SCIENTIFIC INFORMATION DOSSIER

"VI-AQUA"

VITALIZED WATER

THE AQUAFERTILIZER SYSTEM.

Z.P.M. (EUROPE) LIMITED,

THE INNOVATION CENTRE,

NATIONAL TECHNOLOGY PARK,

LIMERICK,

IRELAND.

CONTENTS.

Rainfall, Sunshine Chart, Other Charts & Data available on request.

ABSTRACT.

This dossier reviews the published scientific data supporting the evidence that Electro-magnetic fields can enhance plant growth.

Results of recently conducted independent controlled research projects which confirmed the beneficial effect of "Vi-Aqua" on a cross-section of vegetation from Rye Grass to ornamental plants of various species are reported in detail.

The grass experiment concluded that the treated samples produced significantly higher carbohydrate concentration, which would increase the ensilability of the grass even under conditions climatically unfavorable for grass growth. The plant experiment confirmed enhanced vigor of growth and stronger plant structure, which increased damage resistance in the treated specimens.

It is very evident that this study confirms the observations reported to us by Z.P.M. Inc. for a number of species of vegetation. The importance is inestimable in terms of conversion of light energy to chemical organic energy on which all multi-cellular life on this planet is dependent"

(Warrenstown Horticultural College and the Chemical & Environmental Science Dept., University of Limerick, Ireland.)

INTRODUCTION;

INTRODUCTION

All vegetation-derived energy on this planet is solar in origin. Only approximately 1% of the solar energy, which impinges on the Earth, is captured. This is through the agency of Chlorophyll in most forms of plant life. Animal life on this planet is critically dependent upon the continued availability of energy donating vegetation for its survival. Since all living organisms have evolved in the presence of a strong natural geomagnetic field the possible influence of magnetic fields on living organisms increasingly has become the subject of research endeavors. The possibility of enhancing plant growth utilizing a natural activity such as magnetism has stimulated research over at least the past six decades.

The Company Z.P.M. Europe Ltd., The Innovation Centre, National Technology Park, Limerick., requested that Teagasc at Grange Research Centre determine the quantitative and the qualitative effects of an electromagnetic field activated water on a typical species of grass (Lolium Perenne) used for cattle feeding in Grasslands and Silage; the activation being produced by a specific radio frequency [R.F.] elicited electromagnetic field being delivered by a helical resonator source described by Morse et al in U.S. Patent Number 5,606,273 (1997). The helical resonator and R.F. signal generator form an instrument that is to be marketed under the trademark 'Vi-Aqua' by Z.P.M. (Europe) Ltd. The Company also requested Warrenstown Horticultural College at Drumree, Co.Meath in collaboration with the Chemical and Environmental Science Department; University of Limerick in Ireland to conduct studies utilizing the same apparatus to observe the effects in a variety of species of plants.

The Development of Relevant Research.

Controlled research Studies of the effects of magnetism on seed germination and plant growth enhancement began in 1930 (Savostin 1930) and have continued since. (Phitke et al 1996).

Although multiple theories were put forward that attempted to model the interaction of water with electromagnetic (EM) radiation and with magnetism, there was no clear consensus in the Scientific Community as to what this fundamental interaction was. This lack of consensus was in large part due to the lack of instruments that could deliver electromagnetic radiation in controlled ways into water. Another limitation was that there were no clear indicators of the electromagnetic effect on water or biological systems.

In recent years, extremely sensitive analytical techniques have been developed in an effort to characterize previously elusive effects.

The direct and lasting effects of electromagnetic radiation on water have been repeatedly and reproducibly documented. Amongst the more recent being the publication of a report of the "Effects of Amplitude of the Radio frequency of electromagnetic radiation on aqueous suspensions and solutions," by Miroslav Colic and Dwain Morse. (Journal of Colloid and Interface Science, 200;265-272) (1998): The same authors also published a paper describing the long term effects of electromagnetic radiation on solutions and suspended colloids (Langmuir 1998, 14783-787.) [Langmuir is published by the American Chemical Society.]

