28	0.2		

6.2. Raw data

Rep	Treatment	Wet weight kg	Dry weight g
1	Penergetic	3.32	448
1	Control	2.14	305
2	Penergetic	4.95	653
2	Control	3.36	475
3	Penergetic	5.22	682
3	Control	3.73	479
4	Penergetic	4.37	624
4	Control	4.11	505
5	Penergetic	6.10	850
5	Control	5.26	792