Further Submission on Lake Rotorua Nutrient Management - Proposed Plan Change 10

Clause 8 of Schedule 1, Resource Management Act 1991

Please send your submission to be received by **4:00 pm, Monday, 1 August 2016.**

Further Submission Number
Office use only
FS 01

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18 JUL 2016
Bay of Plenty Regional Council

TO: The Chief Executive
Bay of Plenty Regional Council
PO Box 364
Whakatāne 3158

FAX: 0800 884 882

EMAIL: rules@boprc.govt.nz

Name: CHRISTOPHER RUSSELL HOOK
[Full name of the person or organisation making the submission]:

This is a further submission in support of or opposition to a submission on Lake Rotorua Nutrient Management - Proposed Plan Change 10 to the Bay of Plenty Regional Water and Land Plan.

1. I do ~~or do not~~ wish to be heard in support of my further submission. *[Delete as required].*
2. If others made a similar submission I ~~would or~~ would not be prepared to consider presenting a joint case with them at any hearing. *[Delete as required].*
3. I am: [Please tick one]

   ☐ *A person representing a relevant aspect of the public interest. (Specify on what grounds you come within this category).*
   ☑ *A person who has an interest in the proposal that is greater than the interest the general public has. (Specify on what grounds you come within this category).*

   On the following grounds:
   I HAVE KNOWLEDGE & EXPERIENCE FROM WORKING WITH SUMAGROW TECHNOLOGY IN EUROPE.

Signature *[of person making submission or person authorised to sign on behalf of person or organisation making submission. A signature is not required if you make your submission by electronic means].*

Address for Service *[Provide full postal details]:* C/- P.O. BOX 27793 MT ROSKILL AUCKLAND

Telephone: **Daytime:** 09 436 5923 **After Hours:** 021 909. 874

Email: Chris@farmorganix.com.au. **Fax:**

Contact person *[Name and designation if applicable]:*

Note: A copy of your submission must be served on the original submitter within 5 working days after making this further submission.

FURTHER SUBMISSION POINTS:

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Submission number *[Submission number of original submission as shown in the "Summary of Decisions Requested" report]*	**Submitter name** *[Please state the name and address of the person or organisation making the original submission as shown in the "Summary of Decisions Requested" report]*	**Section reference** ***(Submission point)*** *[Clearly indicate which parts of the original submission you support or oppose, together with any relevant provisions of the proposed plan change]*	**Support/oppose**	**Reasons** *[State in summary the nature of your submission giving clear reasons]*
90-1	CHRISTOPHER RUSSELL HOOK 12 CHARLISE PLACE ONERAHI WHANGAREI 0110.	ALL.	SUPPORT	SEE LETTER + SUBMISSION FOR DETAILS.

Note: A copy of your submission must be served on the original submitter within 5 working days after making this further submission.

FS 01

C R (CHRIS) HOOK

12 Charlise Place,
Onerahi
Whangarei 0110
Ph: 09 436 5923

12 July 2016

The Chief Executive
Bay of Plenty Regional Council
PO Box 364
Whakatane 3158

Dear Sir

Proposed Plan Change 10
Lake Rotorua Nutrient Management

I enclose my supplementary submission on the above matter after having reviewed the summary schedule of all submissions and read those by Federated Farmers and the Lake Rotorua Primary Producers Collective.

I have no comment to make on the opposing submissions other than to say that virtually all assume the only way to continue fertilizing agriculture land in the catchment is with NPK. This is no longer a valid assumption.

Only parties who lack knowledge about the performance capability of polymicrobial technology known as Sumagrow, which is an organic bio-fertilizer recently registered with the Ministry of Primary Industries, or have vested interests in supporting the continued use of NPK as the principal fertilizer for pastoral land and food crops, have reason to oppose Proposed Plan Change 10.

Parties who support the proposed changes are focused on water quality and the environment, but have limited interest in the economic impact on farmers if forced to reduce their present levels of chemical nitrogen inputs or change their properties land use.

A fertilizer regime based on Sumagrow will either solve or go a long way towards solving the problem of excess nitrogen in the lake, and satisfy the outcome sought by all parties with perhaps the exception of chemical fertilizer suppliers.

Need for Regulation

Experience tells me that regulation is the only way to effect a meaningful change in farmers fertilizer practices within a reasonable period of time.

This is reinforced in a recent publication from AgResearch, DairyNZ, and others, who performed trials under the 2011 Sustainable Farming Fund Project relating to dairy farming in the Lake Rotorua catchment.

I quote below from the section dealing with farmer engagement;

"The final conclusion being that any significant changes (over and above the efficiencies undertaken by catchment farmers) would require a shift in the regulatory environment and or provision of incentives".

The study concluded that;

"Farmers also have a strong desire to see recommended mitigations fully tested locally at the farm scale rather than just modelled or tested in small plot trials".

Need for trials

Large scale, on-farm trials with Sumagrow are what I recommend over a three year period, during which some financial incentive might be appropriate; E.g. some farmers may take this opportunity to convert to organic production.

Abron Limited has made application under the Low Nitrogen Land Use Fund, to conduct pasture trials with Sumagrow. These are being supported with free product and technical support from the US manufacturer of Sumagrow.

The Abron trials will not cover the full spectrum of benefits that accrue to users of Sumagrow, nor are they likely to be held in sufficiently high regard by the scientific community and Federated Farmers for the available product containing Sumagrow ("StandUp") to become a new industry fertilizer standard.

While farmers within the Lake Rotorua catchment can be confident about growing grass and fodder crops with Sumagrow there is limited data regarding the beneficial effects that it will have on nitrogen leaching from cow urine, and quality and quantity of milk production. We know there will be benefits, but further research is required to quantify and value them.

For these reasons comprehensive trials need to be conducted by an appropriate party that can act independently and without any external pressure or influence.

Expertise is available to conduct a comprehensive trial programme similar to that conducted under the 2011 Sustainable Farming Fund referred to above and Council has funding available for such research.

Farmorganix Europe S.R.L., a licensee of Sumagrow technology, and a company in which I am a director and shareholder, is in preliminary discussions with the EU Directorates for Agriculture and the Environment with a view to conducting a trial programme with Sumagrow and having it included in one of the subsidy schemes offered to farmers who reduce the use of NPK or want to convert to organic production.

The EU has committed a huge sum of money over the next five years to improve water quality in the badly polluted rivers and waterways of Europe and to encourage farmers with various incentives to reduce their consumption of NPK fertilizers.

Several countries within the EU have already placed restrictions on the use of NPK either as to the amount that can be applied and or when it can be applied. They have determined that effective control of nitrogen leaching requires regulation.

Third party influence

There are many parties whose economic livelihood is dependent on the continued use of NPK. Collectively they have a powerful voice, and their opinions carry weight with politicians and parties who do not understand the real long-term benefits that can be achieved using polymicrobial technology.

Those in the fertilizer industry know that polymicrobial technologies are beginning to challenge the use of chemicals and that once accepted by farmers the use of NPK will begin into decline.

Worldwide growth in the use of microbes for agriculture is already significant and is projected to increase over the five years ending 2020 at the compound rate of 15%, and the projected value of products used will be approximately US$5 billion.

The chemical fertilizer industry is in a very similar position to the tobacco industry of some 20 years ago. Cigarette manufacturers knew then that smoking tobacco was harmful to human health but they remained in denial until there was overwhelming evidence to the contrary.

Cigarette smoking has only declined significantly in New Zealand because of regulation; increasing excise tax, enforcing the use of plain packaging, prohibiting advertising, and requiring retailers to hold cigarette stocks out of sight in cabinets.

Plan Change 10 provides a real opportunity to clearly demonstrate that bio-technology has advanced to a point where it is no longer necessary to use NPK in large volumes to grow food for cattle and humans.

Sumagrow technology will provide Council with a solution to a significant environmental problem within its territory, and to which there is much opposition from farmers who do not want to change their historical use of NPK.

Sumagrow also provides Council with an opportunity to be seen as decisive in the face of broad opposition to Plan Change 10, and to lead the way for other Regional Councils that have similar water quality issues to resolve.

Sumagrow technology offers farmers an option to continuing to use NPK, and in particular those who face the possibility of being required to change their land use because of excess nitrogen leaching from their properties.

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Finally, there can be little doubt that StandUp with Sumagrow inside and other polymicrobial products will become widely used throughout agriculture, which will have long-term benefits for New Zealand's primary industries, and the Government's vaunted, very expensive but somewhat tarnished "Clean Green" image New Zealand projects to the World.

I leave for Europe later this month but plan to return in time for the hearing and have indicated I wish to be heard.

In the meantime, I will be available via email, and if there is any interest on Council's part to have a discussion about Sumagrow technology, a senior executive of Bio Soil Enhancers Inc. is resident in New Zealand and would be available to attend.

Yours faithfully,

C R Hook

CC: Prof. Warren McNabb – Director of Research, AgResearch Limited
Gisele Schweizer – Co Chair, Lake Rotorua Primary Producers Collective

Gmail by Google

Chris Hook <chris@durabanauckland.co.nz>

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Sumagrow technology - as a replacement for NPK

2 messages

Chris Hook <chris@durabanauckland.co.nz> Tue, Jul 12, 2016 at 11:24 AM
To: "McNabb, Warren" <warren.mcnabb@agresearch.co.nz>

Hello Warren,

We have not spoken for a long time regarding the use of this poly-microbial as an alternative fertilizer to NPK.

I have also been spending considerable time in Eastern Europe setting up a new Farmorganix operation, registering and establishing distribution of Sumagrow.

I am returning to Europe shortly and will be having discussions with the EU Commission in Brussels and the Sustainable Agriculture Institute. Our aim is to get Sumagrow into one of the EU subsidy programmes that are focused on encouraging farmers to reduce the use of chemical nitrogen.

Lowering nitrogen inputs is a big issue being addressed by the EU, and several member countries have already put new regulations in place that limit application rates and time of year when NPK can be applied.

A product called "StandUp" (active ingredient being Sumagrow) is now registered with MPI in NZ as a bio-fertilizer and a number of trials will be starting next spring with pasture and vegetables.

Sumagrow is USDA NOP certified and registered with OMRI as an organic input.

My recent discussions with Assure Quality indicate that StandUp will be certified as organic and that should mean it is an organic input for milk and meat production.

I have learned a great deal about fertilizing land over the last three years and there can be no doubt that new poly-microbials such as Sumagrow will play an increasingly important role in future.

We have conducted more than 100 field trials in Greece, Bulgaria, Romania and Ukraine, and these confirm that with cereals, vegetable crops, cotton, and some fruits, the inclusion of Sumagrow in a fertilizer programme outperforms NPK in terms of crop yield, and provides growers with a number of other benefits including significantly lower leaching rates and greenhouse gas emissions.

We have not conducted trials on pasture in Europe but a large number of independent trials with corn, pasture and fodder crops have been conducted in the USA.

I don't understand why mainstream research still being conducted by DairyNZ and AgResearch assumes that fertilizing with Urea is the only practical way to grow grass, and fodder crops.

Poly-microbials such as Sumagrow are the fertilizers of the future. Why is no research being undertaken with them?

Much evidence has been accumulated worldwide that confirms the need for farmers and growers to change their fertilizer programmes from the use of NPK to biological products if agriculture is going to become sustainable in the long-term.

The view held by numerous people with whom I come into contact is that the chemical fertilizer industry is a significant blockage to progress, in the same way the tobacco industry was to reducing cigarette smoking.

Government intervention and regulations became necessary to lower cigarette consumption and the same intervention appears likely to be necessary to reign in the use of NPK once bio-fertilizers are accepted as a new industry standard at a senior political level.

There is an increasing awareness of the imperative to reduce the use of chemical fertilizer in this country, and in a publication I read recently by AgResearch / DairyNZ, who conducted a study under the 2011 Sustainable Farming Fund Project in the Lake Rotorua catchment, it is stated that regulation will be necessary to change farmer habits and reduce the annual nitrogen discharge into Lake Rotorua.

We are taking a keen interest in the Bay of Plenty Regional Council's Plan Change 10 which is addressing nitrogen leaching into Lake Rotorua.

I have made a submission supporting the changes and I think I am the only submitter to say that the reduction can be achieved more quickly than proposed through requiring farmers to replace NPK with a bio-fertilizer.

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I have recommended that chemical nitrogen be prohibited from use in the catchment for pasture and forage production after a three year transition period, and that it is limited to 50% of the current grower standard application rate for food and horticultural crops.

I have also read much of the material published by DairyNZ including "Reducing Nitrogen Loss" and "Forage Systems to Reduce Nitrate Leaching".

Modern dairy farming has become a sophisticated business, and I won't pretend to understand the science, but it seems to be getting overly complicated for farmers through having to compensate in many ways for the detrimental effects of chemical nitrogen.

Once farmers know there is a proven bio-fertilizer readily available that can replace Urea, keep their animals healthier, produce more and better quality milk, and contribute to protecting the environment for future generations, they will use it.

Furthermore, farms are likely to be able to carry higher stock numbers, which will lead to higher incomes and increase the value of properties rather than have values impacted negatively by the Overseer model, and regulations, which, from what I have read in the submissions to Plan Change 10 are not well received by many farmers.

Surely, the new poly-microbial technology warrants the attention of our agriculture scientists? It is in the interest of New Zealand's economy and environment to do so.

It also concerns me that so much public money is being spent on wide ranging research based around the use of NPK, when new technology available that solves many of the problems associated with it use.

In NZ, the big volume market is in fertilizing pasture, and Sumagrow is proven to be particularly effective and can essentially replace Urea.

We have the product available, its cost is competitive, it is more productive, and environmentally friendly. Is this not what progressive farmers are seeking?

Sumagrow is stable, has a long shelf life at ambient temperature, and is available in large volumes. It is applied conventionally as a spray, and can be co-applied with other nutrients.

Given the pre-eminent position of AgResearch, I believe it has an obligation to farmers, the Government, and the New Zealand public to take the lead in establishing an independent research programme as it is apparent that farmers are not willing to accept the science of Sumagrow already established in the USA without backing from the agricultural scientists on whom they rely for advice and direction, and fund.

People like Phyllis Tichinin are experts in the biological science of soils and animals, and the attached article by her summarizes succinctly the benefits to farmers from using a product such as StandUp in preference to NPK.

Farmer conservatism and confidence in the performance of chemical fertilizer is a challenge we are facing in Europe and the USA. Farmers know they need to change their fertilizer practices but all want to see Sumagrow perform on their own property and in their growing conditions.

Adoption of Sumagrow by farmers in the Lake Rotorua catchment will solve much the nitrate leaching issue and all parties affected by Proposed Plan Change 10 will get the outcome they seek, whereas now, most of the submissions are in opposition to any change, and no matter the final decision taken, there will be many dissatisfied parties.

I would like to see is a collaborative research programme between Government, (MPI) AgResearch, DairyNZ, and the BOP Regional Council
to demonstrate the benefits of Sumagrow for farmers in the Rotorua catchment..

The BOP Regional Council has substantial funding available to conduct such a programme and AgResearch / DairyNZ have the necessary resources.

I have sent you a copy of my submission by courier. I hope you will read it and respond as whether or not AgResearch is willing to co-operate in establishing a research programme that we are confident will confirm what we already know from extensive research in USA.

I look forward to hearing from you.

Best regards

Chris Hook

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BIOFARMING

After attending some recent rural seminars it became obvious farm expenditure on fertiliser has taken a significant hit in recent times. I have limited knowledge of this field but understand enough to know that although a fertiliser program can be temporarily avoided or scaled back, in the end some sort of solution has to be found. This is why when I read of a possible alternative my interest was sparked and I thought that at the least farmers could explore their options via this article and make up their own mind. The below is a description of this alternative solution from someone who understands this science.

- Seamus

Hi, I'm Phyllis Tichinin and I work as a biological farming consultant and educator. I've been asked to give you a perspective on a powerful new approach to farming.

Biological agriculture is a comprehensive, natural sciences approach that answers the issues vexing our environment and economy. It provides a new farming model that creates fertile soils while growing tasty, nutrient dense products with less fertiliser and eventually no pesticides. I work for the firm Abron where the most crucial aspect of our biological farming program is creating complex soil carbon, called humus, while increasing your bottom line farming profit.

The goal is to create maximum biodiversity and resilience in your soils. This requires an understanding of the complex relationships that govern soil chemistry, microbiology and physics. A full spectrum approach is needed to restore soil mineral balance and microbes, not just single silver bullet products. This full spectrum program involves a focus on calcium, trace elements, bio-stimulants and microbe friendly fertilisers, including humic acids, which feed soil microbes and stimulate carbon sequestration. Regular farm monitoring of the changes in your soil and pasture response are key to the Abron approach. 'You can't manage what you don't measure.'

Biological farming is a new wholistic, hard science approach that improves the performance of fertilisers, so less is used. On an Abron program often a quarter to a half less N or P is applied in the first year, with further reductions over time. The cost per hectare is initially the same and eventually less than a standard urea or superphosphate program. Less water soluble fertilisers in the soil prompts the natural soil microbes to kick in. These microbes can pull nitrogen out of the atmosphere for free and can solubilise locked up phosphorous making it available to the plant. The result is pasture and crops that have higher mineral levels and are healthier, meaning they are tastier to animals and to us. It's about increasing farmer efficiency, productivity and profitability by working **with** the natural system rather than against it.

What I've noticed using an Abron program on my 48 ha irrigated block on the Maraetotara is 5 times higher sugar levels in the forage, with tremendous clover and chicory growth. I've seen big leaps in rooting depth with darkening of the soil profile, along with heaps more worms – as much as 30+ per spade square. Pasture yields are up dramatically. The animals lap it up and put on weight fast. Fertiliser options include everything from dry ferts to fine particle and high tech foliar blends. This approach is catching on fast and we service clients throughout both islands and Australia. In the Hawkes Bay, Abron provides cutting edge, high performance farming programs to various dairies, The Amazing Maize, Village Press Olives, horticulture and hundreds of sheep and beef farms. With a better knowledge of the soil, we harness the power of soil microbes to increase photosynthesis and plant production. This entails the smart use of carefully selected amounts of fertilisers and specialised amendments along with management techniques to boost soil health and production.

The results are humus rich soils that hold more water and don't require high input of agricultural chemicals but get great yields. This approach ticks all the environmental boxes while making soils more balanced and effective in delivering to their full potential. We can improve soil quality while providing real solutions to climate change and the environmental challenges of fertiliser leaching into our streams and rivers. It's about growing great tasting produce that is nutritionally superior and about growing New Zealand's farming profit.

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Proposed Plan Change 10
Lake Rotorua Nutrient Management

This submission supports the nitrogen reduction proposal for Lake Rotorua and I believe the goal can be achieved in a much shorter time frame if the following recommendations are implemented;

1. Prohibit the use of all chemical fertilizers on pastoral land after three years from the date that Plan Change 10 becomes operative.

   Dairy, beef cattle, and sheep farmers to change their fertilizer programmes from NPK to a bio-fertilizer, (Sumagrow) within three years, the effect of which will be to eliminate **all** leaching of nitrates and greenhouse gas emissions from fertilizer inputs.

2. For other than pasture applications, the continued use of NPK should be strictly controlled and regulated to not more than 50% of current application rates, with the chemical fertilizer reduction to be replaced with an appropriate quantity of a polymicrobial bio-fertilizer.

3. While not regarded as essential, Council may consider it appropriate to provide a financial incentive to pastoral farmers and growers who cease or reduce the use of NPK on their properties voluntarily before the implementation of Plan Change 10 or during an agreed transition period after new regulations become enforceable.

   Farmers and growers to be required to support any claim for economic loss as a consequence of converting from chemical fertilizer, which I would not anticipate because of the proven benefits from the adoption of Sumagrow and, e.g.

   i) Farmers have an opportunity to convert to organic production and obtain the benefits of higher prices paid on the global markets for dairy products and meat.

   ii) The cost of Sumagrow is likely to be lower than the cost of NPK.

4. The BOP Regional Council to fund an independent research programme to confirm the benefits for farmers and growers in the catchment who convert from using NPK to a bio-fertilizer.

Should BOP Regional Council decide to implement a research programme involving Sumagrow, I am confident that the technical resources of Bio Soil Enhancers Inc. will be made available to assist, and that an initial supply of Sumagrow will be offered to farmers and growers on favourable terms.

FS 01

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12 Charlise Place,
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Ph: 09 436 5923

5 July 2016

The Chief Executive
Bay of Plenty Regional Council
PO Box 364
Whakatane 3158

Dear Sir

Supplementary Submission
Proposed Plan Change 10
Lake Rotorua Nutrient Management

My original submission was prepared in some haste after the April'16 cut-off date.

Since then I have gathered more data, and reviewed the detailed submissions by Federated Farmers and the Lake Rotorua Primary Producers Collective, ("the Collective") which can be summarized by saying they oppose any proposal that seeks to regulate the present farming activities of landowners in the Lake Rotorua catchment.