Pure water has been documented to have a high dielectric constant in the R. F. range (Franks 1972) which would prevent the stimulation of water. However the Vi-Aqua device in particular and other devices now available have been designed, and effectively used, to manipulate water.

The benefits of using E. M. radiation rather than static magnetic fields, like those generated by permanent magnets, are due to the ability to deliberately alter amplitude (pulse intensity), pulse sequence and duration (duty cycle) and pulse frequency (wavelength)

Studies employing Electron Spin Resonance measurements have confirmed that no reactive radicals are produced by activation of water with the device. Furthermore Hamnerius et al. Utilizing the 'Ames Test' for mutagenicity or toxicity of unknown compounds have confirmed that, using radio frequency wavelengths, similar to those emitted by the Vi-Aqua device, at very high power settings, no DNA damaging or mutagenic effects were detected.

Magnetic Water Memory.

The magnetic water memory effect is a controversial and exciting issue that is not explained by any current theory. Relaxation phenomena in water solutions and suspensions occur at a timescale in the range or pico-seconds to seconds. It is not clear therefore how one can treat solutions, suspensions or biological systems (cells, tissues etc.) and then observe the modified behavior even when the water is used hours or days after the EM treatment.

How do the Plants change? -

Sophisticated tests which measure hydrogen bonding properties indicated that EM radiation reduced the size of hydrogen bonded water networks. In particular the changes in the hydrogen bonding networks affected the solution of naturally dissolved gases in the water. This hydrogen bonding modification slowly decayed to undetectable levels several hours after the treatment was stopped.

Modifying hydrogen bonding has had several possible consequences for live plants Loosening the hydrogen bonding in cell walls permitted the faster growth of plants due to reduced resistance to cells elongating during the growth process (Cosgrove

1993. McQueen-Mason & Cosgrove 1994). Improved nutrient uptake and transport by the modified water could have improved the efficiency with which nutrients had been absorbed by plant tissue, resulting in generally healthier plants In the process of dissolution of oxygen in the water, very small trace amounts of hydrogen peroxide have been generated by electromagnetic treatments which have been shown to have stimulatory effects on plant growth (Murrell et al 1990) Root structure changes have been observed in ZPM -treated and magnetically treated plants (Krizaj & Valencic 1989, Peteiro-Cartetle & Cabezas-Cerrato 1989. Pittman & Ormond 1971). These changes were consistent with the contention that the water treatment facilitated nutrient uptake and transport. The reduction of smaller lateral feeding roots and general increased growth of the central tap-root indicated a reduction in nutrient limitation and faster root maturation.

Commonly the effects of magnetic or electromagnetic plant growth enhancements were that root and shoot growth was enhanced and that seed germination was accelerated (Phitke et al. 1996). Even though there are exceptions, peach seeds did not appear to respond to magnetic stimulation when apple and apricot seeds did. (Chao and Walker 1967). Otherwise, mitosis (an indicator of cell division) in onions (Allium cepa) was enhanced (Peteiro-Cutelle and Cabezaz-Cerrato 1989), plant growth hormone indicators like Phenylalanine Ammonia-lyase (PAL) were significantly increased in beans and potatoes (Phaseolus vulgaris and Solomon berthaultii: Jones et al. 1986), water cress roots were elongated (Lepidium sativum,-Krizaj and Valencic) and buds of chestnuts were stimulated in their growth.Castanea sativa. (Ruzie et al. 1992).

Summary:

Anecdotally the effects of the Vi-Aqua treatment have matched those observed by researchers employing magnetic or electromagnetic stimuli. To date no supporting scientific papers have been published. Plants in field trials provide the best indicators of the success of the technology. They will offer the most sensitive and stable gauge of the beneficial effects of electromagnetic radiation. Successful plant growth enhancement serve as the most rigorous applications test, because the plants would have had integrated changes in temperature, water chemistry, fertilisation, solar irradiation and soil chemistry.

Because the radiation that is emitted from the Vi-aqua device is of long wavelengths that do not induce chemical reactions and is contained within the treated water, **it does not form** ionizing or harmful radiation, **does not induce** the formation of radicals or reactive species in the water and **does not cause** DNA or hereditary materials damage, it is safe to assume that the device is safe to use on live plants.

