emnz

EFFECTIVE MICROORGANISMS: A GLOBAL TECHNOLOGY

HARNESSING THE POWER OF MICROBES FOR SUSTAINABLE FOOD PRODUCTION, SOIL HEALTH, AND ENHANCED CROP GROWTH

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What is EM?

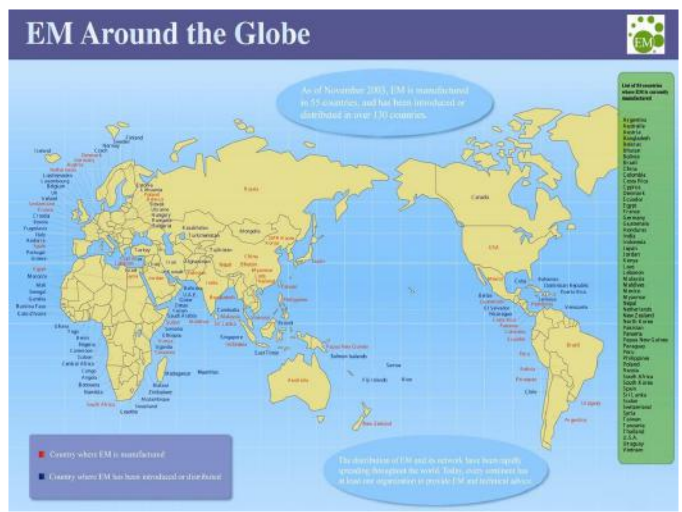
EM was developed in Japan 35 years ago and is now a Global technology with an enormous following around the world. EM is the unique composition of a diverse group of bacteria, yeasts and fungi (multiple families containing multiple species) which has been thoroughly tested and proven safe for humans and Animals. One of the strengths of EM is that it is a diverse combination of microbes, and this gives it versatility in terms of a wide scope of applications that it can be used on.

Development of EM

EM was developed by Professor Teruo Higa in the early eighties. The seed of what was to become EM germinated when Dr. Higa was researching mandarin oranges for his doctorate in Horticulture at Kyushyu University Graduate School. It was there that he realized the potential of microorganisms in agriculture and this discovery took his research in a new direction. After he returned to University of the Ryukyus in Okinawa, he continued his research with safe and harmless microorganisms only. For this reason, he usually collected several strains all in the same bucket in order to dispose of them at the end of the day. One day, he felt it was such a waste to flush these strains down the drain, considering their costs, and decided to sprinkle them on a patch of grass instead. A week later, an obvious difference was noticed in the growth of the grass where the strains were applied. That was when he realized that the key was the combination of microbes. After many trials and errors, Dr. Higa discovered an optimal mix in 1980 that promoted healthy plant growth and coined the name "EM" for that group. His development of EM has brought him international recognition and now he provides guidance and assistance in the application and research of EM around the world through EMRO the EM Research Organisation. Under the guidance of EM Research Organization (EMRO), the use of EM has quickly spread quickly and is a truly global technology. In 2016, 4,145,343 litres of EM1 was made globally across 53 nations and used in over 150 nations. The image (right) gives a good overview of just how prevalent EM use is around the world.

EM in New Zealand

Following 24 years as a Researcher working in Agricultural and Horticultural Research, Mike Daly heard a presentation about EM at an IFOAM conference in Brazil in 1992. EM was then imported into New Zealand from Japan for research purposes in 1994 and Scientists from Government research institutes, AgResearch and
HortResearch, conducted research from 1994 to 1997. The research was based on using EM in New Zealand systems and positive results using EM were obtained (Daly 1996, Chamberlain et al., 1997, Daly & Stewart 1999), which encouraged New Zealand researchers and growers to seek the further development of EM technology in this Country.



In early 1998 an EMRO Technical Officer from Japan came to New Zealand and facilitated the setting up of a production plant to make EM under a charitable trust, NZNFS. Following this Naturefarm/EMNZ was founded in 2001 by Mike Daly as a trading company for EM in New Zealand. From small beginnings the company now has a factory and office in the heart of Christchurch. The company manufactures EM products for distribution and sale throughout New Zealand.

The Power of EM: Functions and Benefits

1 IMPROVE FERT PERFORMANCE

There are many compounds both organic and inorganic that are largely unavailable to plants, in fact a lot of these compounds are nutrients we add in fertilisers and also organic matter recycling. This leads to wastage and nutrient leaching as they are not being used by the plants. However, EM can solubilise these compounds and make them available for uptake by the plants root system. These microbes will also make it easier for plants to access these nutrients and allow the plant to put more energy into growth. In performing this important function the microbes create a more efficient use of added nutrients, generating a better growth response from fertiliser inputs.