They wish to continue the existing research programmes on the basic premise that the only effective way to grow pasture and fodder crops is with nitrogen based fertilizers ("NPK").

However, the recent availability of new polymicrobial technology known as "Sumagrow" offers a real alternative to the continued use of NPK.

I believe that if farmers and growers change their fertilizer practices and use the new technology the volume of nitrates leaching into Lake Rotorua will reduce significantly without any adverse effect on production, or income of farmers and growers.

Simplistic analysis of the likely reduction in leaching is as follows;

Plan Change 10 requires 240 tons of nitrogen reduction to be achieved through new regulatory rules and voluntary land use change.

I believe much of this reduction can be achieved by farmers switching to the use of Sumagrow.

As I do not have accurate information relating to the tonnage of nitrogen applied annually in the catchment, or the rate of leaching, I have therefore referred to public information released by the Waikato Regional Council, and applied conservative NPK application and leaching rates to the 5,050 ha of dairy farms and 16,125 ha of sheep and cattle farms operating in the Lake Rotorua catchment. Assumptions;

1. An average NPK application rate of 150kg/ha* for dairy farms and 10kg/ha for sheep and cattle farms, which means the total NPK applied each year within the catchment is approximately 900 tons. (*low for intensive dairy farming).

2. Leaching rate from NPK applied; 30% and 40%.

The NPK leached into streams and rivers would approximate 300 tons at a rate of 30%, and if 40% it would be closer to 350 tons.

If all dairy, sheep and cattle farms converted to a Sumagrow based fertilizer programme the target reduction required by Plan Change 10 is likely to be achieved, and there would be no need to change land use.

It is apparent from the Collective's submission that they believe Council is seeking to use Plan Change 10 to force a change in land use from pastoral farming to forestry, which from many perspectives would be a retrograde step.

Such can be avoided by farmers in the catchment if they adopt the new polymicrobial fertilizer option, and they will soon come to the realization that NPK is neither efficient nor cost effective when compared with Sumagrow.

How much nitrogen can be taken out of Lake Rotorua annually through changing fertilization from NPK to Sumagrow needs to be determined through careful evaluation and trials.

DairyNZ has been conducting extensive nitrogen leaching trials with NPK over the last four years, so they have the facility, personnel, and resources to conduct trials with Sumagrow and readily determine the benefits from adopting Sumagrow.

However, I would still advocate that Council prohibits the use of NPK on at least all pastoral land, in which case an immediate and significant benefit will be achieved, and any local trials will only serve to confirm what is known from extensive trials in the USA.

Much research to date has been focused on nitrogen leaching from cow urine and we know that changing from NPK to Sumagrow will have a beneficial effect. Soil will retain more urine in the area of root systems for use by the plants, and will certainly prevent surface runoff in rain water where the soil is compacted and has low organic matter ("OM"), which is typical of soil fertilized with NPK. (Refer schedule item 2).

In this paper by Dr. Allen Williams, who is one of the leading agricultural scientists in the USA, he has said that for every 1% increase in soil organic matter more than US$750 of organic N P & K is available for pasture growth plus other vital macro and micro nutrients.

This paper also refers to the various microbes that contribute to high OM soil and plant growth etc. All of these are present in the Sumagrow formulation.

However, despite the extensive research by eminent scientists in the USA, and the clear evidence of the benefits of high OM pasture, New Zealand farmers and agricultural scientists will only be convinced by authorative and independent trials conducted in New Zealand.

Based on personal experience, including that obtained from working in Europe over the last three years, I believe the only effective way for Council to reduce the volume of nitrogen entering Lake Rotorua is through regulation and one way to guarantee a substantial reduction is to prohibit the use of NPK as an input for pasture growth, and limit its use with other crops.

In my original submission I referred to the new technology developed in the USA and known as "Sumagrow", which is now well proven as a practical and cost effective organic fertilizer.

In future, Sumagrow technology and new derivatives will have far reaching beneficial effects on agriculture production while also having a beneficial impact on the environment.

The schedule to this submission provides various papers relating to the discovery of Sumagrow at Michigan State University and from recognized experts in the field of soil biology. These discuss the value of high soil organic matter (OM) and the consequences of continuing to use chemical fertilizer that creates soil with low OM.

Also included are summary reports on a large number of trials conducted in the USA which have as their overall focus demonstrating the benefits of Sumagrow fertilized pasture when compared with NPK and others.

What is Sumagrow?

Sumagrow is a multi-functional consortium of soil microbes in very high concentrations that are carried in a food source of potassium humates at a concentration of 12%.

The primary functions of Sumagrow are to fix nitrogen, solubilize phosphorous and potassium in soil which plants cannot otherwise access, act as a plant growth promotor, bio-control agent, phytohormone producer, and a soil microbe population enhancer.

Sumagrow raises the Brix levels, improves taste and extends the shelf life of fruits in particular. It also improves the water retention capacity of soil.

Sumagrow creates soil with high OM while the use of NPK create soils with low OM.

High OM is critical to the productivity of land and in a study conducted in New Zealand, the value of soil organic matter for crop production and carbon storage function was quantified. (Sparling et al, 2006)

Sparling determined that high OM pastures produced an additional NZ$150/ha in milk solids. The study concluded that the accumulated loss for low OM pasture, accounting for decreased forage dry matter and milk solids production, was NZ$1,239/ha.

In today's currency, these benefits would be significantly higher than they were in 2006.

The benefits from increasing organic content of soil are well understood, and according to Harro Von Blottnnitz, Associate Professor of Chemical Engineering at Cape Town University, synthetic fertilizer requirements can be reduced by up to 40% and N2O emissions by 50%.

These are the benefits that can be obtained by farmers and growers who adopt Sumagrow as their principle fertilizer.

"StandUp" (with Sumagrow inside) is understood to be the only MPI registered bio-fertilizer currently available in New Zealand in large volume and effective for growing pasture and fodder crops.

Sumagrow is manufactured in the USA by Bio Soil Enhancers Inc. (www.sumagrow.com).

It will be of interest to note that Bio Soil Enhancers Inc. has already announced its intention to set up a Sumagrow manufacturing facility in New Zealand to service the growing demand for its technology throughout the Asia/Pacific Region.

No farms in New Zealand have used Sumagrow to date. A number of field trials are in the planning stage and StandUp is to be released commercially in the spring of 2016.

Extensive trials have been conducted in the USA, and Europe, on a broad spectrum of plants, and while results vary under different growing conditions and in different soil types, we can generalize and say;

1) For pasture growth, Sumagrow can essentially replace chemical fertilizers.

2) For most vegetable crops the NPK application rate can be reduced by up to 50%.

Sumagrow as an organic fertilizer

Sumagrow is the first polymicrobial available in large quantities that offers a practical alternative to farmers in New Zealand who wish to reduce or eliminate the use of NPK.

Sumagrow is compliant with USDA NOP (United States Department of Agriculture - National Organic Programme), and is registered as organic with OMRI (Organic Materials Registration Institute).

Sumagrow is to seek organic certification with Assure Quality, and indications are that StandUp will be certified as organic in the near future.

There is a significant economic benefit for dairy and meat producers if they convert to organic production through the elimination of the use of chemical fertilizers.

Polymicrobial fertilizers and the environment

The introduction of a polymicrobial fertilizer as a full or partial replacement for NPK will have a beneficial impact on fresh water quality through the reduction of nitrates in run-off water from farm land.

Furthermore, microbes convert chemical nitrogen to nitrous oxide, which is a harmful greenhouse gas that contributes to global warming. Current levels of emissions will reduce significantly if Sumagrow is used as a replacement for NPK.

The chemical fertilizer industry argues that the continued use of NPK is energy efficient and helps to fix 10-15 times more energy than that used in the production transportation and application of fertilizer (Ref: Fertilizer Europe, Carbon Footprint Reference Values").

However, the energy required to produce a stated volume of polymicrobial fertilizer is but a small fraction of that which is required to produce the equivalent volume of chemical fertilizer.

The standard raw material for NPK is natural gas, which is a finite resource and over time the price will continue to rise under market forces of supply and demand as there are end users willing to pay higher prices.

Other factors to consider are the comparative capital cost of plant and equipment to produce, transport, and apply chemical fertilizer versus polymicrobial fertilizer.

NPK represents the old technology for growing crops efficiently, and in order to achieve the goal of sustainable agriculture the use of chemicals must go into decline in future and be replaced by polymicrobials and new advancements on the current technology.

The case for restricting or eliminating the use of nitrogen based fertilizers within the Lake Rotorua Catchment

Available evidence relating to the overall benefit to soil, animal health, quality of crop and increased yield, reduction in nitrate leaching into water reserves, and reduction in emission of greenhouse gas, present a persuasive argument in favour of reducing if not eliminating the use of NPK within the Lake Rotorua catchment.

If implemented, Plan Change 10 will have a significant long-term beneficial effect on the quality of fresh water entering Lake Rotorua and also reduce the present level of greenhouse gas emissions from chemical fertilizer applied to farm land in the catchment.

While farmers who are most affected by the proposed restriction on nitrogen discharge from their land oppose the change, what they propose is expensive in terms of continuing research costs and there is no fixed time frame or guarantee that the reduction in nitrogen discharge from the farm land required by Plan Change 10 will ever be achieved.

Further, given the availability of Sumagrow, there is little benefit to be gained by continuing down the same research path that has been going on for many years. Future research and development should be focused on getting the best possible outcome for the farmer and the environment by adopting the new polymicrobial technology.

It is also clear that farmers will be very slow to change their fertilizer regimes without regulation.

There is now extensive evidence from university studies in the USA and large scale field trials in various states that support the adoption of Sumagrow in fertilizer programmes and in doing so will achieve significant reductions in nitrate leaching from agriculture land.

Different soil types and local environments influence the performance of Sumagrow as can be seen from the trial data provided in the attached schedule, but generally, Sumagrow can be used as the principal fertilizer to grow pasture and fodder crops.

Sumagrow offers a real input alternative to NPK and there is a significant body of evidence to show that pasture fertilized with Sumagrow generally outperforms pasture fertilized with NPK.

Pasture

Research and field trials can be summarized by saying that if pasture is fertilized with a product containing Sumagrow, the crop yield and dry matter nutrition value will generally be at least equivalent to pasture fertilized with NPK.

In fact, the actual research and field trials conducted in the USA clearly demonstrate that yield and nutrient values will be higher than for pasture fertilized with NPK.

These are facts, which are supported by various independent researchers, some of whom are referred to in this submission.

Animal feed crops - maize turnips etc.

There is a considerable body of evidence to confirm that NPK application rates can be reduced by 50% and replaced with Sumagrow at the rate of 10 litres/ha.

Crop yield increases of up to 20%, are generally achieved and in the case of maize which was also subject of an independent trial conducted in Illinois by Arise Research and Discovery, the nitrogen in runoff water from the containment bays was almost 80% lower than in the containment bays fertilized with the grower standard NPK application. (See schedule, item 5) .

I believe the BOP Regional Council can implement Plan Change 10 and be confident that provided pastoral farmers adopt Sumagrow into their fertilizer programmes nitrogen leaching will reduce significantly. If farmers chose to use Sumagrow to convert to organic production leaching will be eliminated.

Making such a proposition will no doubt give rise to a strong response from the chemical fertilizer companies and the supporters of the need for continued application chemical nitrogen to grow pasture.

There will also be some skepticism or concerns expressed by farmers and growers that such a change in their fertilizer programme will have a detrimental effect on the economics of their business.

However, the evidence presented here, and which is also available for a wide range of food crops says there should be no detrimental effect on production volumes or quality, or to financial returns currently achieved from historical farming practices.

To the contrary, farmers can anticipate that their revenue will increase, as will the capital value of farm properties, rather than reduce through controls imposed by "Overseer".

The science behind Sumagrow technology, which was developed over a number of years at Michigan State University, (MSU), and extensive trials conducted in the USA by other universities, research organizations, and commercial users, provides a large body of evidence that says Sumagrow works as an effective bio-fertilizer.

Farmers can have confidence in Sumagrow.

The following statement is the conclusion reached by Dr C A Reddy who lead the team of soil scientists at MSU in the development of Sumagrow (referred to as F2);

"Polymicrobial formulations similar to F2 (Sumagrow) have the potential to greatly increase crop productivity, with less dependence on chemical fertilizer and pesticides, greatly reduce the cost of cultivation, and alleviate negative health and environmental consequences associated with the use of the latter compounds.. Polymicrobial formulations also help to solubilize key plant nutrients such as phosphate and make it available for uptake by the plant. Moreover, products such as F2 consisting of microbes that naturally occur in nature, are eco-friendly, conserve soil health in increasing the number of bacteria beneficial to crop productivity, ensure better utilization of our natural resources, and are highly compatible with sustainable agricultural practices". (The full article is item 1 in the schedule attached)

Through various subsequent university studies and evaluations by independent research institutes in the USA, and field trials across a wide range of crops in numerous countries around the world, it has been established that products containing Sumagrow perform consistently.

Other benefits for pastoral farmers

There is clear evidence that animals prefer to eat grass fertilized with Sumagrow and when they do they are generally healthier, and put on weight faster.

This will contribute to the reduction in the use of antibiotics, which is becoming an imperative, and the cost to farmers in maintaining the health of their animals.

There is evidence to indicate that when cows are fed grass fertilized with Sumagrow (high OM pasture) they produce more milk solids per litre of raw milk, (Sparling et al 2006).

The biological science supporting the above is well understood and summarized in an article published by Phyllis Tichinin of True Health in April 2014, and another by Dr. Allen Williams of the USA under the title "The value of Soil Organic Matter". (Items 2 & 3 in the schedule attached).

Need for Regulation

Manufacturers and various parties that support and promote the continued use of NPK represent a powerful lobby with governments worldwide. They will continue to work for self-interest and try to ensure continued use of NPK to grow crops efficiently.

Based on personal experience in working with Sumagrow over the last three years it is clear that the chemical fertilizer industry has considerable influence over its farmer customers, close involvement with the agricultural scientists, and governments, such that they can and do exert pressure to maintain the status quo and protect their self-interest.

I have recently met several prominent growers who say publically that they are supportive of new technologies to improve productivity and move towards sustainable production by reducing the harmful effects of chemical fertilizer on their land.

But when asked if they would adopt Sumagrow technology their response is invariably to say something like "we are not prepared to take the risk with our crops".

In 2013, senior personnel at DairyNZ said they did not believe Sumagrow offers any benefit for dairy farmers, and had no interest in conducting trials. They also declined an invitation for one of their senior scientists to visit the USA on an all-expenses paid basis to conduct their own evaluation of Sumagrow.

At that time Dairy NZ was a member of a Ballance lead consortium conducting research into trying to improve the efficient use of chemical fertilizer. I was disappointed by DairyNZ's attitude.

A large investment has been made in the development of Sumagrow technology, in co-operation with some of the world's best soil scientists at Michigan State University.

Nobody in this country has any right to challenge the efficacy of the science that developed Sumagrow, or be skeptical of its performance in the field if used correctly.

The BOP Regional Council is entitled to act on the evidence presented here and to regulate the use of NPK in the sensitive catchment area supplying Lake Rotorua.

Notwithstanding, agricultural scientists, farmers and growers, and other parties with an interest in the economic wellbeing and environment of New Zealand, are entitled to be confident that this new polymicrobial technology will perform here as well as it has been found to perform in various growing conditions all round the world.

Sumagrow and similar polymicrobial products that will become available in future represent a paradigm change in fertilizer technology and they will become increasingly important if global food production is to reach a sustainable level for the population, ensure an adequate supply of fresh water, and contribute to the reduction in the rate of global warming.

But this important change will happen very slowly if the market and parties that influence its direction are left to decide the rate at which chemical fertilizer usage will reduce.

Conclusion:

The introduction of Sumagrow technology provides farmers in the catchment with an effective alternative to NPK, and they have a social obligation to the community and New Zealand to help reduce the current level of nitrogen entering Lake Rotorua from their properties, and greenhouse gas emissions which results from the use of NPK.

The Council has substantial funds available to assist achieve its goal and I believe that only a small fraction of this is required to complete a comprehensive evaluation of Sumagrow, and provide farmers with the confidence to use it in future.

To do this effectively may require up to three years of trials, but I believe a significant portion of the $40 million available to compensate for nitrogen reductions by landowners under the new regulations will not need to be paid out if they adopt Sumagrow into their fertilizer programmes.

If the findings of Sparling in 2006 are proven to be correct, dairy farmers who adopt Sumagrow into their fertilizer programmes will gain a considerable economic benefit.

Sheep and beef farmers will also benefit through having healthier stock that put on weight faster.

Both will benefit further if they convert to organic production, and both will contribute to improving the environment which is now generally accepted to be under serious threat.

I hope this submission is of value to those charged with making the decision on implementing Plan Change 10.

Yours faithfully

C R Hook

FS 01

Schedule of Enclosures

1. **Polymicrobial Formulations for Enhanced Productivity of a Broad Spectrum of Crops.**

   A paper by Dr C A Reddy and Lalithakumari J – Department of Microbiology and Molecular Genetics, Michigan State University.

2. **The Value of Soil Organic Matter**

   A paper by Allen R Williams PhD, in which he quotes the results of research conducted in New Zealand on the value of pasture containing high organic matter, and the financial value of milk solids produced by dairy cows (Sparling et al, 2006)

3. **Animal health problems – sick calves and heifers not reaching target weight**

   A paper by Phyllis Tichinin, general manager of True Health and a biological farming consultant from Hawkes Bay

4. **Improving the Green to Improve the Green**

   A paper by Dr.Allen R Williams PhD on the subject of how to be excellent managers of pasture to achieve good performance from livestock

5. **A summary of the trial report by Arise Research and Discovery, of Illinois, USA relating to nitrate reduction in run-off water when including Sumagrow in a fertilizer programme for corn.**

   The report identifies that when Sumagrow was applied with 50% of the grower standard chemical fertilizer application for corn, the crop yield increased by up to 20%, and the nitrates in run-off water reduced by 79%.

6. **Reports (4) on Bio Soil sponsored trials with Corn - conducted in Arkansas, Arizona, Nebraska, and Wisconsin**

   These trials were for various purpose, and principally to identifying the various benefits of Sumagrow when included in a fertilizer programme.

   a) *Arkansas - when added to the normal NPK application, the Sumagrow treated area produced a crop yield increase of 17.71% over the area fertilized with only NPK.*

b) *Arizona - this corn silage trial was for the purpose of identifying the crop yield increase from a field treated with Sumagrow only, and a control that received no treatment. The Sumagrow treated field produced a 16.84% yield increase.*

c) *Nebraska - This trial demonstrated that fertilizer can be reduced by 50% while still maintaining a crop yield increase in excess of that achieved with the grower standard application of 100% NPK*

d) *Wisconsin - This trial with organic corn demonstrated that the replicate comprising 50% chemical fertilizer plus Sumagrow, produced a crop yield increase of 21% over the grower standard fertilizer application.*

7. Reports (2) on Bio Soil sponsored trials with Forage crops - conducted In Pennsylvania and Virginia

a) *Pennsylvania - The pasture fertilized with Sumagrow produced an increase in dry matter yield of 49.67% when compared with a control that received no treatment. In addition, the Brix level also increased from 4.29 to 6.03.*

b) *Virginia – This trial was undertaken to determine the effect of Sumagrow on pasture at Lakota Ranch. The Sumagrow treated pasture outperformed all of the other variants in terms of dry matter yield and Brix levels.*

8. Reports (5) on Bio Soil sponsored trials with forage and Hay – conducted in Alabama, Kansas, Kentucky, Louisiana, and Montana.

a) *Alabama - This trial, comprising four replicates compared the dry matter yield results and Brix levels from a pasture of mixed grasses, between an area treated with Sumagrow and another with Fish Oil, Sea salt, Ca mix.*

The Sumagrow area produced an average yield increase of 9.05% and a significantly higher Brix level.

b) *Kansa - This trial was focused on crop yield and AUM (animal unit months) comparing pasture treated with Sumagrow, another with nitrogen only, a third with organic broiler litter, and a control that received no treatment.*

The Sumagrow treated area produced a crop yield increase of 75% over the nitrogen only treated area and achieved an AUM of 2.36 compared with the nitrogen fertilized pasture of 1.34

The Sumagrow treated pasture had more grazing days available in a 150 day grazing season.

c) *Kentucky - This trial was conducted by Murray State University with Sorghum beef cattle to compare the average daily weight gain (ADG).*

Cattle that grazed on the Sumagrow treated pasture achieved the highest ADG and the highest input cost benefit.

d) *Louisiana- This trial, comprising three replicates compared the crop yield and Brix levels from a pasture of mixed grasses.*

The Sumagrow treated pasture produced yield increase of 62% over the grower standard application of NPK and a significantly higher Brix level.