The most effective demonstration of the efficacy of this technology is the assessment of plant growth and quality parameters. Standard tests of crop yield and photosynthetic performance are applicable in direct comparison to untreated plants.

The fact that the electromagnetic modification is imprinted in the water for several hours, slowly decaying with time, is of immense practical significance. It means that water can be treated at a central location under controlled conditions and then pumped through the irrigation systems to remote locations to do the required work without losing the desired effect. The ability to so liberates the users of this technology from the need to grow their plants directly next to spinning magnets or other sources of static magnetic fields.

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REPORT

on an experiment to determine the
QUANTITATIVE AND QUALITATIVE EFFECTS OF VI-AQUA ACTIVATED WATER ON THE GERMINATION AND GROWTH OF LOLIUM PERENNE

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National Technology Park,

Limerick.

Carried out by:
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Teagasc,
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31 December 1998

PROTOCOL

HYPOTHESIS.

1. Treated water will stimulate faster and more complete germination.

2. Treated water will stimulate more rapid vegetative growth.

3. Treated water will increase grass digestibility.

4. A relatively low rate of addition of treated water will be sufficient to stimulate the above effects.

METHODOLOGY.

Forty plastic gardening pots (23 cm diameter on top; 10 1 capacity) were filled to within 5 cm of the top with a weighed amount of a mixture of soil (455 1), peat moss (910 1 of "seed and potting compost) and fertiliser (1. 11 kg of a 100 g N + 100 g P + 200 g K/kg fertiliser). On 15 May, 0.92g. of the tetraploid mid-season cultivar of Lolium perenne (perennial ryegrass) 'Twins', was evenly spread on top of the seed bed in each pot, and then covered by a 0.5 cm. layer of the soil/peat moss/fertiliser mixture. Each pot then had a layer of domestic aluminium foil wrapped around its outer vertical surface. The forty pots were randomly allocated to 10 blocks of four. Pots within blocks were positioned 0.5 m apart while blocks were 1.0 m apart. Pots within blocks were randomly allocated one of the following treatments, and labelled accordingly. They were stored outdoors on short grass in a relatively sheltered site (Figure 1).

Treatments:

1. Untreated water applied at 165.43 mI per pot at the start, and weekly thereafter.
2. Activated water applied at 1. 93 m1/pot plus untreated water at 163.5 ml/pot, at the start. Untreated water applied at 165.43 ml per plot at weekly intervals thereafter.
3. Activated water applied at 165.43 m1/pot at the start. Untreated water applied at 165.43 ml per pot at weekly intervals thereafter.
4. Activated water applied at 165.43 ml per pot at the start, and weekly thereafter.

Thus, every pot would receive 165.43-ml water at the start and at weekly intervals thereafter.This was applied to the soil surface. Rainfall falling on the pots would provide additional water to this.

Two labelled, heavy-gauge, black plastic 300 litres capacity troughs positioned 5 meters apart, and more than 5 m from the pots, were used for storing the water applied to the pots. Both were filled with fresh (potable) water each week, with one being repeatedly and consistently used for the Vi-Aqua activated treatment. The Vi-Aqua device, used according to the suppliers' instructions, was immersed in the appropriate water trough for at least one hour before water was withdrawn to apply to the pots. All remaining water after treatments were applied was removed each week from the two troughs.

An energy detector supplied by ZPM Europe Ltd. was used to obtain readings for the soil and seed at the start of the experiment and for each trough of water and pot of soil/grass at weekly intervals thereafter.

Any weed seedlings seen to germinate in the pots were removed by hand. Twenty-two days after sowing the seed, an estimate was made of the rate of germination plus establishment of grass seed in each pot. Mean plant height above soil level was measured on a series of occasions.

On 10 July, after 56 days growth, the following procedures were carried out:

- mean plant height per pot was measured.
- grass in each pot was cut at the height of the top rim of the pot, and weighed.
- sub-sample of grass was dried at 40ºC. for 48 hours in an oven with forced air circulation and used to estimate dry matter (DM) concentration. Dried sub-samples were

milled through a 1 mm screen and analysed for in vitro dry matter digestibility (DMD), in vitro organic matter digestibility (OMD), ash, crude protein and buffering capacity. Undried sub-samples had aqueous extracts obtained which were used for determination of water soluble carbohydrate (WSC) and nitrate concentrations.