2 ENHANCE PLANT GROWTH

EM will prevent the production of ammonia during protein decomposition, metabolizing proteins in such a way that amino acids are produced instead. These amino acids can be directly absorbed by plants. In addition, EM stimulates the biological production of plant growth regulators- PGRs. PGR compounds are hormones, and have an important role in plant growth, often called phytohormones, they regulate growth, development, and the plants responses to stimuli.

3 INCREASE SOIL DIVERSITY

Huge beneficial effects are generated when the groups of microorganisms in EM, activate native microorganisms in the environment and harness their intrinsic power. EM will stimulate and support the growth of other beneficial organisms like mycorrhizal fungi, worms, and insects already in your soil, bringing nature back into balance and helping to product a healthy functioning biological soil.

4 DECOMPOSE ORGANIC MATTER

EM will help the decomposition of organic materials, and during fermentation will produce normally unavailable organic acids, such as lactic acid, acetic acid, amino acid, malic acid and bioactive substances and vitamins. A key ingredient in this process is organic matter which is supplied by pasture residuals, (dead matter) recycling crop residues, and green and animal manures. In addition, this process leads to increased humus in the soil.

5 IMPROVE SOIL STRUCTURE

EM will help build soil structure by stimulating the biological function in the soil. EM adds both fungi and bacteria to a soil and stimulates resident microbes to speed up the biological function of a soil to breakdown organic matter and build a positive soil structure. Soil microorganisms produce many different kinds of organic compounds including polysaccharides, which help to bind soil particles together into stable aggregates and improve the soil structure.

6 REDUCE COMPACTION

A healthy soil and stimulated biological activity help build stable aggregate and soil structure. Increase aggregate stability prevents the pore spaces between the aggregates from collapsing during heavy, saturating rains and reduces compaction. Improved soil aggregate stability reduces soil erosion and run-off. Soils are better able to absorb and retain moisture, as well as cycle nutrients.

7 PROTECT AGAINST DISEASE

By applying EM pests and pathogens are reduced or suppressed through natural processes by enhancing the competitive and antagonistic activities i.e. through competitive exclusion. The competitive exclusion principle of ecology states that two species competing for the same resources cannot coexist if other ecological factors are constant. So when you inoculate with EM you provide an advantage and the beneficial microbes prevent pests, diseases, and pathogens via 3 pathways: 1. by taking up the physical space so that competitors have no space in which to live; 2. by taking up the resources so that competitors have no resources upon which to live; 3. by feeding upon and killing competitors, thus directly reducing pests, pathogens, and diseases.

8 ENHANCE FOLIAR NUTRIENT UPTAKE

EM will enhance foliar nutrition response by the stimulation of stomatal openings, following the sudden influx of CO_2 (from the billions of organisms per teaspoon). This has been referred to as Microbial-enhanced nutrient delivery, a concept which states "The higher the number and diversity of micro-organisms living on the leaf-zone or root-zone, the more efficient the utilisation of applied nutrients".

Results - Pasture

Independent Pasture Trial - Canterbury NZ

An independent pasture trial run by PastureFirst showed that EMNZ Products Enhance Production, Clover and help to reduce Nitrogen. All three EM products showed that they have a positive effect on pasture production. While on their own the level of dry matter production was lower than that of high rates of nitrogen, in combination with lower rates of nitrogen they provide significant benefits.

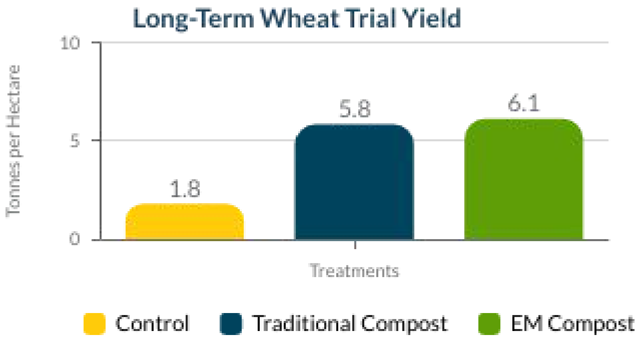
The total dry matter produced by combining either Plant-Stim or EM Soil and Crop with 40kg urea/ha, was equivalent to that grown by applying 80kg urea/ha. This means that farmers can reduce their nitrogen inputs, but can grow equivalent amounts of pasture by adding in one of theses EM products. This has significant production, economic and environmental benefits. The increased level of clover being able to be produced by implementing the above system, compared to high nitrogen systems, will also be a long-term benefit for pastoral farmers.