This trial also demonstrated that the application of Sumagrow in addition to the grower standard of NPK did not perform as well as 100% Sumagrow.

e) *Montana - This trial was focused on dry matter yield from a crop comprising Austrian Winter Pea, Oates, and Barley and compared an area treated with Sumagrow at the rate of 0.5gal/acre and another with Dramm product at the rate of 4 gallons/acre + 1 gal SP1 at emergence.*

The Sumagrow treated pasture produced a dry matter yield increase of 24.66% tons/acre., and higher Brix levels.

9. **Reports (2) on Bio Soil sponsored trials with Alfalfa (Lucerne) - conducted in Montana and Nebraska**

a) *Montana - Two trials were conducted to compare the crop yield between pasture treated with Sumagrow and the grower standard of Dramm Forage Boost +1 gal/acre SP1.*

Sumagrow treated pasture produced yield increases over the grower standard of 27% and 46%

b) *Nebraska – Three different treatments were applied to a mixed crop and the Sumagrow treated pasture produced a yield increase of 17.85% over the grower standard NPK application.*

FS 01

10. Reports (2) on Bio Soil sponsored trial with food plots to measure changes in organic matter (OM) on plots treated with Sumagrow – conducted in Mississippi and Pennsylvania

a) *Mississippi – a test performed by Barenbrug's US subsidiary with Tecomate to observe protein levels with different replicates containing Sumagrow. The results were conclusive in showing that protein levels increased as the volume of fertilizer was decreased.*

b) *Pennsylvania - Significant increases in OM were noted between 2009 and 2010 when Sumagrow was applied. Increased OM releases many nutrients as it broken down, improves the soil structure, and increases the Cation Exchange Capacity.*

Polymicrobial Formulations for Enhanced Productivity of a Broad Spectrum of Crops

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Short Title
MICROBES FOR ENHANCED CROP PRODUCTION

Title
Polymicrobial Formulations for Enhanced Productivity of a Broad Spectrum of Crops

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Abstract:

Our principal aim in this research is to develop stable, efficacious, and eco-friendly microbial formulations containing naturally occurring diverse phylogenetic groups of microbes with complementary functions designed to enhance productivity of a broad spectrum of crops. The formulation is designed to provide the observed beneficial effects through enhancement of nitrogen fixation, direct or indirect inhibition of plant pathogens, solubilization and mobilization of minerals such as P, and production of plant growth stimulants. We constructed two such formulations (F1 and F2) using humate (12%, ph 7.0) as a carrier. F2 formulation was found to be more effective than F1 in enhancing the productivity of a broad spectrum of crops and was the focus of this study. Substantial increase in productivity was observed with the following crops: *Zea mays* (corn), *Sorghum bicolor* (sorghum), *Glycine max* (soybean), *Phaseolus vulgaris* (Garden bean), *Pisum sativum* (pea), *Phaseolus sp.* (wonder bush bean), *Arachis hypogea* (peanut), *Oryza sativa* (rice), *Lycopersicon esculentum* (tomato), *Solanum melongena* (eggplant), *Hibiscus esculentus (*okra*),* and *Cucurbita maxima* (squash). For example, when compared to controls, corn height increased by 40.3%, eggplant 41% (not shown); wonder bush beans 40%, tomato 16.6%, soybeans 71%, pea purple hull 50%, and okra 32.6%. Significant increase in yield was also observed. For example, mean yield of tomato increased >400%, okra increased by 258%, soybean yield by 127%, peanut yield 233%, and rice yield by 301%. In general, the F2-treated plants appeared healthier and showed early flowering and fruiting with good root nodulation in legumes. Yields obtained in field trials were consistent with those from the greenhouse experiments in that substantial increases were observed in F2-treated crops as compared to controls, but the increase in yields were not as high those seen in green house experiments. The results indicate that polymicrobial formulations such as F2 reduce input for nitrogen fertilizers and pesticides, enhance productivity of a broad spectrum of crops, non-polluting, and contribute to the conservation of soil health.

Key Words

Microbial formulation, enhanced crop production, polymicrobial, nitrogen fixation, phosphate mobilization, biological control

INTRODUCTION

Facing a steep rise in the price of energy, a growing concern over global warming, and a quickly growing world human population (estimated at 6.9 billions in 2010), the need has never been greater for an increase to crop productivity on a long-term, sustainable basis in an energy efficient and eco-friendly manner (Triplett et al. 2007). Therefore, the working hypothesis is that it is possible to develop stable, efficacious, and ecofriendly microbial formulations containing diverse groups of microbes with complementary functions designed to enhance productivity of a broad spectrum of plants including legumes, non-legumes, vegetables, cereals, ornamentals, and fodder crops with little or no input of nitrogen fertilizers and chemical pesticides. The formulations are expected to provide the observed beneficial effects by multiple mechanisms including but not limited to the following: enhancement of nitrogen fixation; control of plant pathogens either directly or indirectly by inducing systemic resistance in plants against the pathogens; solubilization and mobilization of minerals such as P and others; and production of growth stimulants. While the idea of microbial inoculants for stimulating crop production is not new, careful and deliberate design of a formulation to contain multiple naturally occurring phylogenetic groups of organisms with complementary functionalities and putting them together in a manner that they retain viability over a long period of time at ambient temperature and with little or no need for added chemical fertilizers and pesticides is innovative.

Symbiotic N_2-fixing bacteria such as *Rhizobiales* (associated with leguminous crops) and free-living N_2-fixing bacteria such as the *Azospirillum* group (associated with the roots of cereal crops such as rice, wheat and corn, and certain forage grasses) account for a major portion of biological nitrogen fixation on earth (Bashan et al.2004;; O'Hara et al., 2003; Rai, 2006; Xavier et al. 2004). These beneficial bacteria decrease the need for added nitrogen fertilizers for crop production, contribute to conservation of fossil fuel energy resources that are currently used for manufacturing N-fertilizers, and help reduce pollution and public health problems associated with the high use of chemical fertilizers. Other free-living microbes that contribute to N_2-fixation in soils include: *Acetobacter* and *Herbaspirillum* strains associated with sugarcane, sorghum and maize (Balachandar et al., 2007; Boddey et al., 2000) and *Alcaligenes, Bacillus, Enterobacter,*

Klebsiella and *Pseudomonas* strains associated with a range of crops such as rice and maize (Somasegaran and Hoben, 1994). Moreover, rhizosphere bacteria such as *Paenibacillus*, *Burkholderia*, and (α-, β-, γ-) proteobacteria were reported to give 'positive plant growth response attributed to their ability to fix N_2 and/or their ability to produce secondary metabolites and phytohormones (Polianskaia et al., 2003; Petersen et al., 1996; Rai, 2006; Rudresh et al., 2005.). Phosphate-solubilizing bacteria (PSB) such as *Pseudomonas, Bacillus, Azospirillum, Rhizobium, Alkaligenes, Paenibacillus,* and *Penicillium digitatum* contribute to plant growth by producing organic acids and make insoluble P compounds soluble for uptake by the plant (Sundara et al. 2002; Rodriguez and Fraga, 1999).

An array of pesticides belonging to different chemical classes is used for controlling a variety of plant diseases. A number of pesticides are recalcitrant to degradation, persist in the environment, and enter the human/animal food chain constituting a threat to public health and a potential hazard to the environment. Some are toxic to humans even at parts per billion levels. Therefore, there is increasing public concern regarding the continued use of chemical pesticides at high levels and there is a growing need for developing environmentally friendly approaches to control common plant diseases and contribute to the goal of sustainability in agricultural production. In this regard, there is much ongoing research on bio-control agents (bio-pesticides) for inhibiting pathogenic fungi, bacteria, and even nematodes and small insects that cause crop losses. Soil-borne, non-pathogenic bacteria and fungi that are able to control different plant pathogens are attractive alternatives to the use of chemical pesticides. A number of bacteria and fungi that serve as biological control agents (BCAs) as well as plant growth-promoting rhizobacteria (PGPR) are catabolically versatile, have excellent root-colonizing abilities, and have the capacity to produce a wide range of metabolites that act against plant pathogens. Soil-borne fluorescent pseudomonads have received particular attention. Some of these have been shown to elicit induced systemic resistance in plants. Strains of *Bacillus subtilis* are known to suppress soil-borne fungal diseases and nematodes, produce metabolites that stimulate plant and root growth, and colonize the root zone resulting in exclusion of some of the pathogens by 'competitive exclusion' (Walsh et al., 2001) .

Trichoderma are free living and fast growing fungi in soil and root ecosystems of many plants. *Trichoderma* have been demonstrated to inhibit a broad spectrum of root and foliar pathogens by one or more of the following mechanisms (Harman et al. 2004; Mathivanan et al.

2000; Carver et al. 1996): antibiosis, antagonism, and competitive exclusion. Furthermore, *Pseudomonas* and *Trichoderma* species that function as bio-control agents do not inhibit nitrogen fixers, arbuscular mycorrhizal fungi, and other beneficial microbes that positively impact plant growth (Walsh et al. 2001; Rudresh et al. 2005)Mathivanan et al. 2000). *Trichoderma* species have also been reported to serve as plant growth promoters by producing phytohormones and solubilize/mobilize phosphates (Yedidia et al.2001).

There is much published information on the benefit of individual microbes to plants (Xavier et al. 2004; Somasegaran and Hoben, 1994; Kannaiyan, 2000), but there is hardly any commercial product that is capable of conferring all the beneficial effects on crop productivity mentioned above. Our overall objective in this study was to construct a microbial formulation containing multiple groups of functionally complementary microbes (bacteria and fungi) that hold promise in enhancing productivity of a broad spectrum of plants including legumes, cereals, vegetables, and forage crops. Many of the commercial microbial inoculants have not lived up to their claims in that Brockwell and Bottomley (1995) reported that 90% of all inoculants have no practical value whatsoever on the productivity of legumes. A desirable microbial growth promotant should have good efficacy, ease of application, eco-friendly, stable, and safe for use. Furthermore, rhizobial species in the inoculant must be able to nodulate diverse legumes under various soil and environmental conditions.

RESULTS

Construction of Polymicrobial Formulations

The research presented here highlights a rational approach to the use of diverse groups of organisms with complementary functionalities to confer multiple beneficial effects on growth and yield of a broad spectrum of crops. As a first step, numerically predominant bacteria from the root nodules of various leguminous plants as well as from soil and rhizosphere samples collected from diverse environmental sources were isolated and characterized. Dominant rhizobial as well as the non-rhizobial species were isolated from the root nodules of pea, cow pea (*Vigna sinensis*), green gram (*V. radiata*), black gram (*V. mungo*), red gram (*Cajanus cajan*), soybean, and agati (*Sesbania grandiflora*) collected from temperate and tropical regions using established procedures (Hung et al. 2005; Kannaiyan, 2000; O'Hara et al. 2003; Pandey et al.,

2004). The microbial isolates were identified based on morphological, physiological and biochemical characteristics as well as their 16S rDNA sequencing data. Functional characteristics such as nitrogen fixation, phosphate solubilization/mobilization, root nodulation using different leguminous plants, and growth under acidic and alkaline conditions were used in further grouping of the isolates. Isolates were also characterized as to their saprophytic competence (Weaver and Frederick, 1972). Similarly, a large number of bacteria isolated from various soils were isolated and identified and key functional characteristics were determined.

A number of *Trichoderma* species isolated from different soil samples (representing cultivated and uncultivated agriculture soils, tropical, subtropical, and temperate climates) because of their reported beneficial effect in positively influencing productivity of different crops. Individual strains were isolated using single spore isolation technique using plates of potato dextrose agar. Identification was based on macro-microscopic features, colony color, and rate of growth, using standard procedures (Sariah et al. 2005). *Trichoderma* isolates were then screened for their potential as biocontrol agents against known plant pathogenic fungi such as *Alternaria alternata* and *Curvularia Sp., Bipolaris oryzae, Magnoporthe grisea, Rhizoctonia solani* using dual plate technique (Carver et al. 1996). Also, all the *Trichoderma* strains were tested for their saprophytic competence in soil.

Species representing several genera of *Rhizobiales*, several root-nodulating non-rhizobial species (consisting of both α-, β-, and γ- proteobacteria), a number of phosphate solubilizing bacteria, microbes (both bacteria and fungi) with proven ability as biocontrol agents, and other beneficial bacterial species with growth-promoting properties were used in constructing two bacterial formulations F1 and F2 using 12% humate as the base. The microbial species composition of F1 and F2 was different but each contained over 20 different microbial strains representing selected combinations of bacteria and *Trichoderma* strains with the beneficial characteristics mentioned above.

The PCR amplification and sequencing of 16S rDNA of the isolates revealed both nodulating *Rhizobia* such *as Ensifer meliloti (Rhizobium meliloti; Sinorhizobium meliloti), R. trifoli,* as well as *Azorhizobium caulinodans, Sinorhizobium fredii*, and non-Rhizobial nitrogen fixers including *Pseudomonas spp., Burkholderia spp., and Paenibacillus polymyxa.* Other bacterial isolates included in the formulations were *Pseudomonas fluorescens, P. striata*, and *Bacillus subtilis* representing multiple functions such as phosphate solubilization/mobilization,

nutrient uptake, and phytohormone production. Nodulation experiments confirmed the nodulating ability of bacteria in the polymicrobial formulation (Fig. 1). *Trichoderma* isolates included strains of: *T. harzianum, T. viride, T. virens,* and *T. longibrachiatum.*

Green House Evaluation

Baccto premium potting soil (Michigan peat Company, Houston, TX) was used for growing the selected test plants in the greenhouse experiments. A randomized replicated design was used to set up growth experiments for testing the efficacy of F1 and F2 formulations. For each 12"X12"X12" pot, two split applications of the liquid formulations (10^{10} cfu per pot) were given during the crop period. The first application was given as soil treatment at the time of sowing and the second application was given at the base of the plant one month after the first application. The experiments were set up in such a way to compare the efficacy of F1 and F2 formulations in comparison to a control (HG) containing 12% humic acid alone without any added microbes. Hence, 3 treatments, i.e. F1, F2, and control (HG), each with 4 replications were tested. Exogenous fertilizers or pesticides were not added to any of the three treatments during the crop period. Most inoculant standards contain a minimum number of viable microbial cells of at least 10^{9}rhizobia /gram soil (Brockwell and Bottomley, 1995; Xavier et al. 2004). Plant minerals (minus N) was added to each treatment 15 days after germination. A broad spectrum of crops which includes cereals, vegetable crops, legumes, forage grasses and also biofuel grasses were tested. Plants including garden beans, wonder bush beans, purple hull beans, pea, cowpea, green gram, black gram, soybean, tomato, eggplant, okra, squash, zucchini (*Cucurbita pepo*), corn, sorghum, rice, and peanut were tested to compare the efficacy of F1 and F2 in enhancing productivity. Observations were made at monthly intervals during the entire crop period. In a separate experiment, the efficacy of F1 and F2 on germination and growth of commercially available forage legumes seed mixture (Tecomate Monster Seed Mix, Todd Valley Farms, Nebraska) was tested. Plant height, total number of leaves, leaf area, leaf color, flowering time, fruiting time, shoot and root biomass, and the incidence of pests and diseases were monitored.

The results (Table 1, Fig. 2 to 5) showed a significant increase in plant height with F2 treatment followed by F1 and control. For example, when compared to controls, corn height increased by 40.3%; egg plant 41% (results not shown); wonder bush beans 40%; tomato 16.6%, soybeans 71.1%, pea purple hull 50%, and okra by 32.6%. Yield also significantly increased in F2 treatment. For example, mean yield of tomato increased by about 400% as compared to the

control. Okra yield increased by 258.4%, soybean yield by 127%, peanut yield by 233% and rice yield by 301%. With rice, both F1 and F2 showed an increase in seedling vigor, plant height, number of tillers and their carry over effect on grain yield. All legumes tested showed early flowering and fruiting, good root nodulation, and no disease was observed in both the experimental and control plants during the crop period. (results not shown).

There is a significant commercial interest in products that substantially increase productivity of forage crops. The present results further confirm that F2 formulation enhances the growth of a commercial seed mixture of forage crops called Tecomate Monster Mix, as compared to humate alone as control (Fig. 6)

Table 1: Green House evaluation of polymicrobial formulations F1, F2, and control (C)

Crop	Plant Height [cm]			Yield [g]		
	F2	F1	C	F2	F1	C
Corn	142	125	101.2	-	-	-
Sorghum	74	68.5	49	-	-	-
Rice	65	60	55	20.85	15.76	5.2
Tomato	77	72	66	1900*	755*	380
Soybeans	167.7	160.5	98	11.58*	7.9	5.1
Pea	45	38	33	13.99*	10.48*	7.52
Okra	130	93.7	98	138.7*	100*	38.7
Peanut	42	42	35	21.62*	14.67*	6.48
Pea purple hull	60.96	46.48	40.64	14.75*	12.23*	10.75
Garden beans	135	128	102	48.6*	42.6*	23.5
Wonder bush beans	88.9	76.2	63.5	72.9*	63.6	35.6
Squash	57	41	36	650*	230*	0

* Significant, P = 0.022

Field Evaluation

Field trials were conducted with the cooperation of BioSoil Enhancers (Hattiesburg, Mississippi) to test the efficacy of the polymicrobial formulations on soybean, corn, cotton, yellow squash, tomato, green beans, bell pepper (*Capsicum annuum*) and banana pepper (*Capsicum spp.*). The yield data obtained in field trials were consistent with results of green house experiments in showing a distinct increase in yield of all the crops tested. For example, crops treated with polymicrobial formulation F2 showed 75% increase in yield for tomatoes;

27% for bell peppers; 40% for banana peppers; and 61% for yellow squash (Table 2). Increase in corn yield was 30.0% and cotton plants treated with the polymicrobial formulation also showed increased plant height, good branching, and large sized healthy bolls when compared to control (results not shown). Both green house and field trials indicate that appropriately formulated polymicrobial formulations have excellent potential to enhance productivity of a broad spectrum of crops. Moreover, the need for nitrogen fertilizers and pesticides greatly decreased, which substantially contribute to the conservation of soil health, and conservation of fossil fuel energy sources. Further research progress in this area would be a substantial contribution to boosting crop production compatible with sustainable agriculture practices.

Table 2: Field evaluation of polymicrobial formulations

Crops	F2 formulation (oz)	F1 formulation (oz)	Control (oz)	F2 - % increase in yield over control
Squash	1559	1414	963	61
Tomato	836	514	477	75
Banana Pepper	35	15	25	40
Bell Pepper	102	87	80	27

DISCUSSION

The results showed much better growth with F2 in terms of increased plant height, total number of leaves and total biomass of tested crops. It was expected that leguminous plants which support symbiotic nitrogen fixation such as soybean, garden bean, wonder bush bean, pea and other legumes would give better performance with F2 formulation as it contains symbiotic nitrogen fixers, as well as some free-living nitrogen fixers, and biocontrol agents. However, it is noteworthy that even non-leguminous plants such as tomato, eggplant, zucchini, squash, rice, corn, and sorghum, which are not associated with symbiotic nitrogen fixation, showed impressive growth response. These results suggest that free-living N_2 fixers, biocontrol agents, and organisms that produce nonspecific growth stimulating compounds in the formulations are contributing to the observed positive growth response. These results appear to validate our hypothesis that enhanced plant growth and productivity can be obtained with a broad spectrum of

plants when grown with microbial formulations containing microbes representing several different complementary functional groups. It is also remarkable that the growth response with rice and corn, two of the most important food crops worldwide, was quite encouraging suggesting that either non-N_2 fixers that give a growth response by producing metabolites/micronutrients that boost plant growth or hither to not well characterized nonconventional N_2-fixers (Balachandar et al. 2007) may be contributing to the observed positive growth response. For example it has earlier been reported that association of *Pseudomonas sp.* and *Trichoderma sp.* with cereal crops such as rice will result in increased productivity (Rudresh et al. 2005). Pseudomonads and *Trichoderma* not only act as biocontrol agents but also produce metabolites that enhance plant growth (Yedidia et al 2001). Furthermore, Yanni et al (1997) report that *Rhizobium leguminosarum bv.* trifolii shows endophytic association with rice and increase productivity of the latter. It is also possible that other free living N_2-fixers such as *Paenibacillus* and *Burkholderia* may be contributing in part by providing fixed nitrogen to the plant (Balachandar et al.2007). In addition to nitrogen, phosphorous made available by phosphate-solubilizing bacteria may also be contributing to increased growth of cereals (Sundara et al. 2002). These possibilities need to be tested in future. The results presented above further suggest that other non-nitrogen fixing microbes in our formulations are able to confer substantial boost in productivity.