- tiller density per pot was measured.

Pots were then re-positioned in the storage area previously used. The treatments originally imposed were continued for a further 18 days (until 28 July), after which time herbage was again cut, weighed and had its DM concentration determined.

Grass dry matter (DM) concentration was assessed by drying for 48 hours at 40ºC. in an oven with forced-air circulation. Dried samples were milled through a 1 mm screen and assayed for in vitro dry matter and organic matter digestibility (Tilley and Terry, 1963), buffering capacity (Playne and McDonald, 1966), ash (muffle furnace at 550ºC for 5 h) and crude protein (N x 6.25; AOAC (1990) using aLECO FP 428 nitrogen analyser). Samples stored at -18ºC were finely comminuted and thawed, and had a liquid sample extracted for quantification of the concentration of water soluble carbohydrate (WSC; Wilson, 1978) and nitrate (Beutler and Wurst, 1986).
Statistical analyses were conducted using one-way analysis of variance, with significant intertreatment differences being judged using the least significant difference procedure.

RESULTS

The mean (s.d.) weight of soil in each pot was 7.67 (0.295) kg. Table 1 summarises the results recorded in the experiment. Although grass seeds were slow to germinate due to the dry weather conditions prevailing after sowing, germination was gradual and appeared similar for each treatment. The similar number of established plants per treatment confirmed this twenty-two days after sowing. Grass plants on each treatment during the primary (first) growth appeared to grow at a visually similar rate as indicated by similar plant heights on days 22, 28, 35, 42, 49 and 56 post sowing. The grass in each of the ten pots of Treatment 4 appeared to lose turgor and wilted visibly. This was not observed in any other pots.

Primary growth grass was dry at harvesting on July 10 (mean DM concentration of 230 g/kg for Treatment 1), and DM concentration was higher ($P<0.001$) for Treatment 4 than for any of the other treatments. This clearly reflected the herbage-wilting phenomenon observed above. Although fresh yields were numerically higher for Treatment 2, this did not approach statistical significant ($P>0.05$). Similarly, the trend towards a higher DM yield with Treatment 4 and Treatment 2 was not statistically significant ($P>0.05$). There was no evidence of a treatment effect on grass dry matter or organic matter digestibility ($P>0.05$), while the minor trends towards numerically higher concentrations of crude protein and ash with Treatments 2, 3 and 4 compared to Treatment 1 were not statistically significant ($P>0.05$).

Grass water soluble carbohydrate concentration, expressed on a herbage aqueous phase basis, and buffering capacity, are two complimentary indices of ensilability. Treatment of grass with activated water did not significantly ($P>0.05$) alter buffering capacity. Although activated water treatments did not alter ($P>0.05$) WSC concentration when expressed on a DM basis, Treatment 4 did increase ($P<0.001$) WSC concentration when expressed on an aqueous phase basis, reflects the higher DM concentration (i.e. lower water concentration) associated with this treatment.

Collectively, these data indicate that, under the prevailing conditions, the primary growth of grass subjected to Treatment 4 was easier to ensile than other treatments. Grass regrowth (second growth) was measured over a relatively short duration of 18 days. At the end of this period, the number of plants per pot did not differ across treatments ($P>0.05$), and were similar to the values previously recorded twenty-two days after sowing. This indicates that plant survival rates were not differentially altered by treatments in the intervening period. Grass DM concentrations were high, reflecting dry weather conditions prior to harvesting and relatively short grass. The trend towards higher fresh yields, DM yields and taller plants for the grasses treated with activated water, and which were numerically most evident with Treatment 4, did not reach statistical significant ($P>0.05$).

Combining the DM yields for the first and second growths produced cumulative relative crop DM yields of 100, 115, 106 and 123 for Treatments 1, 2, 3 and 4, respectively. Treatment effects were not statistically different at $P<0.05$.