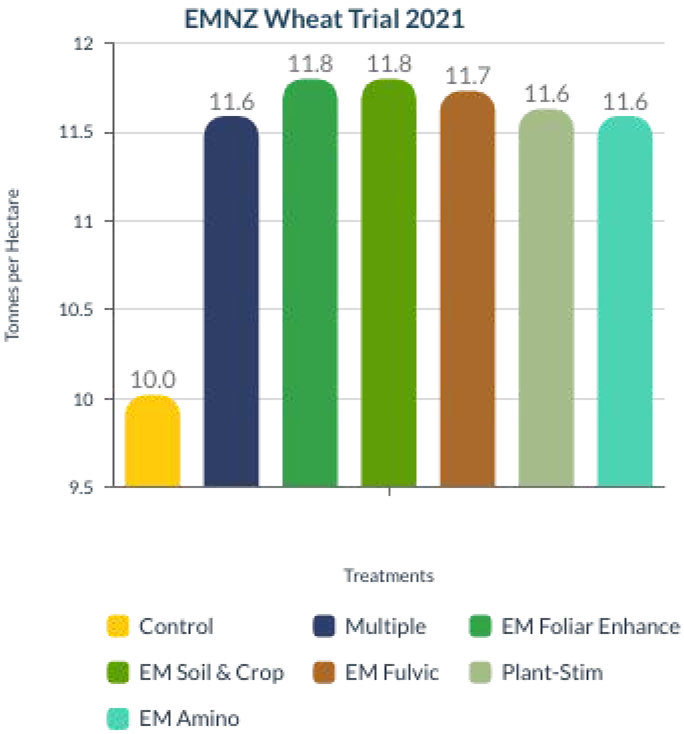
TREATMENT	TOTAL	
Control	11668	d
Urea Full (80 units)	14665	a
Urea Half (40 units)	13134	bc
EM Soil & Crop (20L)	12340	cd
EM Soil & Crop (20L) + Urea (40 units)	14242	a
Plant-Stim (1L)	13117	bc
Plant-Stim + Urea (40 units)	14389	a
EM Fert Enhance (10kg)	12951	c
EM Fert Enhance (10kg) + Urea (40 units)	14034	ab
CV%	6.6	
LSD 5%	1036	
F prob.	0.000	

Results - Wheat

Peer-review International Wheat Trial - China

A long term trial (Cheng & Yingchun, 2012) over 11 Years conducted at China Agricultural University's Qu-Zhou experiment station found that the long-term application of EM compost gave the highest values for the measured parameters and the lowest values in the control plot. The application of EM in combination with compost significantly increased wheat straw biomass, grain yields, straw and grain nutrition compared with traditional compost and control treatment. Wheat straw biomass, grain yields, straw and grain nutrition were significantly higher in compost soils than in untreated soil. This study indicated that application of EM significantly increased the efficiency of organic nutrient sources.





EMNZ Wheat Trial

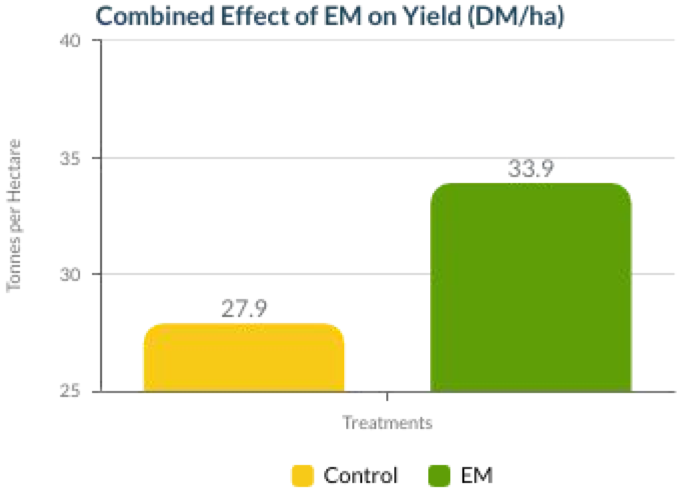
This replicated field trial was designed to determine the effectiveness of EM treatment variations against competitor products and an untreated control on Wheat in Aylesbury. The results showed that EM based foliar products performed very well against a control treatment in addition EM based products generated significant profits over the control.