CONCLUSIONS

To the best of our knowledge there is no microbial formulation on the market today that is specifically designed to contain a comprehensive set of microbial groups with multiple complementary functions and with documented efficacy for substantially increasing productivity of such a broad spectrum of important pulses, cereals, vegetable, and forage crops as reported here. Heavy use of chemical fertilizers and pesticides that are often employed for increasing crop productivity now result in leaching of nitrates which at high levels pose a health hazard to humans. Further more, when soils become anaerobic, nitrate (NO_3) is reduced to nitrous oxide N_2O, which is over 300 times more potent than CO_2 as a greenhouse gas. Polymicrobial formulations decrease the need for nitrogenous fertilizers (by almost 50%) and pesticides. Therefore, polymicrobial formulations similar to F2 (or even more improved future products) have the potential to greatly increase crop productivity with less dependence on chemical

fertilizers and pesticides, greatly reduce the cost of cultivation, and alleviate negative health and environmental consequences associated with the use of the latter compounds. Polymicrobial formulations also help solubilize key plant nutrients such as phosphate and make it more available for uptake by the plant. Moreover, products such as F2, consisting of microbes that naturally occur in nature, are eco-friendly, conserve soil health in increasing the number of bacteria beneficial to crop productivity, ensure better utilization of our natural resources, and are highly compatible with sustainable agricultural practices.

Acknowledgements

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Figure Legends

Figure 1. Nodulation observed on roots of garden bean grown in the presence of polymicrobial formulation, F2.

Figure 2. Plant height (2a) and yield (2b) of soybean grown in the presence of polymicrobial formulations F1 and F2 as compared to a control with no formulation added.

Figure 3. Plant height (3a) and yield (3b) of rice grown in the presence of polymicrobial formulations F1and F2 as compared to a control with no formulation added.

Figure 4. Plant height (4a) and yield (4b) of tomato grown in the presence of polymicrobial formulations F1and F2 as compared to a control with no formulation added.

Figure 5. Plant height (5a) and yield (5b) of wonder bush beans grown in the presence of polymicrobial formulations F1and F2 as compared to a control with no formulation added.

Figure 6. Growth observed with a commercial forage seed mixture (Tecomate Monster Mix) in the presence of formulation F2 (right) and control (left).

Figure 1

Figure:2a

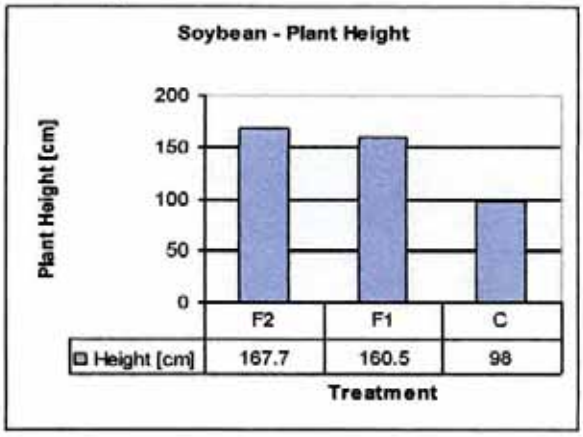
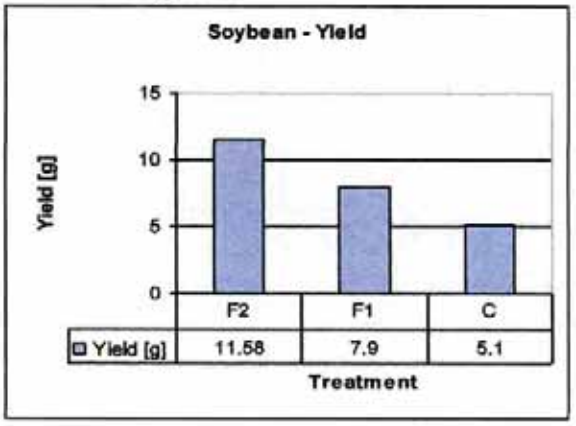


Figure:2b



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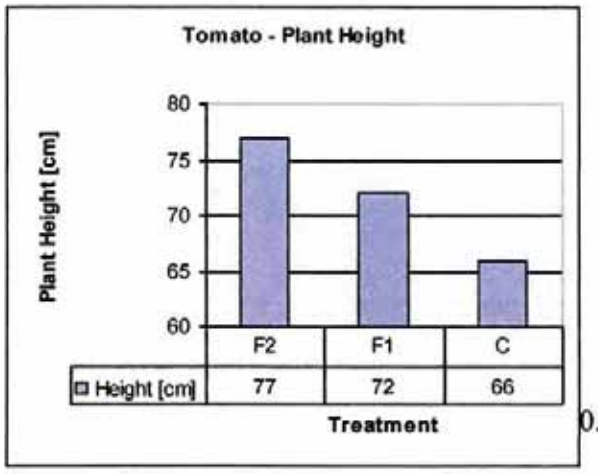

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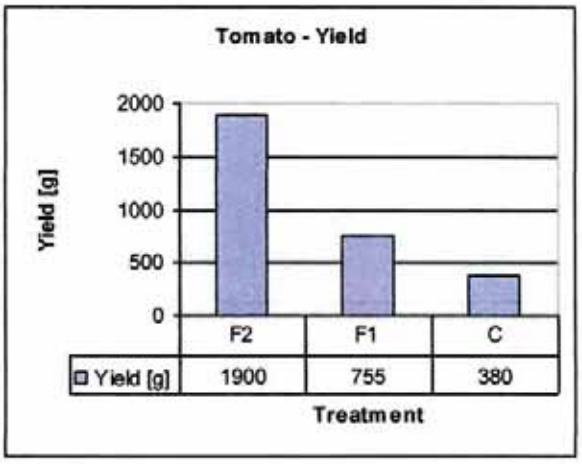

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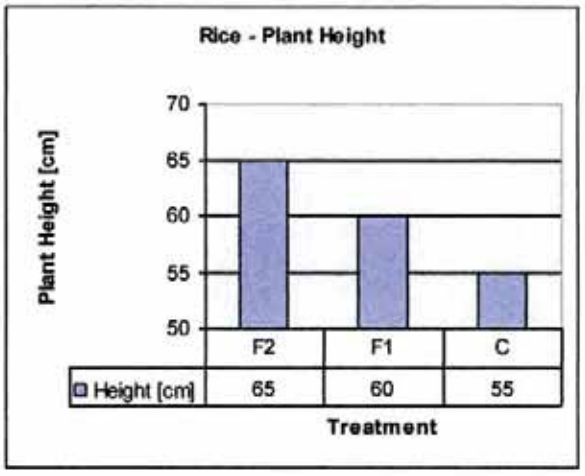

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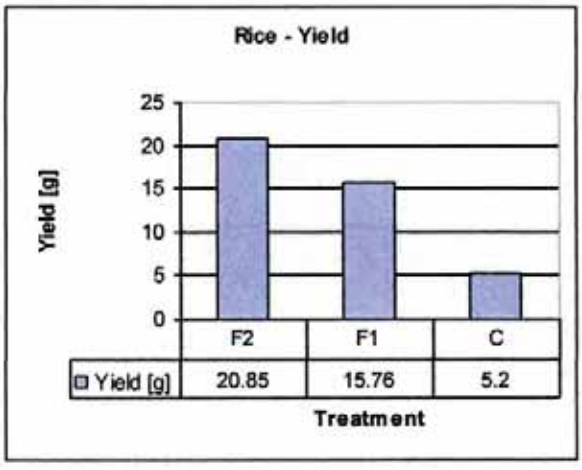


Figure: 5a

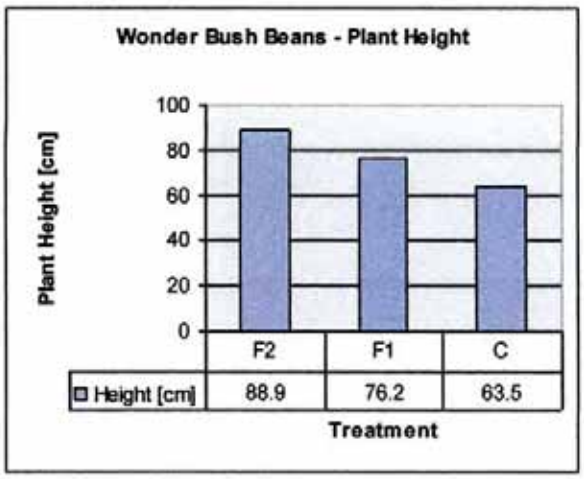


Figure: 5b

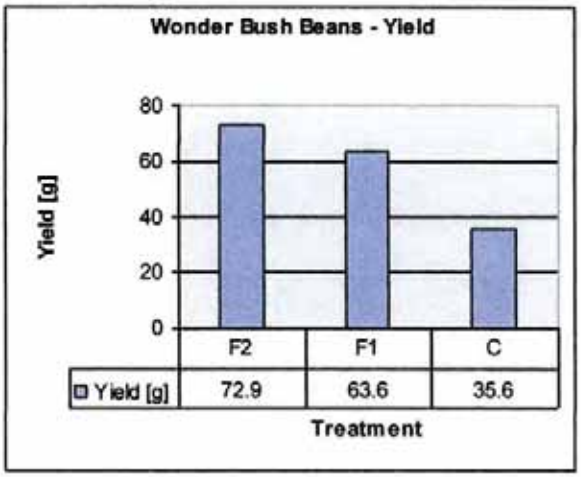


Figure 6

FS 01

The Value of Soil Organic Matter

Allen R. Williams, Ph.D.

Healthy soil has a good balance of physical, chemical, and biological characteristics. Healthy soil has highly functional water infiltration properties, resists soil erosion, moderates its temperature, is high in organic matter and soil carbon, and is teeming with soil microbes. Healthy soil has increased value and is rich in vital soil nutrients. In fact, if you can grab just a handful of healthy soil, you would be holding more biodiversity in the microbial population than exists in the entire animal life in the Amazon basin.

Soil microbes perform a variety of crucial functions within a healthy soil profile. For example, the important role of nitrogen fixation by rhizobia and other bacteria for plant growth has been well documented (Morissey, J.P., Dow, J.M., Mark, G.L., O'Gara, F. "Are microbes at the root of a solution to world food production?" European Molecular Biology Organization's *EMBO Reports*: October 2004, 5(10): pp. 922-926). However, microbes also have a pervasive influence on both plant health and growth, through enhanced stress tolerance, increased disease resistance, more efficient nutrient availability and uptake, and the promotion of biodiversity.

The greatest interactions between microbes and plants generally take place in the rhizosphere (root zone). This is the interface between plant roots and the soil and is where soil microbes most influence on plant health and productivity (Bloemberg, G.V. and Lugtenberg, B.J. 2001. Molecular basis of plant growth promotion and biocontrol by rhizobacteria. Curr. Opin. Plant Biol. 4: 343–350). One clear benefit for plants that is directly linked to soil microbes is significantly better access to soil nutrients through Arbuscular mycorrhizal fungi (AMF). These fungi form vast and intricate networks of hyphae that serve as root hair extensions for each host plant. This network of fungal hyphae is associated with the supply of available phosphorus to the plant (Smith, S.E. and Read, D.J. 1997. Mycorrhizal Symbiosis 2nd ed. San Diego, CA, USA: Academic). Moreover, bacteria from the *Azospirillum* genus function to increase and enhance root mass and to facilitate efficient nitrogen uptake from the soil working in synergy with indole-3-acetic acid, a plant hormone. Development of increased soil microbial populations provides significant environmental benefits through potential for reduction of inorganic fertilizer use, particularly nitrogen and phosphorus.

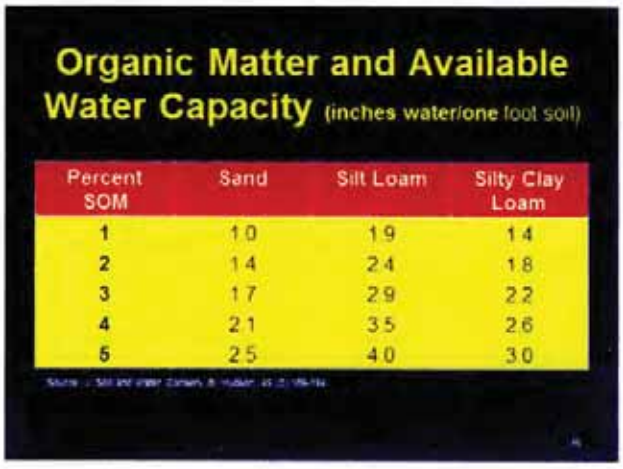
Soil microbes also can act as biological control agents and confer varying degrees of protection against an array of plant diseases. For example, bacteria and fungi of the genera *Pseudomonas*,

Bacillus, and *Trichoderma* have been shown to produce metabolites against phytopathogenic fungi (Walsh, U.F., Morrissey, J.P., O'Gara, F. 2001. *Pseudomonas* for biocontrol of phytopathogens: From functional genomics to commercial exploitation. Curr. Opin. Biotechnol. 12: 289–29). Certain soil bacteria can produce plant antibiotics that assist in plant disease control (Raaijmakers, J.M., Vlami, M., de Souza, J.T. 2002. Antibiotic production by bacterial biocontrol agents. Antonie Van Leeuwenhoek 81: 537–547). The potential exists for development of soil microbes that could be viable alternatives to heavy fungicide applications.

Other soil microbes, such as rhizobacteria, have direct effects on plant growth and can confer health-promoting qualities on plants they interact with through a process known as induced systemic resistance (ISR). ISR occurs when interactions between non-pathogenic bacteria work to provide a degree of disease resistance on plants (van Loon, L.C., Bakker, P.A., Pieterse, C.M. 1998. Systemic resistance induced by rhizosphere bacteria. Annu. Rev. Phytopathol. 36: 453–483).

Soil Loss and Prevention

Globally, approximately 75 billion tons of soil lost on an annual basis. Annual soil loss in the U.S. accounts for 6.9 billion tons of this total. As a result, farmers spend approximately $20 billion a year to make up for the loss of nutrients carried off by soil erosion (D. Pimentel, Professor Emeritus, Cornell University). According to the USDA NRCS, if we can build soil organic matter to effective levels, we can have a significant impact on drought effect mitigation and soil water retention. For example, at 1% soil organic matter, the soil can only hold 21% of a ten-year storm (5.5 inches rainfall), whereas at 5% organic matter the soil can hold 53% of a ten –year storm, and at 8% the soil can hold 85% of a ten-year storm. The table below illustrates the increased water holding capacity in various types of soil as organic matter increases.



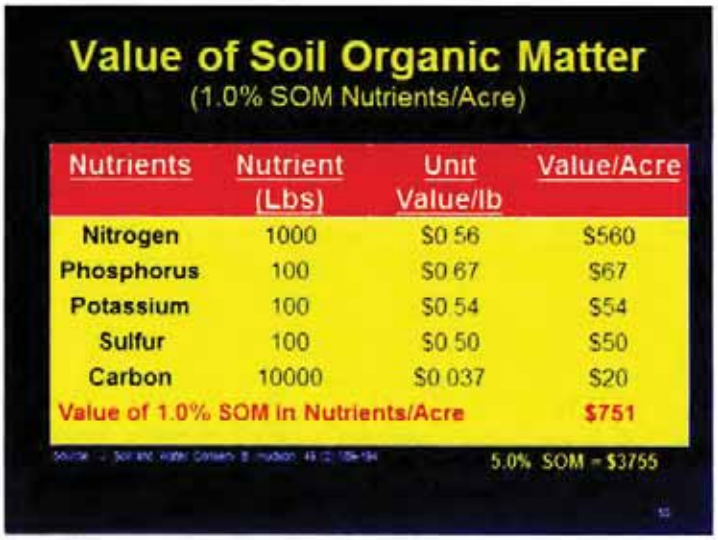
Organic Matter and Available Water Capacity (inches water/one foot soil)

Percent SOM	Sand	Silt Loam	Silty Clay Loam
1	10	19	14
2	14	24	18
3	17	29	22
4	21	35	26
5	25	40	30

Additionally, soil management practices can have a significant impact on reduction of water runoff and soil erosion. The picture below is a USDA NRCS Rainfall Simulator. Each panel represents a common soil management practice. From left to right, Panel 1 represents soil that has been conventionally tilled, Panel 2 is farmed soil that has been planted into a cover crop, Panel 3 represents No-Till soil, Panel 4 depicts tightly grazed pasture, and Panel 4 represents properly grazed pasture. With one inch of simulated rainfall, you can see from the collection jar at the front of Panel 1 that water runoff and soil erosion was significant. Similar results are noted in Panels 3 and 4. However, by employing better soil management practices, both water runoff and soil erosion were significantly reduced (Panels 2 and 5).

Value of Soil Organic Matter

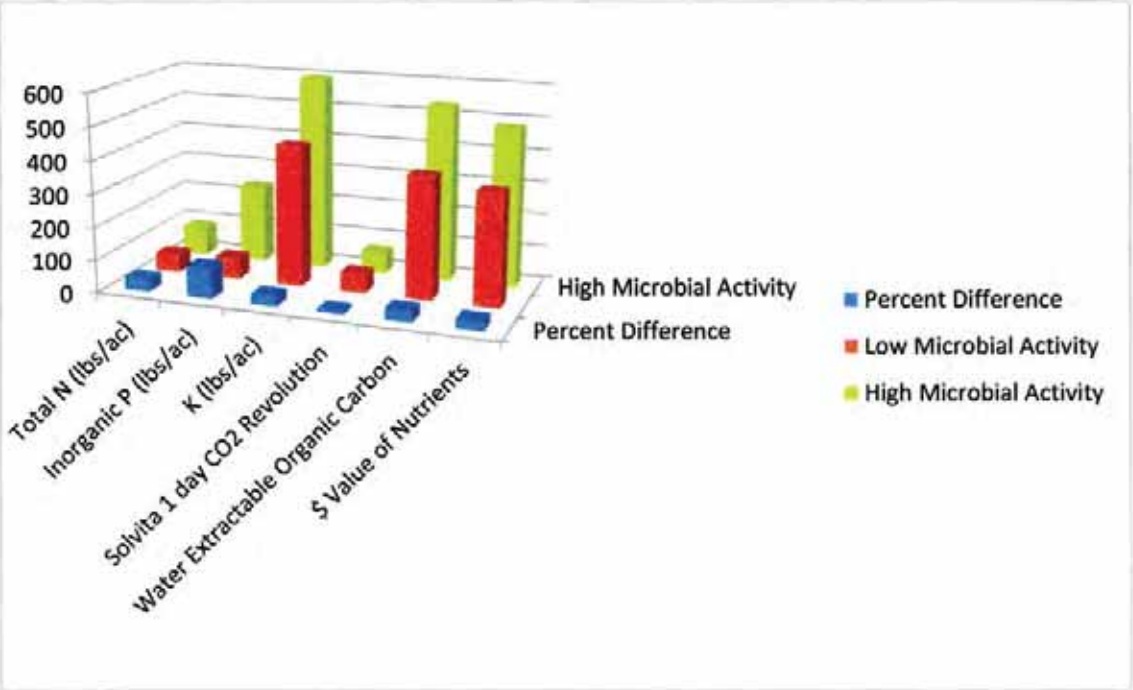
It is important to understand that for each 1% of soil organic matter, there are 1,000 pounds of soil nitrogen, 100 pounds of phosphorus, and 100 pounds of potassium (potash) in the top 6 inches of the soil (James Hoorman, Soil Specialist, Ohio State University). So for every 1% soil organic matter, there is more than $750 worth of N, P, K available, along with other vital macro and micro-nutrients. In soils with organic matter contents of 4% to 5%, the value of the soil organic matter exceeds $3000 (See table below).



In a study conducted in New Zealand, comparisons were made between high organic matter (OM) pastures and low organic matter pastures in dairy operations. The researchers examined forage dry matter (DM) yields and the financial value of milk solids produced by the dairy cows. Results showed that the low OM pastures produced decreased forage DM yields and the cows grazing the low OM pastures produced significantly lower milk solids, whereas the cows grazing the high OM pastures produced significantly greater milk solids and forage DM yields were higher. The high OM pastures produced and additional NZ $150/hectare in milk solids. The study concluded that the accumulated loss for the low OM pastures, accounting for decreased forage DM and milk solids production, was NZ $1239/hectare (Sparling, et.al., J. Environ. Qual. 2006. Mar 1:35(2):548-557.).

In another study conducted by the USDA NRCS in the Burleigh County Conservation District in North Dakota, comparisons were made between high microbial activity row crop fields and lower microbial activity fields (see graph below). The data revealed that available nitrogen, phosphorus, and potassium were significantly higher in the high microbial activity fields. In addition, one day CO2 evolutions (as determined by Solvita) were higher, substantiating higher microbial activity. The study also showed a significantly greater amount of water extractable carbon stored in the soil and significantly higher dollar value of nutrients per acre.