Trends in grass DM yields were evident, but were not statistically significant at $P<0.05$. However, treatments did affect grass DM yield of the first growth at $P=0.067$, grass height of the second growth on 28 July at $P=0.057$ and total DM yield for the first and second growths combined at $P=0.081$.

CONCLUSIONS

- Activated water did not appear to effect germination of grass seed.
- Activated water did affect grass growth (P--0.067). This effect on the first growth was most evident for Treatment 4, least evident for Treatment 3 and intermediate for Treatment 2.
- Activated water showed no effect on herbage digestibility

- Although neither Treatment 2 nor 3 affected grass ensilability, Treatment 4 improved ensilability by increasing the concentration of fermentable substrate (i.e. water soluble carbohydrates expressed on an aqueous phase basis).

ACKNOWLEDGEMENTS

The skilled technical input of Mr. John Marron and Mr. James Hamill, the help of Mr. Jack Lynch, the chemical analyses conducted by Grange Laboratories and the typing of this report by Ms. Mary Smith are acknowledged with gratitude.

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REPORT

On an experiment to determine the effects of

Vi-Aqua Activated Water on **Seed Germination** and **Subsequent Growth.**

Carried out for

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RESULTS SUMMARY

Seedling of Impatiens, Dahlia and Salvia were much greener with the treated water compared to similar seedlings in college water. No visible difference in colour was apparent between the seedlings of Marigold for either the treated or college water treatments. The treated water seedlings grew faster and were more advanced at all stages during the germination phase. Once the cotyledons were fully expanded all seedlings were pricked-off into 216 cell trays containing Bord na Mona seed and modular compost. The cell trays were irrigated with either college or treated water as relevant. After pricking-off the seedlings were placed on a bench in the glasshouse. A Vi-Aqua machine was installed and commissioned in the same glasshouse. The cell trays were irrigated on demand. Before drawing water from the tank containing the Vi-Aqua machine a separate hose connected to the tap was placed in the tank. This was allowed to run for 15 minutes before siphoning water from the tank. Because of previous experimental design faults attributed to the nature of the activation process, special precautions to avoid repetition were observed.

1. **The supply for "Treated" water was carefully isolated from any possible cross-reaction with "College" water supply. Separate supply points and separate watering containers were used.**

2. **The Control and Treated plants were adequately separated, spatially by one metre or more at all stages of development.**

3. **The Control and Treated groups of plants were arranged in the glasshouse so that any exposure to temperature gradients was evenly distributed between the two groups of plants.**

PERCENTAGE OF SEEDLINGS PRICKED FOR THE DIFFERENT TREATMENTS

PLANT NAME	PREVICUR + COLLEGE WATER	COLLEGE WATER ONLY	PREVICUR + TREATED WATER	TREATED WATER ONLY
DAHLIA	50%	47.2%	58.8%	64.8%
SALVIA	100%	100%	100%	100%
IMPATIENS (avg of 4 varieties)	93%	91%	93%	90%
MARIGOLD	59%	69%	65%	69%

Plants were selected for ashing on a random basis. Two analytical points were used.

Point one was at four weeks post germination.

Point two was at flowering and pre-dispatch for sale.

Table 1 Ash weight in grams four weeks post germination

Treatment	Name	Impatiens	Salvia	Dahlia	Marigold
Control	Code	1A	1B	1C	1D
Treated	Code	2A	2B	2C	2D
% difference		+118%	+22%	-2.9%	+45.86%

Table 2 Ash weight in grams Pre-Dispatch for Sale

Treatment	Name	Impatiens	Salvia	Dahlia	Marigold
Control	Code	3AA	3BB	3CC	3DD
Treated	Code	4AA	4BB	4CC	4DD
% difference		+33%	-3%	+6.3%	+8.2%