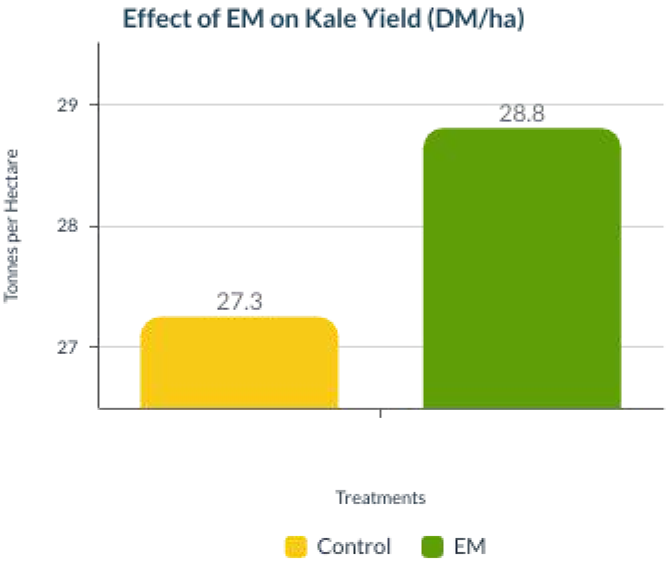
Results - Fodder Crops

Analysis of Five Different Fodder Beet Trials Across Four Years

These trials looked at using EM in both conventional and biological systems (Daly M. J., EMNZ Fodder beet Trial 2014) (Daly M. J., EMNZ Fodder beet Trial Ashcroft 2015) (Daly M. J., EMNZ Fodder beet Trial Seaton 2015) (Daly M. J., EMNZ Fodder beet Trial 2016) and were conducted in Canterbury, New Zealand on Fodder beet. Fodder beet is a crop that has become popular due to its yields and as an important part of dairy cow winter feeding systems. The trials were analysed by Dr Tim Jenkins (Independent Scientist), a summary of the results is as follows:

- The trials conducted from 2014 – 2017 showed great results with an average increase in yield of 19% across 5 different trials.
- EM treatments gave a significant increase over control.
- Nitrogen enhanced EM (EMN-RTU), looks promising.
- Reducing N inputs by 50% and combining EM looks to be a viable option as half rate of N with EM performed as good or better than a full rate





EMNZ Kale Trial

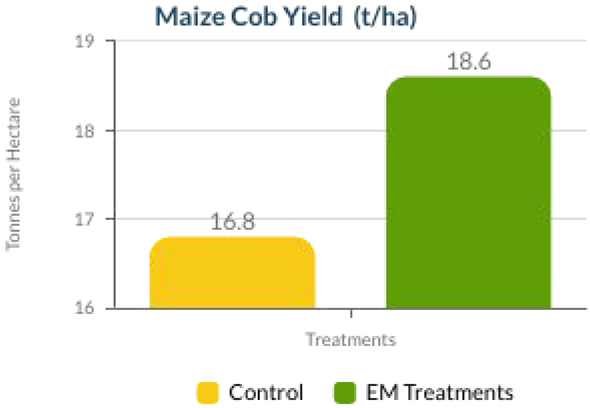
This replicated trial was conducted in Canterbury, New Zealand on Kale and showed a significant result was gained when EM was applied over a fertilised control. The EM treatment gave a 6% increase in yield.

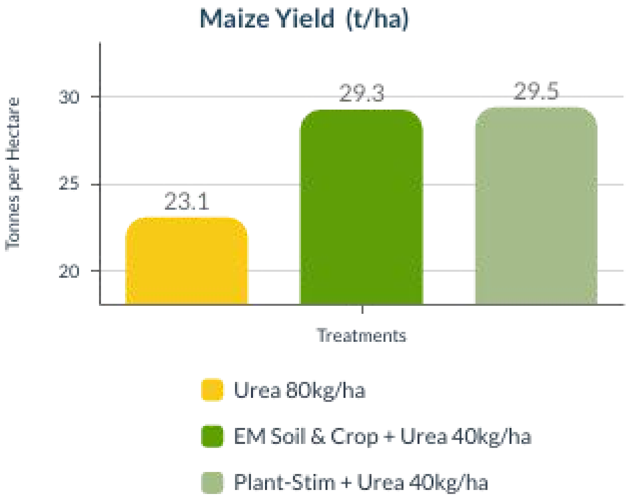
Results - Maize

EMNZ Maize Trial

This replicated trial (Daly M. , 2015) in Canterbury, New Zealand was designed to determine the effectiveness of EM treatments, against a control on Maize, at Ashcroft Farm at Carew. The aim of this trial was to test EM on Maize yield, and in particular compare a number of variations of EM, including some combinations with Nitrogen.