Comparison of High Microbial Activity Fields to Lower Microbial Activity Fields



Soil Nutrients

The nutrients contained in the soil organic matter are released, or become available to the plant, at a relatively slow rate. However, in healthy soil that is high in soil microbial activity, the release of nutrients for plant uptake occurs at two times the rate it does in lower microbial activity soils (The Furrow, The Miracle of Mycorrhiza, Feb.2013). Having a healthy soil microbial profile allows plants to take up significant amounts of N, P, and K and effectively reduce inputs of inorganic fertilizers. One of the greatest savings is with phosphorus. Data from South Dakota corn farmers shows that healthy soil microbial populations can significantly reduce need for inorganic P applications. Some soil scientists and agricultural consultants have expressed concern that reduced applications of inorganic fertilizers would result in "mining out" nutrients in the soil organic matter. However, data from South Dakota corn farmers (USDA ARS, North Central Agricultural Research Lab, Brookings, SD) shows that levels of both P1 (available phosphorus) and P2 (bound phosphorus or P that is not readily available) are either steady or even increasing. The data from the USDA ARS in South Dakota show that in conventionally tilled fields and in no-till fields that are mono-cropped, the presence of mycorrhizal fungi and other favorable soil microbes is very low. Therefore, strategies such as the use of cocktail cover crop mixes and/or soil microbials, is necessary to keep soil microbe

populations at a functional level. It is important to note that the repeated application of phosphorus in inorganic fertilizers can contribute to a significant decline in mycorrhizal fungi, and many other beneficial microbes, in the soil. The overload of inorganic phosphorus simply serves to send a signal to the plant that is doesn't need the P supplied by the fungal hyphae, and when the plant rejects the phosphorus from the fungal hyphae, the mycorrhizal fungi no longer have a living root to partner with and die. When inorganic phosphorus is applied at best only about 20% of the P is taken up by the plants. The rest becomes bound up in the soil. This requires farmers to apply significantly higher amounts of phosphorus than what is really needed in order to achieve sufficient plant uptake. If soil microbial populations were maintained at the appropriate level, available phosphorus levels in the soil would rarely be an issue.

What Does Healthy Soil Look Like?

Healthy soil should contain more than three tons of soil microbes per acre in the top 6 inches alone. Per gram of soil, soil bacteria should number in the 100 millions to the billions, fungi should have hundreds of yards of hyphae, there should be several thousand protozoa, several hundred beneficial nematodes, a few hundred arthropods, and 5 or more earthworms. According to the USDA NRCS National Soil Health website (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/), healthy soil is rich in both below ground microbial life and in earthworm and soil level arthropod life (see table below). One of the most widely used soils textbooks, *The Nature and Properties of Soils* (R. Weil and N. Brady, Cornell University Press), states that the rich microbial life underneath the soil surface is "...populated by a wild array of creatures all fiercely competing for every leaf, root, fecal pellet, and dead body that reaches the soil, along with predators lurking in the dark ready to snatch unwary victims". The soil flora and fauna stabilize soil aggregates, build better soil habitat, improve soil structure, and increase soil fertility and productivity. In fact, biological processes in the soil are responsible for up to 75% of the available nitrogen and 65% of the available phosphorus in the soil. Recycling of organic matter in the soil is dependent on soil microorganisms and organisms such as earthworms and arthropods. This balance of soil life is needed to have an active predator/prey relationship and to keep soil bacteria and fungi in check (J. Clapperton, Agriculture and Agri-Food Canada, Lethbridge Research Centre).

Source: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/

Healthy soil provides an array of crucial functions. These functions include:

- Build soil highways for efficient transport & storage of moisture, gases, and nutrients.
- Decay organic matter.
- Cycle nutrients back into forms that plants can use.
- Unlock chemical bonds in nutrients to make available to plants (i.e., Phosphorus).
- Increase soil water infiltration.
- Increase soil carbon content.
- Increase soil aggregate stability.
- Better mediation of temperature & moisture.

Soil Fungi

Mycorrhizal Fungi have a symbiotic relationship with plants, attaching themselves to plant roots so that they can tap into the plant sugars and carbohydrates that migrate from the plant leaves or blades. In a return gesture, fungal hyphae grow out from the plant roots and absorb water and nutrients for use by the plant. The fungal hyphae or filaments are much finer than the root hair, being only one tenth in size, and are able to contact significantly more of the soil profile. As a comparison, plant root hairs from any can contact approximately 2% of the soil profile, whereas fungal hyphae can contact 20% of the soil profile. Therefore, the fungal hyphae are much more efficient at "grabbing" or extracting nutrients, require less carbon as fuel to do so, are able to extract bound phosphorus, nitrogen, and sulfur, and can take up soil nutrients at a rate six times

faster than plant root hairs. The fungal hyphae even connect roots from different plants, allowing for transfer of nitrogen and other nutrients from legumes to non-legumes.

Another very important function of mycorrhizal fungi is the formation of glomalin. Glomalin is a protein that assists in the binding of soil particles into larger aggregates. Soil aggregates perform several vital functions, including the protection of soil organic matter, retention of soil moisture, and improvement of soil tilth. Glomalin is often referred to as a soil "superglue". Glomalins are primarily produced by arbuscular mycorrhizal fungi (AMF) and are produced by the network of root like hyphae. In the symbiotic relationship between the AMF and plants, the AMF are fueled by the plant sugars and, in return, convert and transfer vital soil nutrients back to the host plants.

As microbial populations build, soil aggregation increases. The increased soil aggregation shelters organic matter that is rich in carbon and plant nutrients. According to Dr. Kristine Nichols, USDA ARS, Mandan, ND, "Organic matter that is inside soil aggregates decomposes at a slower rate, so the more aggregates we can make and the more carbon we can store inside them, the more carbon we can build in the soil". As soil aggregates form, then greater pore space is created in the soil. The greater pore space allows for increased water storage because the effects of evaporation are significantly reduced. Additionally, greater pore space allows for more efficient and effective gas exchange in the soil, thus increasing survivability of soil microbes because oxygen can penetrate more effectively and balance out the CO2.

Glomalin has a long life span with the ability to survive for years in undisturbed soil. The glomalin molecule is approximately 30-40% carbon, so the molecule itself is a powerful storehouse of carbon in the soil. It has been estimated that glomalin alone accounts for up to one-third of the world's soil carbon. In typical tillage practices, native microbial fungi tend to spend all their time trying to form hyphae and are unable to effectively store much carbon or produce much glomalin, so they eventually die out. When this happens, is takes a long time for enough new spores to arrive by wind or water. When, or if, they do arrive, they then have to spread slowly from root to root. In the case of typical agricultural practices, to gain an effective fungi population, it has to be introduced in numbers that are sufficient.

Summary

Healthy soil is critical to long term agricultural productivity and profitability, and to environmental sustainability. Annual global soil loss is a major concern, but can be stemmed through enhanced agricultural practices. Essential to this is the building a strong soil microbial populations that are highly concentrated and highly functional. Strong soil microbial populations are crucial to building soil organic matter. Research delineates the value of increased soil organic matter. The literature also shows that beneficial soil microbes serve to enhance plant health and growth, reduce the need for inorganic fertilizers and chemicals, and reduce harmful environmental impact.

Bio Soil's Sumagrow Improves BRIX Levels

By: Hank Daniels

A BRIX measurement is a measurement of the nutritional value of the sugars, proteins and minerals in a given fruit, plant, crop or forage grass. The BRIX test was introduced in the 19th century by Karl Balling and Adolf Brix. The modern day application of the BRIX test is a science perfected by Dr. Kerry Roberts and the test can be performed by a hand held refractometer.

Fruits, plants, crops and forage grasses with a higher BRIX level will taste better, have a more pleasing aroma and will be healthier than foods with lower BRIX levels. Livestock and w" "life will instinctively seek out forage food with a higher BRIX level. Taste tests by consumers have shown that fruits and vegetables with a higher BRIX level simply taste better.

A BRIX refractometer performs a test on some grapes.

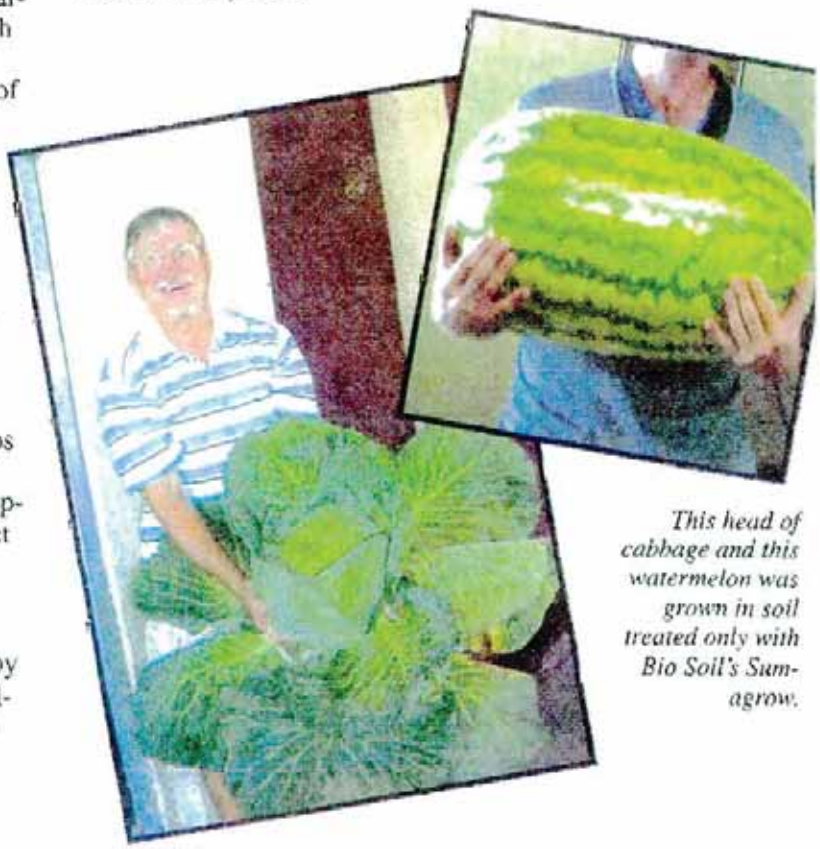
Dr. Allen Williams, who has been on the Board of Directors for the Association of Family Farmers since 2004 and is currently serving as Chairman of the Board of that association recently conducted a yearlong survey test with the TallGrass Beef Company, a Kansas based beef company that markets grass fed and grass finished beef to restaurants and high end supermarkets. Dr. Williams found that with the application of Bio Soil's Sumagrow, the BRIX level of the forage grass rose from an average of "4" to an average of "14", a significant increase.

"Another benefit to this higher BRIX level was healthier cows. TallGrass saw their veterinary bills drop by $40,000 after they started using the Bio Soil Sumagrow product, Dr. Allen said. "Cattle weight went up, the cows were healthier and the cows with calves were lactating at a higher rate. Also, the calves were larger and healthier."

Bio Soil Sumagrow Is a complex multi-functional formula containing beneficial microbes that helps fruits, plants, crops and forage grasses process the nutrients that are already in the air and soil. Bio Soil Sumagrow is an all natural spray application that cannot harm the plants or the soil. The product is extremely affordable. The cost is about ¼ of the cost of artificial synthetic fertilizers.

You can learn more about the Bio Soil Sumagrow product by visiting their website at www.sumagrow.com or by e-mailing them at customerservices@biosoilenhancers.com or by calling them at 1-877-888-2744.

Dr. Allen Williams received his Masters in Agriculture from Clemson University and PhD in Agriculture from Louisiana State University (LSU)



This head of cabbage and this watermelon was grown in soil treated only with Bio Soil's Sumagrow.

Part 1. How come the sick calves? Why aren't heifers reaching target weights?

Another autumn calf rearing in swing and the farmers are coping with scours, rotovirus, failure to thrive and generally not meeting target weights despite feeding milk replacer to instructions and adding calf meal. We need to stop figuring that's normal and realise that it's not. Well-nourished calves are actually bright coated, frisky and tremendous weight gainers. What's gone amiss? Why has it gone pear-shaped?

First thing is feeding calves mastitis milk with its load of antibiotics. Second is feeding milk replacer powder which is usually made from the poor quality skimmed milk that doesn't reach grade. Calves, like any other baby, do best on what is the most natural feed for them. Milk replacers simply don't have the complex profile of natural fats that calves need to fill out properly. It's not nice to fool Mother Nature and we pay the price with cows that don't last long. We feed our future herd a cocktail of antibiotics creating depressed immune systems and antibiotic resistance in them and then wonder why we have heifers calving with mastitis. So we give them dry cow therapy to make sure for next time and make the problem worse. It's not working. We need to deal to the basic issue which is that our animals are not only underfed but undernourished. Exposing them to antibiotics from the get go certainly doesn't help their health or production. For truly healthy, productive cows we need to be feeding calves whole, clean, real milk available whenever THEY want it....just as is ideal with human babies.

Any animal that starts off minerally impoverished will have a weak immune system. Undernourished dairy cows will not be able to mount a satisfactory defence against infections. So we get, according to Dairy NZ, half of the national herd under treatment for mastitis during the year. And then we rely on increasing levels of antibiotics and dry cow therapy to get us through to the next season. What we seem to be ignoring is that antibiotics negatively alter rumen microbes – the key workforce in milk production. And antibiotics impair immune function. A surprisingly large percentage of administered antibiotics spill, still active, from the faeces and urine into the soil and into the waterways. There they do the same thing they do in the gut, especially at continuous low levels. They rapidly create resistance to antibiotics in a wide range of microbes and often to additional classes of antibiotics. E.coli, for example, once a benign and useful microbe on 'our' side, has gone over to the enemy and uses 'plug and play' antibiotic resistance training modules called transposons to teach multiple resistances to completely unrelated microbe species. There's a good chance that the untreatable mastitis infections, like Staph aureus and mycoplasmas, are situations we created through overuse of antibiotics.

In a surprising move in November 2013, the US Food and Drug Administration asked pharmaceutical companies to voluntarily reduce use of antibiotics in animal feeds, signalling that within 5 years it would be putting prohibitions in place. The American Center for Disease Control is clear that use of antibiotics in animal production creates antibiotic resistance that limits human treatment options....we're running out of antibiotics that work consistently for us and there are no further options in the antibiotic pipeline. And if you think we don't routinely put antibiotics into feed or animals in NZ dairying, think again. Any monensin-based coccidiostat /bloat remedy/ growth promoter in animal feed, bolus or water is an antibiotic and has potentially serious impacts on cow fatty acid creation, cell metabolism and insulin levels.

Mastitis is basically a result of undernourishment. Mastitis signals the cow needs more minerals, non-detergent fibre and complete protein than she's getting. Mastitis is associated with high somatic cell count and with high milk urea levels. Excellent nutrition from diverse pasture providing generous levels of all minerals throughout the season, but especially in the dry cow period, is the way to avoid mastitis and the massive financial losses it entails. Repeated applications of urea result in high nitrate (high crude protein), low soluble solids (low mineral) watery grass that simply does not adequately nourish the cow. Instead of changing out of a urea-based fertiliser regime, we use expensive supplemental feeds and antibiotics which don't address the cause of the problem. Increasingly, we won't have the antibiotics in feed and dry cow therapy options available because our markets won't tolerate it.

Massey researchers last year completed a study on Milk Urea. Internationally, dairying countries use the Milk Urea Nitrogen (MUN) test but the NZ standard test is for Milk Urea (MU), both expressed as mg/dl. A MUN figure is 47% smaller than the MU number. Get to know this MU acronym as I predict it will become the key indicator we use for quality dairying in the not too distant future. Open Country Dairy provided over a thousand milk component data points for a several year research project in the Waikato on how MU levels affect milk characteristics. They found MU levels that are rather higher than what is considered normal internationally. They also tested pasture crude protein and soluble solids levels on ten of these farms to link pasture characteristics with milk characteristics. Turns out high crude protein (high nitrate) / low soluble solids in forage creates high MU levels in milk which reduce ALL of the milk component indicators of protein, fat and lactose. Excessive fertiliser urea makes for high MUN and poor component milk. Since there is a direct numerical link between MUN and urea in the urine, we could be using the simple, daily MUN readings as an early warning system for nitrate leachate. It would be a darn sight easier than an Overseer program.

We need holistic animal health advice which is focused on good nutrition and that is truly for the benefit of the farmer's bottom line. When was the last time your vet expressed concern over use of dry cow therapy or suggested that your animal health challenges might have something to do with pasture quality and your fertiliser program? We need to be focusing on optimum nutrition from the soil up, not on applying expensive plasters.

Part 2. Neat Urea not so neat

All farmers want to be farming for a better environment as well as profit. Farmers DO care. So how have we ended up with the slug of serious problems in dairying that we didn't have 40 years ago like reliance on supplemental feeds and antibiotics, poor conception rates, calf scours, high milk urea (MU), nitrate leachate and a stink profit margin? We're spending fertiliser money creating 'funny protein' grass that burns out our cows at 2.5 lactations, pollutes our rivers, propels us in the direction of very expensive barns, alienates consumers and reduces the very healing qualities of milk fat that the world desperately needs and will one day value. We've gone beyond shooting ourselves in the foot. Despite the temporary illusion created by this wonderful dairy payout...the muzzle is aimed higher off the ground.

We CAN grow larger volumes of high soluble solids, complete protein, diverse species pastures that beat the pants off the competition. We can do it by driving our fertiliser programs with lime, key trace elements, humic acid granules and judicious use of foliar urea - all at lower cost than our

present reliance on 350 + kg/ ha/year of urea and certainly at less cost to our environment and health. And it can be done at Olsen P's phosphorous levels below 20. There is no need to continue large applications of cadmium and fluoride tainted Super Phosphate to maintain Olsen P ratings that are already through the roof. Our fertiliser cooperative executives are selling us down the river because there is no margin in lime and they need the high turnover figures to justify their salaries. Sorry, guys. It's time to call a spade a spade. All of these band-aids we 'need' to apply because we grow stink, urea-addicted grass makes everyone else money except us. Farmers are the patsies in all this.

The first illusion that must fall away is that agriculture and pastoral production can successfully function as a chemical system based on petroleum inputs. No, it is a complex biological system governed by microbes which need to be fed the full range of macro and micronutrients in their most biology-friendly forms. Soil microbes crash when we burn them with urea and Super phosphate.

Using urea as the basis for pasture growth creates high levels of nitrate nitrogen in the forage. We've all been assured that we grow 'good' pasture with a crude protein content a 20+%. The international standard for ideal pasture crude protein content is 16%. What our pasture crude protein test actually cheaply measures is elemental nitrogen. It's expensive to measure amino acids or real protein content, so the test measures nitrogen and then multiples it by 6.25 to get an assumed level of 'protein'.

It is indeed a crude measure since to actually get usable protein from nitrogen you need a range of other minerals, lots of energy and healthy microbes to change nitrate into amino acids chains and then into real protein. To turn nitrate into usable protein, the cow's rumen microbes need high levels of carbon/sugar/ energy and trace elements in their diet. The easiest way to get that is to grow grass that's high in soluble solids/brix/ minerals/energy. This simply doesn't happen with reliance on urea as the main fertiliser. One of the most visible effects of high nitrate grass is projectile cow poos.

When we apply urea directly to paddocks, the majority of the nitrogen either off-gases into the air or becomes nitrate leachate through the soil. The nitrate leachate takes calcium, magnesium, copper and other key minerals with it when it heads into the water ways. So we end up with low mineral levels in our grass which are further reduced by the use of glyphosate. Glyphosate locks up soil minerals and promotes the fungi that create mycotoxins in preserved feed. It is an antibiotic which kills many of the beneficial microbes and can take decades to decompose in the soil. Thus we put high nitrate, low energy and low mineral grass into our cows and the rumen microbes can't cope with the excessive nitrogen. And this is where the urea ill-health cascade really kicks in:

Excessive nitrate in the forage promotes the growth of methanogen bacteria in the rumen. This class of bacteria can digest high N feed better than the optimal rumen microbes. Problem is these methanogen microbes create methane which the cows then belch out and get tarred with the 'nasty greenhouse gas producing' shame label. Ruminants don't inherently pollute, it really depends on what they eat.

Excess nitrate in the rumen becomes ammonia and seeps into the blood through the rumen wall. Ammonia is toxic to the animal. It reduces oxygen in the blood. The result is basically sick, underperforming cows that are overtaxing their livers and pulling lactose/ sugar out of their systems

in an attempt to convert the excess nitrate/nitrite/ ammonia back to urea and get it the hell out of their bodies by every conceivable means.

We're feeding our animals unnaturally high levels of nitrate. We observe their frantic efforts to get rid of the nitrogen and assume it's normal. It's NOT; it's just average and a poor, expensive average at that. Cows can be a powerful positive source of soil regeneration but not with the way we're fertilising. If we took the hundreds of millions we're spending on Greenhouse Gas research and used it for lime and trace element applications we'd markedly reduce emissions, have healthier animals AND prompt humus formation, CO_2 sequestration and better infiltration and water holding in the soil.

Since we mistakenly assume that high crude protein/nitrate levels in pasture are good, we don't generally take the timely measures to compensate: things like long stemmed hay for more carbohydrate/ dry matter and a good rumen mat; bentonite clay and humate powder for detox; and molasses for extra energy. Eventually the cow's liver can't cope with the demand to convert ammonia to urea it can get rid of it through pee and the ammonia ends up circulating in the blood where it accumulates in the extremities contributing to lameness. Converting ammonia to less harmful urea in the liver requires lots of energy from the cow prompting the negative energy balance and rapid loss of body condition we see post-calving just when the demands of high milk production coincide with....you guessed it – high nitrate, lush, urea-fuelled spring grass.