Appendix 1 Results of Ash Content at first harvest

College Water	Treated water	College water	Treated water	College water	Treated water	College water	Treated water
Impatiens Pink	**Impatiens Pink**	**Salvia**	**Salvia**	**Dahlia**	**Dahlia**	**Marigold**	**Marigold**
1A	**2A**	**1B**	**2B**	**1C**	**2C**	**1D**	**2D**
Wt/g	wt/g	wt/g	wt/g	wt/g	wt/g	wt/g	wt/g
0.097	**0.183**	**0.120**	**0.143**	**0.711**	**0.543**	**0.333**	**0.676**
0.103	**0.237**	**0.100**	**0.121**	**0.375**	**0.57**	**0.134**	**0.367**
0.140	**0.324**	**0.138**	**0.154**	**0.663**	**0.578**	**0.356**	**0.663**
0.153	**0.18**	**0.104**	**0.133**	**0.527**	**0.502**	**0.407**	**0.247**
0.145	**0.311**	**0.067**	**0.113**	**0.754**	**0.719**	**0.289**	**0.689**
0.094	**0.308**	**0.110**	**0.122**	**0.544**	**0.854**	**0.231**	**0.463**
0.077	**0.322**	**0.129**	**0.137**	**0.532**	**0.407**	**0.409**	**0.452**
0.172	**0.174**	**0.114**	**0.126**	**0.384**	**0.361**	**0.336**	**0.369**
0.077	**0.294**	**0.117**	**0.147**	**0.529**	**0.657**	**0.324**	**0.324**
0.102	**0.271**	**0.107**	**0.162**	**0.425**	**0.400**	**0.323**	**0.336**
0.153		**0.118**			**0.219**		
Average	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**
0.119363636	**0.2604**	**0.111**	**0.1358**	**0.5444**	**0.528182**	**0.3142**	**0.4583**
Std Dev	**Std Dev**	**Std Dev**	**Std Dev**	**Std Dev**	**Std Dev**	**Std Dev**	**Std Dev**
0.033791338	**0.061801115**	**0.018304**	**0.01574**	**0.1311283**	**0.178594**	**0.043902**	**0.161643**

Appendix Table 2 Results of Ash Content at Dispatch for Sale

College Water	**Treated water**	**College water**	**Treated water**	**College water**	**Treated water**	**College water**	**Treated water**
Impatiens Pink	**Impatiens Pink**	**Salvia**	**Salvia**	**Dahlia**	**Dahlia**	**Marigold**	**Marigold**
3AA	**4AA**	**3BB**	**4BB**	**3CC**	**4CC**	**3DD**	**4DD**
Wt/g	wt/g	wt/g	wt/g	wt/g	Wt/g	wt/g	wt/g
0.421	**0.948**	**0.757**	**0.2381**	**1.136**	**0.985**	**0.698**	**0.755**
0.937	**1.144**	**0.560**	**0.318**	**0.941**	**1.596**	**1.125**	**2.13**
1.262	**1.189**	**0.633**	**0.75**	**1.546**	**1.387**	**1.575**	**1.579**
0.652	**1.189**	**0602**	**0.774**	**1.423**	**1.247**	**1.169**	**1.977**
0.868	**1.028**	**0.604**	**0.642**	**0.973**	**1.057**	**1.152**	**1.029**
0.781	**1.301**	**0.458**	**0.277**	**0.818**	**1.164**	**1.382**	**1.421**
0.554	**1.094**	**0.688**	**0.583**	**1.082**	**1.132**	**0.99**	**0.962**
1.183	**1.202**	**0.681**	**0.41**	**1.018**	**1.241**	**0.603**	**1.328**
1.134	**0.854**	**0.776**	**0.805**	**1.086**	**0.874**	**1.224**	**0.729**
1.043	**1.074**	**0.526**	**0.511**	**1.44**	**1.511**	**0.89**	**0.727**
0.826	**1.319**	**0.538**	**0.745**	**1.672**	**1.522**	**1.813**	**1.477**
0.717	**1.136**	**0.641**	**0.596**	**0.837**	**1.199**	**0.946**	**1.043**
0.728	**1.443**	**0.618**	**0.399**	**1.303**	**1.266**	**1.535**	**1.271**
1.007	**1.073**	**0.515**	**0.782**	**1.264**	**0.665**	**1.354**	**1.008**
0.904	**1.252**	**0.79**	**0.639**	**1.359**	**1.102**	**0.828**	**0.857**