- EM gave a significant and economic yield response when applied to a Maize Crop
- EM Soil & Crop, our standard recommended product, was the best performing treatment
- EM with a half rate of N, performed better than a full rate of N not containing EM





Independent Maize Trial - Hawkes Bay NZ

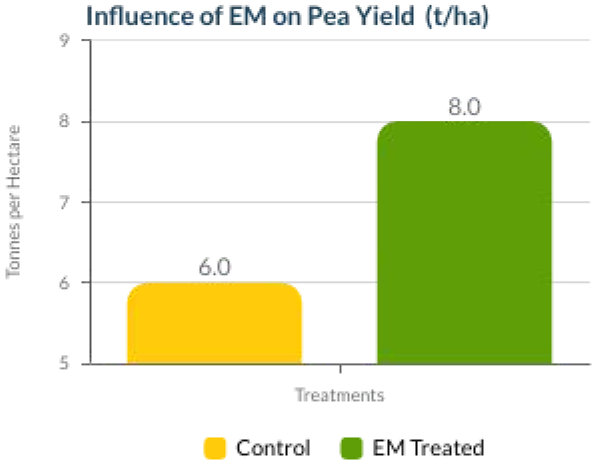
This independent trial run by PastureFirst in Hawkes Bay NZ showed that EM Soil & Crop + 40 kg/ha urea and Plant-Stim + 40 kg/ha urea had the highest maize yield of 29.30 and 29.45 t DM/ha respectively. These treatments were significantly higher than 80 kg/ha and 40 kg/ha urea. These results independently confirmed the following:

- Using EM will give a significant and economic yield response when applied to a Maize Crop
- Both EM Soil & Crop and Plant-Stim are useful tools to stimulate a yield response in Maize
- Both EM Soil & Crop and Plant-Stim with a half rate of N, performed better than a full rate of N not containing EM

Results - Peas and Potatoes

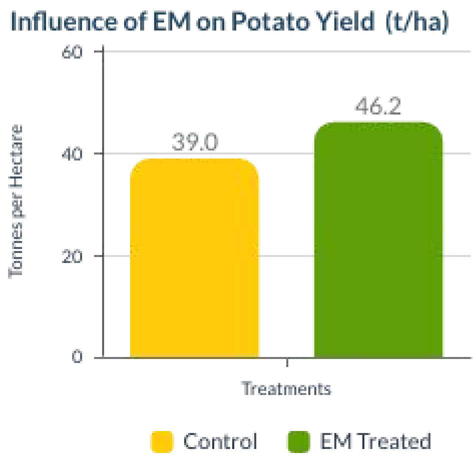
Canterbury Pea Trial

This trial (Daly & Chamberlain, 2002) was conducted in Canterbury, New Zealand on the organic Harts Creek Farm. The peas were sown at 290 kg/ha and had a basal application of 250 kg/ha of reactive phosphate rock applied to correct a low soil phosphate concentration. The trial had four replicates and EM was applied at the previously described rate twice during crop growth. EM increased pea yields by 31% over the control.



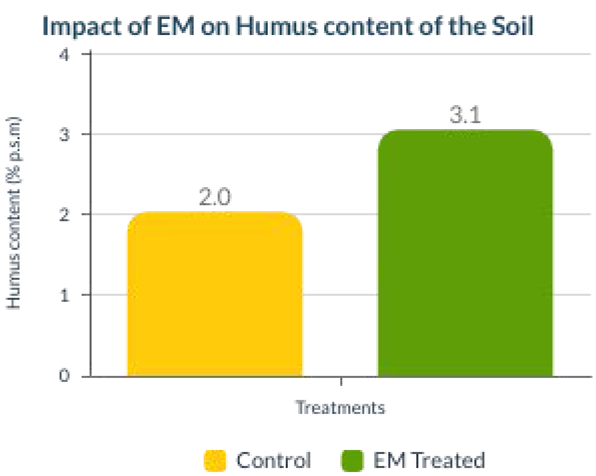
International Potato Trial

This trial (Filarski, 2016) on frites potato was conducted by Agricultural Holding Henryk Makoś, Lebork, Poland. The results showed that EM gave a signficant increase in yield over the fertilised control with an increase of over 7 tonnes per hectare. In additon EM had 2% higher percentage of potatos above 50mm.



Soil Humus Content

In the same trial they looked at the impact EM has on the humus content of the soil. EM was applied on crop residues (straw 100% ploughed) over three years of application. This treatment was across 50 hectares with a large control area. After 3 years soil was tested for the humus content (sample 1 - EM, sample 2 - control).