A cow in a negative energy balance, losing condition, is not going to figure it's a good idea to ovulate and sustain a pregnancy as that could threaten her very existence. So we have non-cycling cows, use of CIDRs to force ovulation, increased phantom pregnancies and an embarrassingly low first mating conception rate of 48% with an overall fertilisation rate of 67%. And we congratulate ourselves on having stalled the decline when we are a long way from the 2016 goal of 78% fertilisation rate. Even if the cow conceives, the circulating ammonia is toxic to foetus which could help to explain our disappointing breed back rates.

So now we have a pregnant cow producing, but losing condition, on a minerally deprived diet which leads to an impaired immune system. We purchase supplemental minerals to put in the water or in the ration to compensate for what is not coming through in the pasture. Where are these soil minerals that the cow's system needs? Well, they weren't there enough in the soil in the first place, or they're locked up or made less available by the low soil pH created by urea and Superphosphate applications or by glyphosate lock up. Or they've ended up in the rivers having been pulled out of the soil profile by the nitrate leaching from straight urea applications and from high N cow urine.

To put it crudely – we are pouring fertiliser nitrogen, that could become usable protein for the cow, down a rat hole instead. We're wasting protein components in the rumen because we're growing minerally poor, low energy grass and the rumen microbes can't utilise all the nitrogen we're throwing at them. So the nitrogen goes into the cow's blood where it creates a variety of havoc and then spills out into the environment where it damages water quality and the ecosystem in general. The cow also excretes excess nitrogen into the milk reducing milk quality, cheese quality and payout. We're creating the problems and expenses associated with dairying by unscientific and minerally impoverished fertiliser programs. It doesn't have to be this way!

You actually get more dry matter and higher sugar content in pasture using a dry fertiliser blend, based on the calcium in lime plus trace elements supplemented with liquid foliar nitrogen, at a fraction of the normal urea used. Production does NOT go backwards with this smarter approach. The resulting higher plant mineral levels and better pasture quality gives more milk, more worms, uses less water, less spent on animal health, the same fert cost and delivers higher profit. This practical approach reduces nitrate leachate and creates better quality milk. We can do...it is being done here right now.

Part 3 The Future is Fat

We're missing out on the real future of milk, which is not in its protein content but in its fat content and the allied fat soluble Vitamins A, D_3 and K_2. These vitamins can only be found, in their right form for us, in saturated animal fats. So I'm –ticking off the vegetarians and vegans here, too. Wake up, folks. Pretty much all our modern health problems can be traced back to poorly mineralised soils growing nutrient deficient crops compounded by a serious lack of the fat soluble vitamin activators. They're called activators because without vitamins A and D as catalysts, the other minerals and vitamins in our diet can't be fully used for protein creation. Proteins are the basis for hormones, enzymes and blood. They are involved in every process in our bodies. And here's the kicker – Vitamin K_2 has to be present for A and D_3 to work properly and it's particularly high in butterfat when cows graze green grass. Vitamin D_3 and A deficiencies are now being implicated in every health problem we've got – heart disease, cancer, osteoporosis, diabetes, mental disorders. We've been chasing the wrong health train for 50 years. It's not about avoiding natural animal fats, it's about embracing them! Our appalling and deteriorating health stats should have made that clear to us decades ago....must have been the impaired mental capacity from lack of butter in our diets.

So how do we get high vitamin A, D_3, K_2 butterfat? Here is where our not so secret but undervalued advantage comes in. Vitamin K_2, which makes butter orange coloured, is only created from cows grazing directly on rapidly growing green, well-mineralised, high calcium, low nitrate pastures. We have the nearly unique potential to create THE natural food components that are critically needed by all pre-conception parents, pregnant women, children, athletes, the aging.... well, everyone, really. These are the same natural, saturated fat vitamin components that give great flavour to the world's great dishes and which solve the pressing problems of dental caries, orthodontia, dementia, atherosclerosis, kidney stones, birth defects and cancer, to name a few.

Instead we're focusing on protein. We export dried, oxidized cholesterol milk powder around the globe, particularly to babies in China, setting them up for a life of immune and mental deficiencies through lack of the natural fats in mother's milk. Surely you didn't think I'd let milk companies get away scott free in this polemic? New Zealand milk companies have made butter oil for decades as a way of preserving cream components for reconstitution with dry milk powder in overseas factories. Butter oil is where the gold is, literally. We need to go back to marketing milk for its real value – butterfat, and its high content of crucial Vitamins A, D_3 and K_2. Keep the milk solids at home and add value by giving them to grass-raised pigs which we then sell to China. Hint...pork lard has the highest Vitamin D_3 content of any food except bear fat and we're not about to start farming bears.

Let's see, I've probably enraged everyone except the Jersey breeders and the pork producers...while I'm at it I may as well finish with a go at the banks. Where do you guys get off? You're clearly not operating in the old mode of conservative advisor who has the farmer and the community's best

interest at heart. Get a life that actually improves the financial strength of farm families and the nation. You can still make a good living. There's no need to be that bloody greedy.

Our present high nitrate, low soluble solids (low mineral content) forage and the resulting water quality problems from leachate is NOT a good reason for sacrificing our low cost pasture-based advantage by moving into barns and total mixed ration for our cows. Fix the basic problem!! Use our cheap lime to drive quality grass growth that creates high vitamin A, D_3 and K_2 butter fat, healthy long-lived cows and a premium product that transforms human health.

We can easily produce the world's best medicinal butterfat at an eye-watering premium while improving the quality of our soils, water and health. There could be tremendous job satisfaction knowing that we're creating food that truly nourishes and eventually heals both people and the environment at a great profit.

I'm happy to supply the research references that substantiate what I have said here.

Phyllis Tichinin

Hawkes Bay

FS 01

BIOSOIL
ENHANCERS

The following article entitled, "Improving the Green to Improve the Green," by Dr. Allen R. Williams, PH.D, written for the April/May/June 2011 edition of Bison World, highlights the significant advantages of using Bio Soil Enhancers' products. Dr. Williams writes,

"The foundation of highly productive pasture is highly active, healthy soil. Without this, our efforts at forage management become frustrating at best . . . A new organic soil microbial introduced by Bio Soil Enhancers, Inc. (www.sumagrow.com) shows significant promise for increased forage and crop yields, improved brix levels, and significant reduction or elimination of chemical and other forms of fertilizer."

For more information about Bio Soil Enhancers' products with SumaGrow, please contact us at
Bio Soil Enhancers, Inc.,
1161 James St., Hattiesburg, MS 39401 ~
(601) 582- 4000 ~ info@biosoilenhancers.com

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FS 01

Improving the Green to Improve the Green

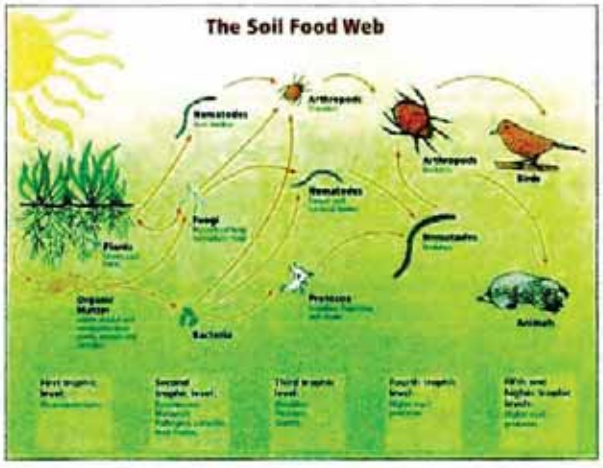
BY ALLEN R. WILLIAMS, PH.D., ANIMAL INSIGHTS, LLC

Editors Note: *The subject of pasture management, generously contributed by Dr. Allen Williams, will be presented in Bison World as a series. The first issue deals will soil biology and how to enrich it.*

I have often heard it said that the best livestock producers were really grass farmers. Certainly, we have to be excellent managers of our forages if we expect good performance from our livestock. However, I believe we have to take it one step further and say that the best livestock producers are really good soil managers. The foundation of highly productive pasture is highly active, healthy soil. Without this, our efforts at forage management become frustrating at best. If our soils are not highly active from a microbial standpoint, then our pastures and rangeland will be only marginally productive and will require large amounts of expensive inputs to reach an acceptable level of productivity. It is important to note that applying fertilizers, liming agents, and the like, is only treating the symptoms of depleted soils, not the underlying cause. With that in mind, let's examine what healthy soil should look like and explore management strategies to improve our soil, our forages, our animals, and our environment.

We first need to realize that healthy soil should be literally teeming with life. If we take a look at the Soil Food Web (Figure 1), we can see that life originates from the sun, soil, and water. We must have active, living soil in order to have thriving life above ground. If we take a page out of the Holistic management handbook, we find that there are four foundation blocks for a thriving ecosystem: Water Cycle, Mineral Cycle, Energy Flow, and Community Dynamics. Proper management of these four foundations is critical to developing a sustainable, profitable livestock operation.

Figure 1: Soil Food Web (www.soilfoodweb.com)



So, what should an acre of healthy soil look like? What kind of life should be present in the soil and to what degree? Healthy soil contains high concentrations of bacteria, fungi, algae, protozoa, nematodes, earthworms, insects and arthropods. These living, breathing organisms are the key to soil vitality. Table 1 illustrates what should be found in a typical acre of healthy soil.

Table 1. Soil Life in an Acre of Healthy Soil.

Type of Organism	number/acre	pounds/acre
Bacteria	800,000,000,000,000,000,000	2,600
Actinobacteria	20,000,000,000,000,0001,300	
Fungi	200,000,000,000,000	2,600
Algae	4,000,000,000	90
Protozoa	2,000,000,000,000	90
Nematodes	80,000,000	45
Earthworms	40,000	445
Insects /arthropods	8,160,000	830

Source: www.soilfoodweb.com

In the past, biological soil discussions have centered on specific minerals being present in more abundance or less abundance in differing areas and regions. These minerals have always existed in differing amounts throughout the United States because of varied rock strata. However, most U.S. soils were fertile until man arrived and upset the natural system. The natural system was derived under roving herds of animals, primarily ruminants. These large herds of wild ruminants left fertile soil everywhere, despite differing levels of soil minerals. Why? Because the soil was teeming with living, breathing soil microbes. The activity of these soil microbes created a naturally fertile soil with high levels of soil carbon. Soil carbon tends to be high in properly managed grazing systems or in unmanaged wild animal systems.

We should note that just as microbes in the ruminant's gut feed the animal, soil microbes feed the plants. These soil microbes get their food supply from the breakdown of trampled plants (ground litter), manure, and urine. Soil microbe health has a direct affect on the health of the plants depending on them. There is a continuous cycle of nutrients involved in this process and proper grazing management and adequate rest periods can significantly improve this process. This process is what I term "beyond sustainable" as it actually creates more energy than it consumes, primarily through increased photosynthetic activity.

Vibrant, active soil tends to have a pH that is close to neutral. Neutral pH soils harbor a great diversity of soil bacteria. This is supported by the fact that Duke University scientists collected soil samples from 98 locations across North and South America. To their surprise, the strongest predictor of high soil microbial diversity was a neutral pH. They found that acidic soils harbored one-half to one-third as many species as did neutral soils. Acidic pH soils tend to be low in organic matter or organic carbon (OC). Organic carbon is the backbone of all life. Without OC, soil microbes cannot flourish, soils become compacted, and soil water holding capacity is greatly diminished. High OC soils are friable, meaning that they can "spring back" to their original state after compression, such as bison walking over the surface of the pasture or

rangeland. Low OC soils will not spring back, staying compacted and not allowing adequate moisture or nutrients to pass through.

Soil OC is an important water storage reservoir, holding water in the root zone available for plant use. If the soil OC is too low, water can pass below the root zone or is not even allowed into the soil and instead becomes surface runoff. Organic matter behaves somewhat like a sponge, with the ability to absorb and hold up to 90 percent of its weight in water. A great advantage of the water-holding capacity of organic matter is it will release most of the water that it absorbs to plants. In contrast, clay holds great quantities of water, but much of it is unavailable to plants. Table 2 illustrates the water holding capacity depending on varying degrees of soil organic carbon (matter):

Table 2: Soil Organic Carbon Water Holding Capacity

Soil OC Water Holding Capacity	
Organic Carbon (%)	Water Per Acre (Gallons)
1%	14,400
2%	28,800
3%	43,200
4%	57,600

Source: www.amazingcarbon.com

The question is, how do we effectively improve soil microbial activity and, in turn, soil organic matter? Conventional grazing and fertilization practices typically contribute to further depletion of our soils. If we want our natural mineral cycle to be healthy and functioning, we have to understand how every input and management practice affects it. The late Dr. William Albrecht recognized the importance of soil carbon and organic matter, but he also realized that plants, and the animals that consume the plants, perform best when everything is in the proper balance.

Unfortunately, chemical fertilizers, which admittedly can provide nutrients to plants, tend to have a detrimental effect on certain soil microorganisms, and some chemical fertilizers are actually acidifying the soil. Dr. Phillip Barak, University of Wisconsin Associate Professor of Soil Chemistry and Plant Nutrition, said, "The soil at the Arlington test site has, in 30 years of "normal" agricultural acid inputs, aged the equivalent of 5,000 years with natural source acid inputs."

Other negative impacts on soil microbes from current agricultural practices are evident as stated by Dr. E. Ingham, Oregon State University, "Every chemical-based pesticide, fumigant, herbicide and fertilizer tested harms or outright kills some part of the beneficial life that exists in the soil, (or on the leaf surfaces) even when applied at rates recommended by their manufacturers... Less than half of the existing active ingredients used as pesticides have been tested for their effects on soil organisms."

In addition to the potentially negative consequences of chemical fertilizers and other chemical inputs, they are also quite expensive and continuing to increase in price. Reliance on these products can significantly increase input costs and negatively impact overall profitability.

continued on next page

FS 01

Improving the Green, continued from page 25

So how do we make improvements without reliance on chemical fertilizers, and other chemical based products? There are two primary strategies that can be employed, and they are not mutually exclusive. In fact, I personally use both in my own grazing practices. The first provides a sort of "jumpstart" to soil microbial activity and allows for immediate increases in forage dry matter yields and plant brix. (Brix is a measure of totally dissolved plant solids as measured by a refractometer. Included in these dissolved plant solids are sugars, proteins, minerals, and amino acids. The higher the brix, the greater the plant solids indicating greater nutrient volume and density.)

The first strategy is the employment of specific soil microbial products that rapidly improve soil microbial activity. A new organic soil microbial introduced by Bio Soil Enhancers, Inc. (www.sumagrow.com) shows significant promise for increased forage and crop yields, improved brix levels, and significant reduction or elimination of chemical and other forms of fertilizers. This new product is a proprietary mix of over 30 natural soil microorganisms specifically selected for their ability to enhance and rehabilitate the soil. Included in this mix are soil bacteria, fungi, and liquid humates. This mixture replaces soil microorganisms that suffered damage due to over-use of nitrates and salts, adds trace minerals, and maintains a healthy soil pH.

Research conducted at Michigan State University and Mississippi State University on various fruit, vegetable, and row crops show yield increases and fertilizer reductions in crops such as tomatoes, squash, corn, soybeans, rice, and cotton. Yield increases have ranged from 10 percent to over 30 percent.

In 2010, demonstration trials were conducted using soil microbials on pastures located in southeastern Kansas. The objectives of the trial were to evaluate the effect of three fertilization treatments on forage yield, grazing days, forage brix level, and residual impact throughout a 150-day warm season grazing period. Approximately 200 acres was allocated to the trial, with pastures split into 6 equal paddocks of 33 acres each. Primary forage species consisted of Kentucky 31 Fescue, Common Bermudagrass, White Clover, and Red Clover.

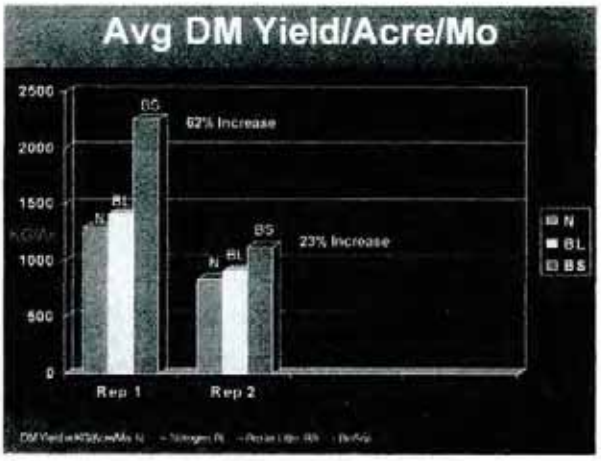
Fertilizer treatments consisted of: 1) 1 gallon/acre of organic liquid broiler manure applied at a 20:1 dilution to pastures 1 and 1A; 2) 1 gallon/acre of soil microbial applied at a 20:1 dilution to pastures 2 and 2A; and 3) 50 pounds nitrogen/acre (46-0-0) applied to pastures 3 and 3A. Cost per treatment was approximately equal. All treatments were applied on May 15, 2010. Each 33-acre treatment pasture was subdivided into daily grazing paddocks based on estimated forage dry matter availability and rotationally grazed at appropriate stocking rates throughout the 150-day grazing period.

Forage yield cages were randomly placed in each treatment pasture and clippings were done every 30 days to determine average dry matter yield. Brix measurements were taken weekly on each individual forage species and total grazing days per treatment noted.

Treatment results indicated advantages for the soil microbial over both the nitrogen and the liquid broiler manure treatments. As anticipated, the nitrogen application showed "quick hit" results that tapered off significantly after 30-45 days. The best residual impact was noted with the liquid broiler manure and the soil microbial, with the soil microbial slightly outpacing the liquid broiler manure throughout the entire 150-day trial period.

Forage dry matter yields averaged 28-40 percent higher for the soil microbial treated pastures compared to the liquid broiler manure and 23-62 percent higher for soil microbial treated pastures compared to the nitrogen treatment (Table 3).

Table 3: Average Dry Matter Yield Results



Brix levels were consistently highest for soil microbial treated forages, with brix levels for the liquid broiler manure being intermediate, and lowest for the nitrogen when averaged across the 150-day grazing period (Table 4 and Table 5).

Table 4: Brix Results – Tall Fescue

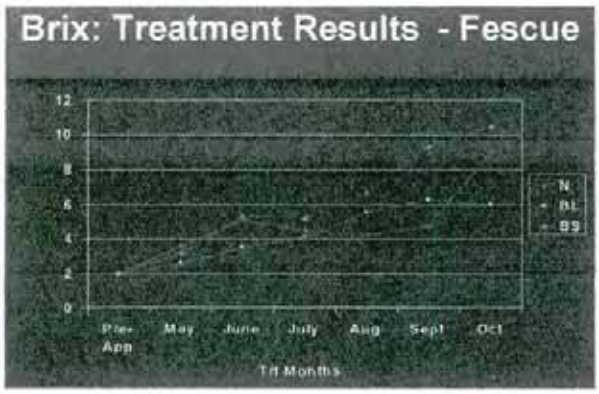
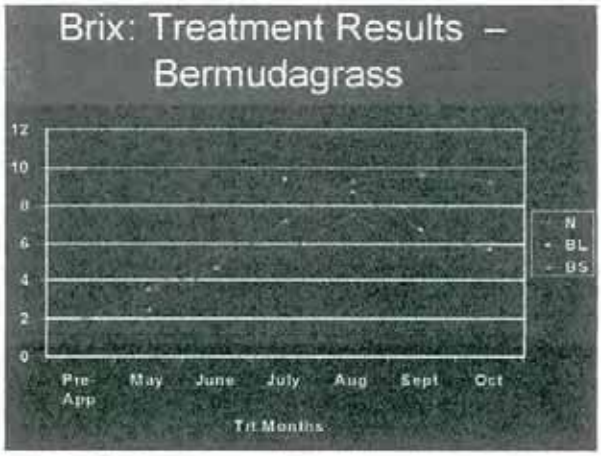


Table 5: Brix Results – Common Bremuda grass



Finally, over the 150-grazing period, soil microbial treated pastures provided 21 more grazing days compared to the liquid broiler manure and 33 more grazing days than the nitrogen treated pastures. We can see the impact of enhanced soil microbial activity in an increased earthworm and insect populations (Figure 2 and Figure 3) and in increased forage density and diversity (Figure 4).

Figure 2: Earthworm Castings and Insect Population in High Microbial Activity Soil

Figure 3: Earthworms Thrive in High Microbial Activity Soils.