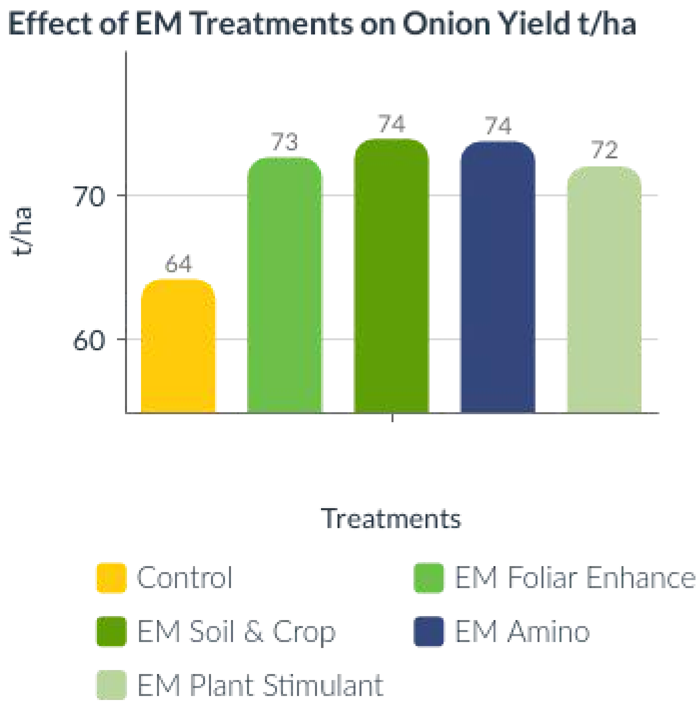


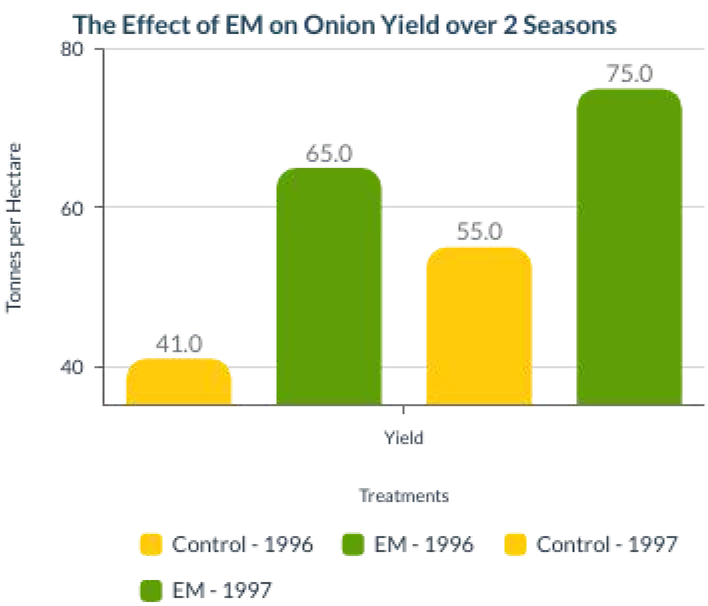
Results - Onion

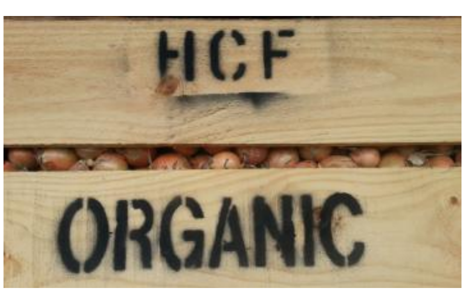
EMNZ Onion Trial - Canterbury 2022

The aim of this trial was to test EMNZ products on Onion yield, table 2 shows the yield results of this trial. The highlights are:

- All EMNZ treatments gave a significant and economic yield response when applied to an Onion Crop
- EM Soil and Crop was the best performing treatment
- None of the EMNZ products were significant against each other
- EM Plant Stimulant showed that the unique combination of plant growth regulators in this product produce powerful plant growth promoting properties







Published Onion Trial

This trial (Daly & Stewart, 1999) run over 2 seasons in Leeston, Canterbury, New Zealand had four replicates and a plot size of 5 by 1.5 m. EM was applied at a rate of 10 L ha-1 with 10 L ha-1 of molasses mixed into water and applied at 10 000 L ha-1 through a watering can onto the foliage of the crop, on November 11, December 22 and January 20.

Crop vigour was accessed visually at bulbing (January 22). At harvest (March 7), the field dried onions were graded and weighed. EM plus molasses caused a significant yield increase over the untreated control and produced more first grade onions. The increase in yield over control when EM was added ranged 15-30% increase in yield. This data has been published in the reputable international Journal of Sustainable Agriculture.

Impact of EM on Soil Properties

In Spain a trial (Valarini, Diaz Alvarez, Gasco, Guerrero, & Tokeshi, 2003) conducted in Madrid, evaluated the properties of a clay loam soil enriched with organic matter and microorganisms under controlled temperature and moisture conditions, over a period of three months. The following treatments were carried out: soil (control); soil + 50t/ha of animal manure (E50); soil + 50t/ha of animal manure + 30L/ha of effective microorganisms (E50EM); soil + 30t/ha of the combination of various green crop residues and weeds (RC30) and soil + 30t/ha of the combination of various green crop residues and weeds + 30L/ha of effective microorganisms (RC30EM). Soil samples were taken before and after incubation and their physical, chemical, and microbiological parameters analysed.

A significant increase was observed in the production of exopolysaccharides and basic phosphatase and esterase enzyme activities in the treatments E50EM and RC30EM, in correlation with the humification of organic matter, water retention at field capacity, and the cationic exchange capacity (CEC) of the same treatments. The conclusion was drawn that the incorporation of a mixture of effective microorganisms (EM) intensified the biological soil activity and improved physical and chemical soil properties, contributing to a quick humification of fresh organic matter. These findings were illustrated by the microbiological activities of exopolysaccharides and by alkaline phosphatase and esterase enzymes, which can be used as early and integrated soil health indicators

Table 1. Physical, chemical and microbiological parameters of a claim loam soil with kinds and amounts of organic matter incorporated, before and after incubation

Parameter	Treatment[1]				
	C	RC30	RC30EM	E50	E50EM
pH[2]	7.79 a	7.36 b	7.43 b	7.42 b	7.39 b
pH[3]	7.74 a	7.74 a	7.26 a	7.65 a	7.40 a
EC (μS cm^{-1} a 25 ºC)[2]	624 a	864 ab	1529 c	1200 bc	1476 c
EC (μS cm^{-1} a 25 ºC)[3]	896 a	1283 a	1429 ab	3077 c	2339 bc
%C (g kg^{-1})[2]	1.49 a	1.69 a	1.72 a	1.54 a	2.04 b
%C (g kg^{-1})[3]	1.49 a	2.71 b	3.76 c	3.67 c	4.32 d
%N (g kg^{-1})[2]	0.15 a	0.21 a	0.21 a	0.3 b	0.33 b
%N (g kg^{-1})[3]	0.20 a	0.24 a	0.29 a	0.30 a	0.33 b
C/N[2]	9.93 a	8.05 a	8.19 a	5.13 b	6.18 b
C/N[3]	7.45 a	10.29 a	12.96 b	12.53 b	12.34 b
%FC[2]	22.98 a	25.03 b	29.59 c	30.56 cd	31.33 d
%FC[3]	24.57 a	25.71 a	34.21 c	31.28 b	34.37 c
CEC(mmol dm^{-3})[2]	13.74 a	14.6 a	14.43 a	15.65 a	16.43 b
CEC (mmol dm^{-3})[3]	14.61 a	14.6 a	15.01 ab	16.42 bc	16.85 c
%CTHE[2]	0.53 a	1.03 b	1.13 b	1.02 b	1.36 c
%CTHE[3]	0.98 a	1.36 b	2.14 c	1.91 c	2.42 c
%CHA[2]	0.21 a	0.22 a	0.40 b	0.60 c	0.76 d
%CHA	0.47 a	0.47 a	0.90 b	1.14 c	1.43 d
%CFA[2]	0.32 a	0.72 b	0.74 b	0.39 c	0.58 c
%CFA[3]	0.51 a	0.88 abc	1.15 c	0.80 ab	0.99 ac
%CTHE/%CHA[2]	2.52 ab	4.16 c	2.93 b	1.64 a	1.75 a
%CTHE/%CHA[3]	2.07 a	2.87 b	2.24 a	1.64 a	1.69 a
%CTHE/%C[2]	0.35 a	0.64 b	0.68 b	0.69 b	0.66 b
%CTHE/%C[3]	0.66 b	0.52 a	0.57 a	0.51 a	0.58 a
%CHA/%CFA[2]	0.67 a	0.32 a	0.52 a	1.56 b	1.33 b
%CHA/%CFA[3]	0.93 ab	0.54 a	0.81 a	1.56 b	1.45 b
Alkaline Phosphatase (μg g^{-1} h^{-1} soil)[2]	66.54 a	125.76 b	163.40 c	114.98 b	127.08 b
Alkaline Phosphatase (μg g^{-1} h^{-1} soil)[3]	152.14 a	344.65 bc	394.11 c	320.09 b	564.17 d
Esterases (μg g^{-1} h^{-1} soil)[2]	35.10 a	60.24 c	81.45 c	47.97 b	69.37 d
Esterases (μg g^{-1} h^{-1} soil)[3]	40.39 a	49.81 ab	92.37 c	59.60 ab	75.10 bc
Exopolysaccharides (mg g^{-1} soil)[2]	0.04 a	0.06 b	0.08 b	0.12 c	0.13 c
Exopolysaccharides(mg g^{-1} soil)[3]	0.26 a	0.71 b	0.96 cd	0.89 bc	1.11 d