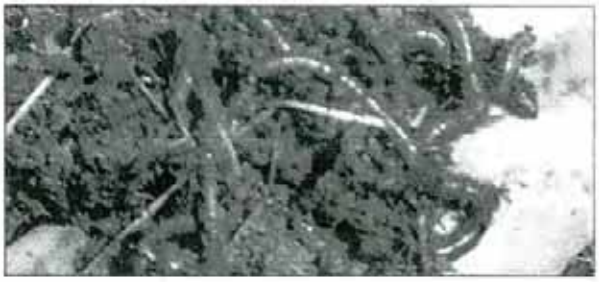


Figure 4: Forage Stand Density and Diversity in High Microbial Activity Soils

Dr. Allen R. Williams is founding partner and President of Livestock Management Consultants, LLC, a livestock industry consulting firm specializing in building natural branded food programs, facilitation of values based value chain food production and management, and ranch/farm grazing management and business planning. He has worked extensively in the grass-fed livestock sectors and serves as chairman of the board of directors for the Association of Family Farms.

He holds a Ph.D. in Animal Breeding and Genetics/Reproduction from Louisiana State University, Baton Rouge, La., and an M.S. and B.S. in Animal Science from Clemson University, S.C. His expertise and responsibilities have included research and business interests centered on farm and ranch financial analysis, development and facilitation of values based food marketing, livestock reproduction and genetics, forage/grazing management, meat science, and cutting edge ultrasound technology. Dr. Williams has worked with the USDA FSIS MPI, and has an extensive farm and ranch background.

He has served on national scientific and industry committees, and has been an invited speaker to over 500 regional, national, and international conferences and symposia. He has published over 50 scientific journal articles and abstracts, as well as over 200 industry publication articles.

2011 SumaGrow Field Trial Report

Allen R. Williams, Ph.D.

Farm Name: Murray State University

Location: Western Kentucky

Principal: Jim Davis, Ph.D.

Crop: BMR Sorghum

Materials and Methods: The primary focus of this study was to determine the effectiveness of different methods of alternative pasture inoculation compared to traditional nitrogen fertilization on beef steer summer grazing performance and ADG. A twelve acre plot was used to measure three different methods of pasture inoculation. The variables measured were brix content (%), Average Daily Gain (ADG), overall animal performance. The 12 acre pasture was divided into four test plots containing 3 acres each. Each section received a different method of treatment with one serving as a control. The treatments regimens were: Treatment 1) Nitrogen application, in the form of Ammonium Nitrate (NH4NO3) at a rate of 60 units per acre per application, applied on May 21st, June 18th, and July 23rd (N). Treatment 2) 1.0 ga/ac SumaGrow (SG) applied at a split rate of 0.5 ga/ac on May 21 and 0.5 ga/ac on June 18 (SG). Treatment 3) Two gallons per acre of raw milk applied at the 2 ga/ac rate on May 21st, June 18th, and July 23rd (RM). Treatment 4) a control with no applications of any fertilization products applied (C). All applications were made using a boom sprayer.

Thirty-two cross bred steers were divided into four equal groups of eight steers each. Steers were randomly assigned to their respective treatment group. The steers weighed an average of 628 lb at the beginning of the first grazing period. The steers initially grazed a stand of 60% Marshal Ryegrass and 40% Red Clover (20 inches in height). This is the standard pasture combination in which MSU starts grazing stocker calves in the spring. BMR sorghum was planted at a seeding rate of 19 lbs/ac on June 24. The BMR Sorghum was no-till drilled in a cross drill pattern to provide a solid stand. The four groups of steers were moved to fresh grazing paddocks when approximately 50% of the available forage DM in each paddock had been consumed. Brix measurements were recorded weekly throughout the growing season using an Atago Master T Refractometer, following Brix testing recommendations developed by Allen Williams, Ph.D.

Cost per acre for treatment and application costs was $137.01 for Treatment 1 (N), $40.00 for Treatment 2 (SG), $45.00 for Treatment 3 (RM), and $0.00 for Treatment 4 (C).

Results: Growing conditions were relatively stable throughout the grazing period with adequate moisture for forage performance. However, temperature and humidity were challenging for the steers, particularly during the second grazing period in July and August.

Brix content for the summer grazing period were not significantly different ($p>0.05$) from each other for any of the four treatments with mean brix of 4.50%, 4.50%, 4.75%, and 4.00% for the N, SG, RM, and C, respectively (Table 1).

Mean ADG were significantly higher ($p<0.05$) for the steers grazing the SG and the RM treatments compared to the N and the C treatments. Mean ADG values for the SG and RM were 2.35 lbs/hd/d and

2.26 lbs/hd/d, respectively, while mean ADG for both the N and C were 2.08 lbs/hd/d. This would result in an additional gain per steer for the SG treatment of 40.5 lbs for a 150-Day warm season grazing period when compared to either the N or the C. The RM would produce an additional 27 lbs gain for a 150-Day grazing period when compared to the N or C (Table 1).

In calculating actual days grazed per number of head grazed per treatment over the summer grazing trial period, Animal Unit Months (AUM) were calculated. An AUM is defined for this trial as the number of 750 lb beef steers that one acre of forage can support for every 30 day period. Mean AUM for the SG and the RM were significantly higher ($p<0.05$) than the N or C treatments with AUM for the SG and RM at 3.67 hd/ac/mo compared to 1.67 hd/ac/mo for the N and 2.00 hd/ac/mo for the C (Table 1).

Per acre cost analysis for the treatment and application costs indicated an advantage of $101.45/ac for the SG treatment compared to the C, with an $67.63/ac advantage for the RM treatment compared to the C. However, the N treatment, due to the increased cost of NH_4NO_3 showed a $170.01 disadvantage compared to the control (Table 1).

Summary: There were no differences between treatments in Brix content in this particular study. However, there were differences between treatments for the ADG, AUM, and cost per acre for treatment. The SG and RM had the best overall performance with higher ADG's, increased AUM's, and better return on investment.

Table 1. Forage & Grazing Performance Data by Treatment.

		ADG			$$
Treatment	Brix (%)	lbs/hd/d	AUM	Cost/Ac	Advan
N	4.50[a]	2.08[a]	1.67[a]	$137.01	-$170.01
SG	4.50[a]	2.35[b]	3.67[b]	$40.00	$101.45
RM	4.75[a]	2.26[b]	3.67[b]	$45.00	$67.63
C	4.00[a]	2.08[a]	2.00[a]	$0.00	

NITRATE RUNOFF REDUCTION

The validation testing at the Arise Research facility was performed primarily to determine the effect of a product containing SumaGrow on the *amount* of tile water runoff and the *percentage of nitrates* contained in the runoff water.

There are five test plots covered by this report: one control plot using the state recommended amount of conventional, petrochemical based fertilizer for corn grown in the State of Illinois; two plots treated with a product containing SumaGrow and 100% fertilizer; and two plots treated with only 50% fertilizer and a product containing SumaGrow.

Throughout the report, treatment #1 are the two plots (or their average) treated with 50% fertilizer and a product containing SumaGrow (SG50). Treatment #2 is the two plots (or their average) treated with 100% fertilizer and a product containing SumaGrow (SG100). Treatment #3 is a single control plot consisting of 100% fertilizer only (100).

The significant findings are as follows:

	100	SG100	% Decrease	SG50	% Decrease
Runoff water 7/20 – Gallons	77.0	40.0	***48.05%***	36.5	***52.60%***
Runoff water 9/30 – Gallons	37.0	19.5	***47.30%***	16.0	***56.76%***
Nitrates in Runoff 7/20	24.0	12.5	***47.92%***	15.5	***35.42%***
Nitrates in Runoff 9/30	37.0	19.5	***47.30%***	16.0	***56.76%***

The runoff water and nitrate data are from page 9 of 17 of the Arise Research report. The runoff water is identified as "Well Water" – runoff water from the containment bays is collected in wells. The nitrates in the runoff are identified in the report as "Water Nitrates." **Both SG50 and SG100 decreased the amount of runoff water significantly** with SG50 reducing runoff water by an average of 54.68% and SG100 reducing runoff water by an average of 47.68%.

Perhaps more importantly, **the nitrates in the runoff water were significantly reduced as well** with SG50 reducing nitrates by an average of 46.09% and SG100 reducing nitrates by 47.61% compared to the conventionally fertilized control plot. Please note the nitrates are measured in Parts Per Million (PPM), therefore, the reduction in runoff water, and a reduced

percentage of nitrates in the runoff water, **combine to reduce the total nitrates by 79.12% for SG50 [1-((1-.5468)*.4609)] and 75.09% for SG100.**

It is imperative to realize this remarkable reduction in nitrate runoff was achieved without cost! In fact, there are additional benefits to farmers, the consumers, and the environment as the chart below highlights some additional data excerpted from the Arise Research report.

	100	SG100	*% Increase*	SG50	*% Increase*
Yield (pg 6)	119.3	145.15	***21.67%***	142.20	***19.20%***
Chlorophyll (9/30)	40.2	54.0	***34.33%***	53.15	***32.21%***
Formazan	314.0	406.5	***29.46%***	444.5	***41.56%***

The yield on the corn crop increased by 21.67% for SG100 and by 19.2% for SG50 compared to the control. Again, please remember the control is what a typical farmer is currently doing. These yield increases are worth over $160 per acre (page 6) and the manufacturer of SumaGrow products recommends at least a 50% reduction in fertilizer which would easily have increased the financial benefit to the farmer by at least another $40 bringing **the total financial benefit to over $200 per acre for the farmer using SG50**, which far exceeds the cost of products containing SumaGrow.

This yield increase is not a fluke as it has been repeatedly demonstrated in numerous field trials and with actual large scale farmers. There is additional data in the Arise report which further lends credibility to the increase yield claim: The plots treated with a product containing SumaGrow had better plant health, wider leaf diameters, bigger stalks and better color.

Consumers of corn grown with products containing SumaGrow benefit since a free market will lower the purchase price for corn as more farmers adopt the use of products containing SumaGrow.

Additionally, chlorophyll is a good proxy for overall plant nutrient value. The corn used is this field trial was field corn which will likely be fed to cattle. Better nutrient values will lead to increased/faster weight gain for cattle eating this corn – another benefit to the consumer of this crop.

Field corn may also be used to make ethanol. While this study did not measure the brix of the corn kernels (just the plant brix), other field trials have demonstrated products containing SumaGrow significantly increase brix levels. Higher brix levels lead to more ethanol per bushel of corn.

The environment is also a winner. In addition to the nitrate runoff reduction highlighted above, fewer gallons of water running off reduce the loss of topsoil and resulting clogging of waterways which would ultimately need to be dredged.

For the soil which does not runoff, the quality has been improved as demonstrated by the Formazan results. The Formazan test provides the biology in a soil sample with a specific amount of a food supply and waits a specific amount of time. The amounts of metabolic enzymes given off by the bacterial and fungal species are measured **when they are active**. The Formazan test is like the speedometer reading of microbial activity in the soil. It is an indirect microbial assay that gives us a picture of the forest—not the individual trees.

Low Formazan readings indicate a poor cycling of carbon, less microbial activity, and the inability of soil to break down organic inputs to supply plants with available nitrogen. The higher the Formazan reading the better and the product containing SumaGrow increased the Formazan levels by 29 to 41%.

The manufacturer of products containing SumaGrow believes the cost/benefit ratio to the farmer is significant enough to allow widespread implementation via the "carrot" approach – where every party benefits – rather than finding an alternative solution utilizing the "stick" approach which will have extra costs for the parties involved.

For additional information, please contact:
SumaGrow
1161 James Street
Hattiesburg, MS 39401
(601) 582-4000
www.SumaGrow.com

FS 01

Trial Results

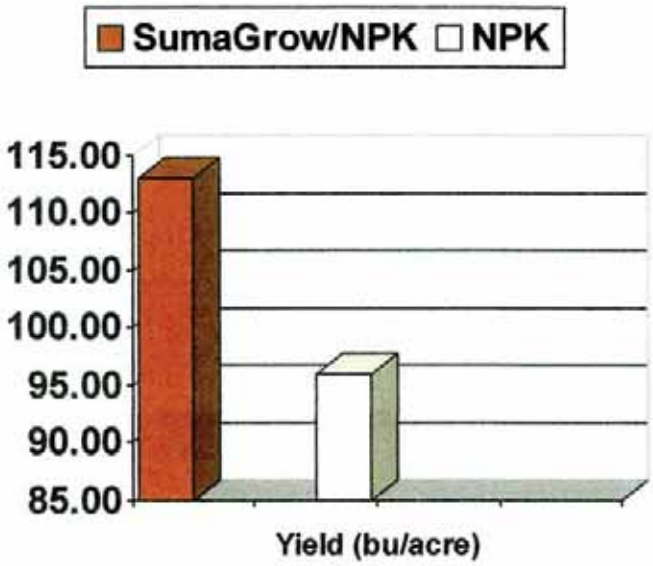
Executive Summary

Corn

Arkansas

Research on the effect of products containing SumaGrow on *Corn*

Yield Results (Bushels/Acre)	
Treatment:	**Yield**
SumaGrow + 100% NPK	113
100% NPK Only	96
% Increase	**17.71%**



Primary Points

Crop:	Corn
Location:	Arkansas
Trial Date:	2011
Treatment Schedule:	20 acre plots
• SumaGrow + 100% NPK	1 gal/acre SumaGrow split application + 100% NPK
• NPK Only	247N, 20P, 30K

FS 01

Trial Results

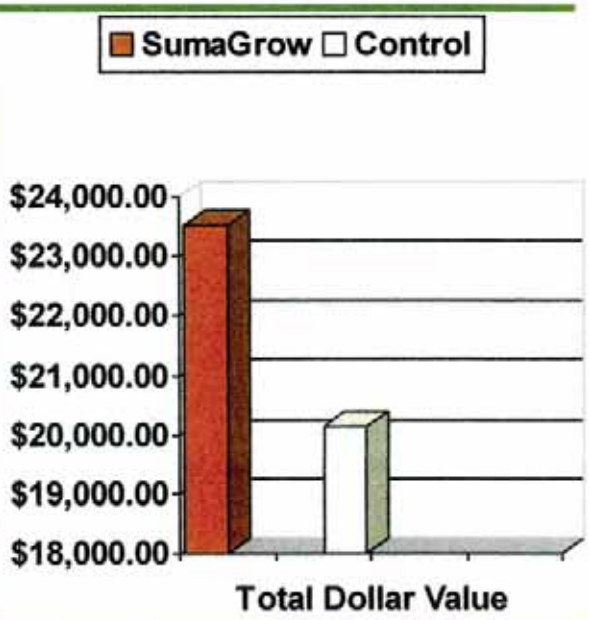
Executive Summary

Arizona

Corn Silage

Research on the effect of products containing SumaGrow on *Corn Silage*

Results		
Treatment:	**SumaGrow**	**Control (no treatment)**
Yield	588.21 Tons	503.42 Tons
Yield/Ac	16.34 Tons	13.98 Tons
Total Value	$23,528	$20,136.80
% Yield Increase	**16.84%**	



Primary Points

Crop:	Corn Silage
Location:	Arizona
Trial Date:	2011
Treatment Schedule:	
• SumaGrow	1 gal/acre at planting
• Control	No treatment

FS 01

Trial Results

Executive Summary

Corn

Plainview, Nebraska

Results: A product containing SumaGrow combined with a 50% reduction in fertilizer increased the farmer's profit.

Treatment	Yield Bu/Acre	Total Treatment Cost/Acre	Value/Acre at $7.92 per bushel	Revenue per Acre	Increase in profit per acre over grower standard
SumaGrow plus 50% fertilizer	239.30	$191.20	$1,895.26	$1,704.06	**$30.38**
Grower Standard- 100% fertilizer only	240.00	$227.48	$1,901.15	$1,673.67	

Crop: Corn

Location: Plainview, Nebraska

Trial Date: 2012

Treatment Schedule:

- SumaGrow plus 50% reduction in fertilizer inputs
- Grower Standard- 100% fertilizer application

Conclusion:

The use of a product containing SumaGrow has demonstrated the ability to reduce fertilizer inputs (by 50% in most cases) and maximize profits. This trial demonstrates that when using a product containing SumaGrow, producers can reduce fertilizer inputs- even in a high nitrogen demanding crop like corn- maintain crop performance, and increase profits. Even though the yields were statistically the same, by reducing fertilizer application 50% and adding a product containing SumaGrow, the producer increased his profit by $30.38 per acre over the grower standard.

FS 01

Trial Results

Executive Summary

Organic Corn

Marshall, WI

Results: A product containing SumaGrow combined with a 50% reduction in fertilizer inputs out-yielded comparison plots by 21% and increased the farmer's profit by over 27% per acre.

Treatment	Yield Bu/Acre	Increase over Grower Standard	Total Treatment Cost/Acre	Value/Acre At $15.90 a bushel	Revenue per Acre	Increase in Profit per acre over grower standard
SumaGrow plus 50% fertilizer	**115.00**	**21%**	$91.87	$1,828.50	$1,736.63	**$329.88 or 27% Profit increas**
SumaGrow plus 100% fertilizer	**106.00**	**11.6%**	$143.75	$1,685.40	$1,541.65	**$134.90 or 6% Profit Increase**
Grower Standard 100% fertilizer only	95.00		$103.75	$1,510.50	$1,406.75	

Crop: Organic Corn

Location: Marshall, WI

Trial Date: 2012

Treatment Schedule:

- SumaGrow plus 50% reduction in fertilizer inputs
- SumaGrow plus Grower Standard- 100% fertilizer application
- Grower Standard- 100% fertilizer application

Conclusion:

The use of a product containing SumaGrow with the recommended 50% (on average) fertilizer reduction has shown to improve crop performance and increase yields. In the above trial, when the fertilizer application was reduced by 50% and a product containing SumaGrow was added, the corn yields increased. It should be noted that even when the fertilizer application was not reduced, when a product containing SumaGrow was added it still out-performed the grower standard and increased profits, even with the additional input costs. However, the maximum yield increase and profit benefit were found when fertilizer was reduced by 50% when using a containing SumaGrow.

FS 01

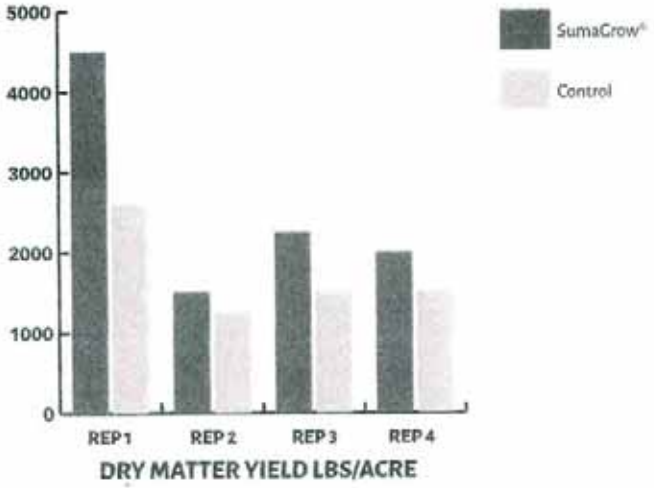
TRIAL RESULTS
EXECUTIVE SUMMARY

FORAGE - PENNSYLVANIA

Research on the effect of products containing SumaGrow® on Orchardgrass, Clover, Alfalfa and Fescue in Pennsylvania

DRY MATTER YIELD (LBS/ACRE) AVERAGE OF FOUR REPLICATIONS	
Treatment:	**Yield** *(lbs/acre)*
SumaGrow®	2,667.5
Control *(no treatment)*	1,782.25
Increase	+ 49.67%

BRIX LEVEL	
SumaGrow®	6.03
Control	4.29



PRIMARY POINTS:

Crop: Orchard grass, Clover Alfalfa, Fescue

Location: South Central Pennsylvania

Trial Date: 2011

Growing Conditions: Challenged– moderate to severe drought conditions

TREATMENT SCHEDULE:

SumaGrow®: 1 gal/acre split application

Control: no treatment

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FS 01

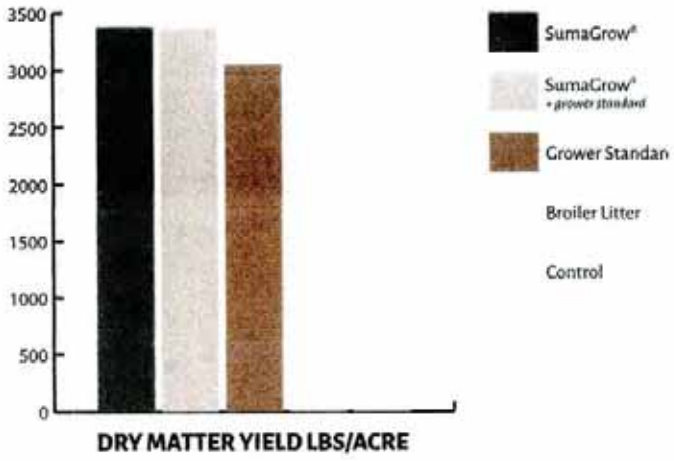
TRIAL RESULTS
EXECUTIVE SUMMARY

FORAGE - VIRGINIA

Research on the effect of Products containing SumaGrow® on Fescue, Clover, Matua and Crabgrass at Lakota Ranch, Virginia