[1] C = soil (control); E50 = soil + 50 t ha^{-1} of animal manure; E50EM = soil + 50 t ha^{-1} of animal manure + 30 L ha^{-1} of effective microorganisms (EM); RC30 = soil + 30 t ha^{-1} of mixed fresh plant debris; EM (RC30EM) = soil + 30 t ha^{-1} of mixed of various green crop residues and weeds + 30 L ha^{-1} of EM. [2] one and [3] months after addition of organic matter in the soil. Average of three replications. Values in horizontal row followed by the same letter(s) are not significantly different according to Tuckey ($P \leq 0.05$).

Impact of EM on Soil Chemical Properties

The long-term soil amendments caused significant changes in soil physical-chemical properties (Table below). Soil bulk density and pH were significantly ($p < 0.05$) lower in the two compost plots than in the control plot. Moreover, soil pH was significantly ($p < 0.05$) lower in the EM compost plot than in the traditional compost plot. Soil organic matter, total N, alkaline-hydrolysable nitrogen, and available K content was significantly ($p < 0.05$) higher in the two compost plots than in the control plot. Soil available P and K content was significantly ($p < 0.05$) higher in the EM compost plot than in the traditional compost plot.

Treatment	Soil organic matter (g/kg)	Total N (g/kg)	Alkaline N (mg/kg)	Available P (mg/kg)	Available K (mg/kg)	pH	Bulk Density (g/cm^3)
Control	12.86b	0.81b	68.43b	4.07c	80.86c	7.53a	1.47a
Traditional Compost	20.86a	1.20a	103.71a	36.29b	161.75b	7.26b	1.32b
EM Compost	21.32a	1.29a	111.98a	50.69a	207.21a	7.15c	1.33b

Another trial (Lim, Pak, & Jong, 1997) conducted in Korea, looked at the effect of EM treatment on the content of nutrients in the soil. The EM treatment increased the content of soluble nutrients. The contents of soluble nitrogen, phosphorous and potassium increased 4.4, 3.6 and 2.8 mg/100g soil, respectively. The increase of soluble N, P and K contents might be attributed to activity of nitrogen fixers and organic acids excreted by the different organisms in EM.

		Content of Soluble Nutrients (mg/100g soil)		
Treatment	pH (KCl)	Nitrogen	Phosphorus	Potassium
Control	5.1	8.3	12.3	20.0
EM + Bokashi	5.2	12.7	15.9	22.8

Impact of EM on Soil Microflora

This trial (Higa & Wididana, 1991) conducted by EM developer Professor Dr Terou Higa and Gene Widdiana at the University of Ryukus in Japan looked at the changes in the Soil Microflora Induced by EM. In the study reported here, EM cultures increased the number of Enterobacter spp. and starch digesting bacteria in soil. EM products markedly suppressed the number of Verticillium, Thielaviopsis, and Fusarium fungal species that are destructive soil borne plant pathogens while also significantly increasing the population of Trichoderma and Penicillium species that are known to suppress plant pathogenic fungi in soils: Soil physical properties, including cultivation depth and porosity, were generally improved by EM treatment.

Treatment	Bacteria x 10^5	Fungi x 10^3	Actinomycetes x 10^4
Control	47.8	9.42	17.9
Fertilised Control	59.4	23.1	8.38
EM	147	35.5	29.6

In another trial (Lim, Pak, & Jong, 1997) conducted in Korea the effect of EM on the number of microorganisms in the soil was measured. The below table shows that the EM treatment increased the number of aerobic bacteria, anaerobic bacteria, nitrogen-fixing bacteria and actinomycetes 10.5, 17.8, 49.6, and 1.7 times over the control, respectively.

Treatment	Aerobic Bacteria x 10^7	Anaerobic Bacteria x 10^6	Actinomycetes x 10^5	Nitrogen Fixers x 10^4	Filamentous fungi x 10^4
Control	1.1	1.3	1.5	1.1	5.3
EM	11.6	23.1	2.6	54.6	6.0

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Note: Copies of these Trials can be provided upon request.

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