DRY MATTER YIELD (LBS/ACRE)
DRY MATTER YIELD ON FESCUE, CLOVER, MATUA AND CRABGRASS

Treatment:	Yield *(lbs/acre)*	Brix Level
SumaGrow®	3,381.43	7.43
SumaGrow® *+ grower standard*	3,372.50	5.75
Grower Standard	3,050.00	6.00
Broiler Litter	2,892.50	4.25
Control *(no treatment)*	2,265.00	7.00



PRIMARY POINTS:

Crop: Fescue, Matua, Clover, Crabgrass

Location: North-Central Virginia

Trial Date: 2011

Growing Conditions: Fair to good with moderate rainfall and conducive temps

Application: Boom Sprayer

TREATMENT SCHEDULE:

SumaGrow®: 1 gal/acre split application

SumaGrow® + grower standard: 1 gal/acre SumaGrow® split application. 100 lbs /acre NPK split application

Grower Standard: 100 lbs /acre split application

Broiler Litter: 1 ton per acre

Control: No product applied

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FS 01

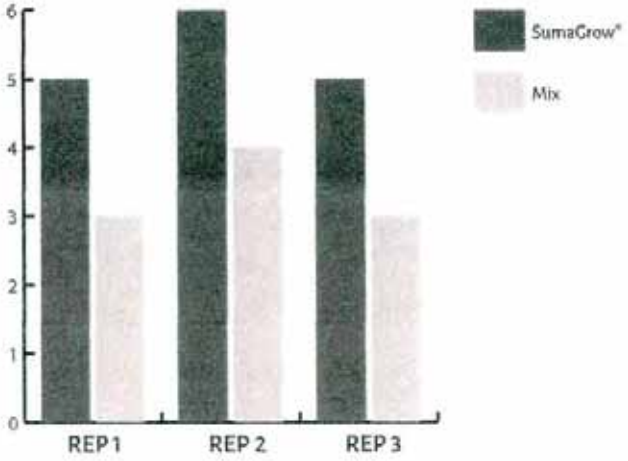
TRIAL RESULTS
EXECUTIVE SUMMARY

FORAGE AND HAY-ALABAMA

Research on the effect of products containing SumaGrow® on Bermuda, Fescue, Dallisgrass, Crabgrass, & White Clover in Bent Tree Farms, Alabama

DRY MATTER YIELD RESULTS
AVERAGE OF FOUR REPLICATES

Treatment:	Soil No_3 (ppm)	Plant No_3 (ppm)	lbs/acre
SumaGrow®	114.5	2,325	2,650
Mix *Fish Oil, Sea Salt, Ca*	99.25	1,132	2,430
Increase	15.36%	105.39%	9.05%



BRIX LEVEL MEASUREMENT

PRIMARY POINTS:

Crop:	Bermuda, Fescue, Dallis grass, Crabgrass, & Clover
Location:	Northeast Alabama
Trial Date:	2011
Growing Conditions:	Challenged from moderate drought conditions
Application Method:	Boom sprayer

TREATMENT SCHEDULE:

SumaGrow®	1 gal/acre at green up
Fish Oil, Sea Salt, Ca Mix	4 gal/acre at green up

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FS 01

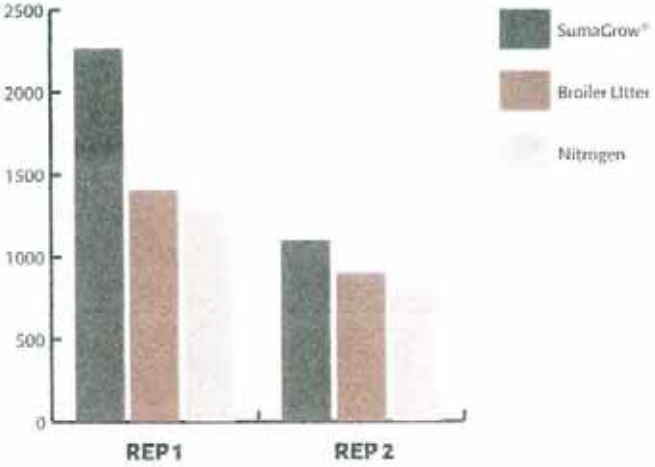
TRIAL RESULTS
EXECUTIVE SUMMARY

FORAGE & HAY-KANSAS

Research on the effect of products containing SumaGrow® on Kentucky 31 Fescue, Common Bermuda Grass, White Clover and Red Clover at LHOP Ranches in Kansas

RESULTS	
Treatment:	**Yield (lbs/acre) Replicate 1**
SumaGrow®	2,263.8
Broiler Litter (BL)	1,405.8
Nitrogen	1,289.2
Increase over Nitrogen	+75%

ANIMAL UNIT MONTHS	
SumaGrow®	2.36
Broiler Litter (BL)	1.46
Nitrogen	1.34



Results indicate significant increases in season long brix content of key forages species for the SumaGrow® compared to the nitrogen, and intermediate results for the broiler litter. SumaGrow® achieved higher yields, greater AUM and overall grazing days available for a 150-day grazing season. Per cost analysis indicated a cost advantage for the SumaGrow® treatments compared to broiler litter and nitrogen.

PRIMARY POINTS:

Crop:	Kentucky 31 Fescue, Common Bermuda Grass, White Clover, Red Clover
Location:	Southeastern Kansas
Trial Date:	2010/Conducted over 150 days
Growing Conditions:	Good with adequate rainfall
Irrigation:	No

TREATMENT SCHEDULE:

SumaGrow®: 1 gal/acre single application

Nitrogen: Single application of 50 lbs 46-0-0

Organic Broiler Litter: 4 gal/acre single application

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FS 01

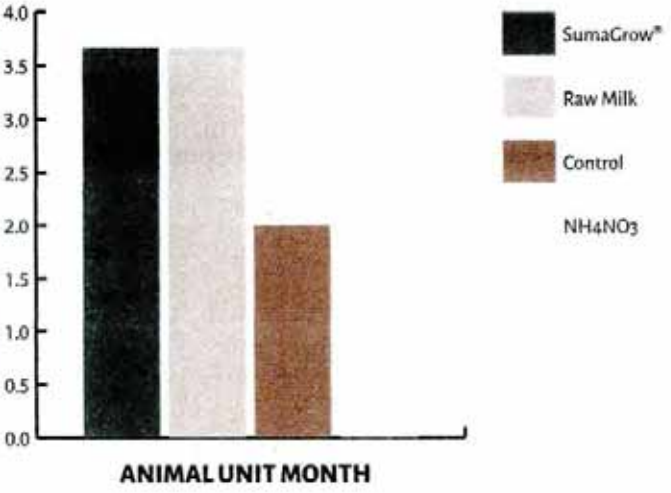
TRIAL RESULTS
EXECUTIVE SUMMARY

FORAGE & HAY - KENTUCKY

Research on the effect of products containing SumaGrow® on Mid Rib (BMR) Sorghum to determine effectiveness on beef steer summer grazing performance and ADG at Murray State University, Kentucky

RESULTS	
Treatment:	**ADG (lbs)**
SumaGrow®	2.35
Raw Milk	2.26
NH_4NO_3	2.08
Control *(no treatment)*	2.08

COST ADVANTAGES *(VS CONTROL)*	
SumaGrow®	+ $101.45
Raw Milk	+ $67.63
NH_4NO_3	- $170.01



PRIMARY POINTS:

Crop: BMR Sorghum

Location: Western Kentucky

Trial Date: 2011

Growing Conditions: Relatively stable with adequate moisture

Application Method: Boom Sprayer

TREATMENT SCHEDULE:

SumaGrow®: 1 gal/acre split application

Raw Milk: 2 gal/acre split application

NH_4NO_3: 100lbs/acre split application

Control: No Treatment

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FS 01

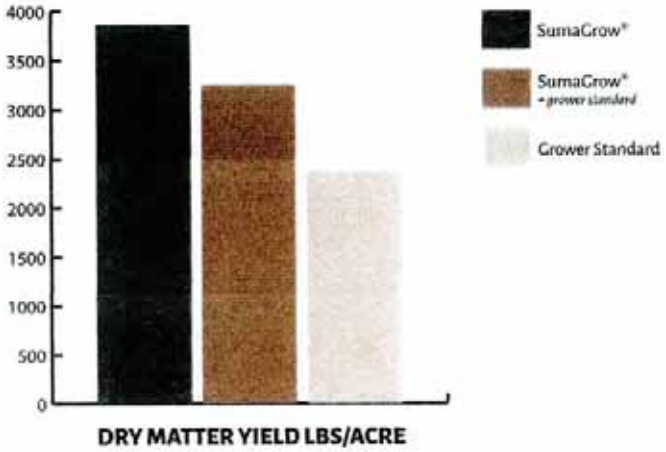
TRIAL RESULTS
EXECUTIVE SUMMARY

FORAGE & HAY - LOUISIANA

Research on the effect of products containing SumaGrow® on Common Bermuda, World Feeder and Crabgrass at Taylor Farms, Louisiana

RESULTS	
Treatment:	**Yield (lbs/acre)**
SumaGrow®	3,859.60
SumaGrow® + grower standard	3,246.00
Grower Standard	2,375.80
Increase	+62%

BRIX LEVEL	
SumaGrow®	7.5%
SumaGrow® + grower standard	5%
Grower Standard	3.75%



PRIMARY POINTS:

Crop: Common Bermuda, World Feeder, Crabgrass

Location: North Central Louisiana

Trial Date: 2011

Growing Conditions: Challenged from severe to exceptional drought

Application Method: Boom Sprayer

TREATMENT SCHEDULE: (RANDOMLY ASSIGNED PASTURES)

SumaGrow®: 1 gal/acre single application

SumaGrow® + grower standard: 1 gal/acre SumaGrow® split application plus 275 lbs/acre 3-1-2

Grower Standard: 275 lbs/acre 3-1-2

SUMAGROW

FS 01

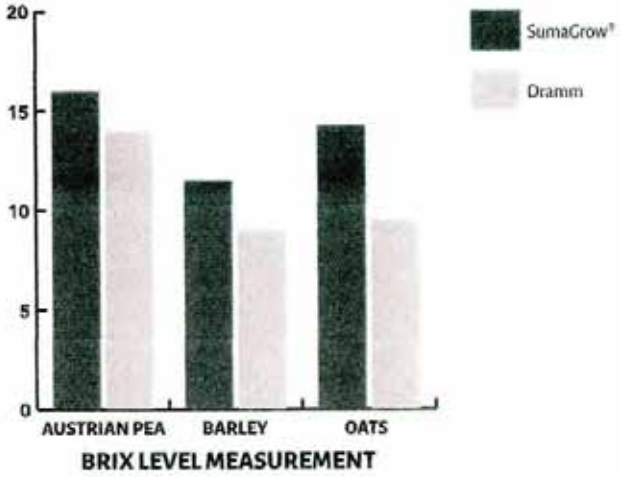
TRIAL RESULTS
EXECUTIVE SUMMARY

FORAGE AND HAY - MONTANA

Research on the effect of products containing SumaGrow® on Austrian Winter Pea, Oats and Barley at 5L Ranch in Montana

DRY MATTER YIELD (TON/ACRE) FIELD: HOME PLACE CROP PERFORMANCE AUSTRIAN WINTER PEA, OATS BARLEY	
Treatment:	**(ton/acre)**
SumaGrow®	11.93
Dramm product	9.57
Increase	+ 24.66%

PLANT NO, (AVERAGE OF TWO TRIALS)		
Treatment:	**SumaGrow®**	**Dramm**
Austrian Winter Pea	880	900
Barley	935	905
Oats	1700	1350



BRIX LEVEL MEASUREMENT

PRIMARY POINTS:

Crop: Alfalfa, Austrian Winter Pea Oats, Barley, Oats Silage Mixture

Location: Southwest Montana

Trial Date: 2011

Growing Conditions: Challenged from excessive moisture

Application Method: Boom sprayer

TREATMENT SCHEDULE:

SumaGrow®: .5 gal/acre at emergence

Dramm Product: 4 gal/acre Dramm + 1gal/acre SP1 at emergence

SUMAGROW

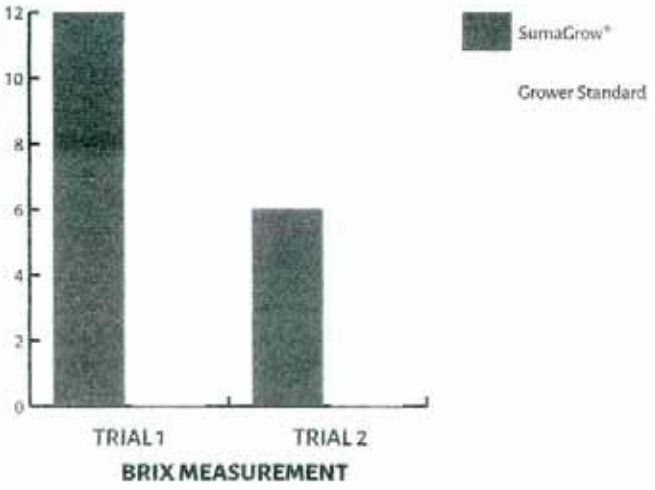
FS 01

TRIAL RESULTS
EXECUTIVE SUMMARY

ALFALFA - MONTANA

Research on the effect of products containing SumaGrow® on Alfalfa at 5L Ranches in Montana

RESULTS		
Treatment:	**Yield** *(Trial 1)*	**Yield** *(Trial 2)*
SumaGrow®	3,243	2,411
Grower Standard	2,550	1,643
Increase	+ 27%	+ 46%
Cost Advantage *Using Sumagrow*	+ $115.73/acre	+ $72.53/acre



Additional Comments: Results indicate significant increases in soil NO_3, plant NO_3 and plant brix with the .05 gallons of SumaGrow when compared to DFB.

PRIMARY POINTS:

Crop: Alfalfa

Location: Southwest Montana

Trial Date: 2011

Growing Conditions: Challenged from excessive moisture/temporary flooding

Irrigation: Center Pivot irrigation

TREATMENT SCHEDULE: (TWO FIELDS)

SumaGrow®: .5 gal/acre single application

Grower Standard: 4 gal/acre (Dramm Forage Boost) + 1 gal/acre SP1 (SP1 is a plant activator containing plant phytohormone stimulators) single application

SUMAGROW

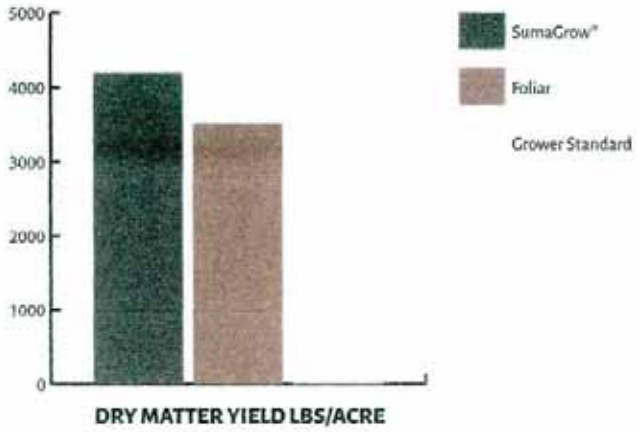
FS 01

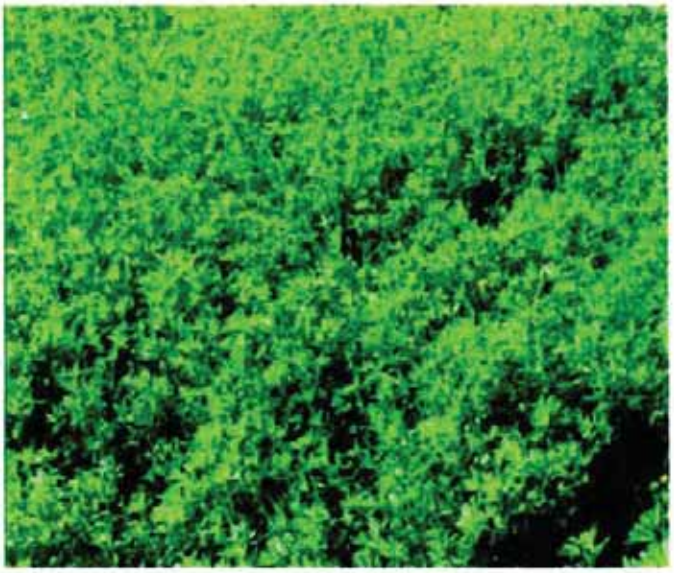
TRIAL RESULTS
EXECUTIVE SUMMARY

ALFALFA - NEBRASKA

Research on the effect of products containing SumaGrow® on Alfalfa

RESULTS	
Treatment:	**(lbs/acre)**
SumaGrow®	4,192
Foliar	3,519
Grower Standard	3,557
Increase	+17.85%





PRIMARY POINTS:

Crop: Alfalfa, Native, Corn, Soybeans, Wheat

Location: Nebraska

Trial Date: 2011

TREATMENT SCHEDULE: *(TWO FIELDS)*

SumaGrow®: .5 gal/acre at green up + .5 gal/acre each cutting

Foliar: 1 gal/acre at green up + 1 gal/acre each cutting

Grower Standard: 100 lbs 18-46-0 + 100 lbs 0-0-60

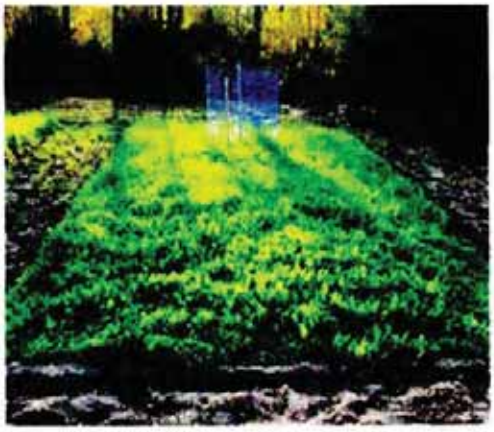
FS 01

TRIAL RESULTS
EXECUTIVE SUMMARY

FOOD PLOTS - MISSISSIPPI

Research on the effect of products containing SumaGrow® on Food Plots in Mississippi

TECOMATE MONSTER MIX TRIAL DATA				
Plot Number	**Fertilizer Rate/Acre** *(lbs.)*	**SumaGrow®** *(gallons)*	**Yield in Volume** *(lbs.)*	**Protein Result** *(%)*
1	300	0	8.75	0.001
2	300	1	8.5	0.42
3	200	1	9.75	0.5
4	100	1	8.5	0.87
5	0	1	8.25	2.33



Left: Fertilizer Only
Right: SumaGrow®, No Fertilizer

TRIAL SUMMARY:

Testing was performed with Barenbrug's U.S. subsidiary, Tecomate for hunters' food plots. The testing was mainly to determine whether products containing SumaGrow® increased the protein levels, which increased dramatically, as higher protein levels are a main factor in the deer growing larger antlers. However, a yield increase was also noted. The Tecomate Monster Mix (in the above table) achieved the highest yield increase with a 1/3 reduction in fertilizer while the Tecomate Max Attract 50/50 (pictured above) showed the highest yield increase with a 2/3 reduction in fertilizer.

SUMAGROW

FS 01

TRIAL RESULTS
EXECUTIVE SUMMARY

FOOD PLOTS - PENNSYLVANIA

Research on the effect of products containing SumaGrow® on Food Plots at Mink Pond Club in Pennsylvania

ORGANIC MATTER				
Lab Number	**Crops**	**2009**	**2010**	**Increase**
1	Chicory, Clover, Alfalfa	3.1	8.8	+183.87%
2	Corn, Soybean	6.7	9.8	+46.27%
3	Clover, Millet, Milo, Sorghum	3.1	4.9	+58.06%
4	Clover, Turnip, Chicory, Soybean	3.1	4.7	+51.61%
5	Sorghum, Sunflower, Clover, Millet	5.9	11.5	+94.92%
6	Chicory, Clover	5.3	5.7	+7.55%
7	Clover, Chicory, Alfalfa	4.4	5.8	+31.82%
8	Milo, Millet, Sunflower	3.2	5.4	+68.75%
9	Clover, Chicory	6.1	10.2	+67.21%

TRIAL SUMMARY:

Above is a soil report summary from the Mink Pond Club, a 2,500 acre private game ranch in Bushkill, Pennsylvania. The chart depicts the impressive increase in organic matter in varied plots from 2009 to 2010 while using a product containing SumaGrow®. In 2007 manager Tim Foglio purchased a product containing SumaGrow® and used it with his fertilizer program. He was so impressed by the results that the following year he eliminated fertilizer altogether.

Foglio has soil tests run each year prior to planting and, of all the data collected, is most concerned about organic matter (OM). OM releases many plant nutrients as it is broken down, improves the soil's structure and increases the Cation Exchange Capacity (CEC). Foglio stated that food production has increased as has the deer weights.

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