0.882	**1.22**	**0.588**	**0.982**	**0.905**	**0.760**	**0.789**	**1.605**
0.799	**1.426**	**0.775**	**0.825**	**0.998**	**2.028**	**1.152**	**1.203**
0.915	**1.151**	**0.574**	**0.45**	**1.195**	**0.988**	**0.868**	**1.521**
1.024	**1.106**	**0.668**	**0.632**	**0.782**		**1.326**	**0.988**
0.818		**0.550**	**0.773**	**0.917**		**1.356**	**1.058**
Average	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**
0.87275	**1.16574**	**0.627**	**0.607**	**1.135**	**1.207**	**1.139**	**1.233**
Std Dev	**Std Dev**	**Std Dev**	**Std Dev**	**Std Dev**	**Std Dev**	**Std Dev**	**Std Dev**
0.20144	**0.1472**	**0.095**	**0.205**	**0.256**	**0.325**	**0.316**	**0.396**

COMMENT:-

While the final increase in dry weight is significant in three of the four species studied, there are some points that should be borne in mind.

1. **The dry weight did not reflect the state of the plants when fully hydrated. The control specimens were clearly less robust and resilient and less green in the colour of their leaves.**
2. **The plants were repotted on a chronological basis and in unison which meant that the treated plants whose root systems were obviously more profuse were retarded in some cases because of the length of time spent in containers of inadequate size (and certainly less available nutrients due to leaching).**

3. **The Salvia were purposely "pinched" because of excessive inter-nodal extension due to close spacing in the cell trays with a consequent regression in dry material gain.**

It is very evident that this study confirms the observations reported to us by ZPM Inc. for a number of species of vegetation. The importance is inestimable in terms of enhancement of Conversion of light energy to chemical organic energy on which all multi-cellular life on this planet is dependent.

EFFECTS OF TREATED WATER AND FUNGICIDAL TREATMENT ON SEED GERMINATION AND SUBSEQUENT PLANT GROWTH.

Objective

This experiment was designed to study the effect of water and fungicidal treatments on the emergence and subsequent growth of a range of seeds.

METHODS AND MATERIALS

Seeds were sown on 4th April 1998 into trays filled with Bord na Mona seed and modular compost and were irrigated according to the placed into two thermostatically controlled propagation boxes. The temperature was maintained at 22 C throughout the experiment. A total of 32 standard seed trays were sown accommodating 16 trays in each propagation box. There were 4 different treatments and within each treatment a total of 8 standard seed trays were sown.

The 4 different treatments were as follows:

1. Control Treatment (College Water + Previcur Drench)
2. College Water only
3. Treated Water + Previcur Drench
4. Treated Water only

In each treatment seeds were sown as follows:

Treatment 1 Control

Name	Variety	Number of trays	Seeds per tray	Total Number of Seeds Sown
Impatiens	Burgundy Pink Lavander Blue Rose	1 1 1 1	1000 1000 1000 1000	1000 1000 1000 1000
Salvia	Fury	2		
Marigold	Disco	1	500	500
Dahlia	Yellow Shades	1	625	625

Treatment 2 College Water only

Name	Variety	Number of Trays	Seeds per Tray	Total Number of Seeds Sown
Impatiens	Salmon Picotee Coral Violet Burgundy	1 1 1 1	1000 1000 1000 1000	1000 1000 1000 1000
Salvia	Fury	1		
Marigold	Disco	1	625	625
Dahlia	Yellow Shades	1	500	500

Treatment 3 Treated Water and Previcur Drench

Name	Variety	Number of Trays	Seeds per Tray	Total Number of Seeds Sown
Impatiens	Carmine Cranberry Apricot Lilac	1 1 1 1	1000 1000 1000 1000	1000 1000 1000 1000
Salvia	Fury	1		
Marigold	Disco	1	625	625
Dahlia	Red Shades	1	500	500

Treatment 4 Treated Water only

Name	Variety	Number of Trays	Seeds per Tray	Total Number of Seeds Sown

Impatiens	White Salmon Pink Red	1 1 1 1	1000 1000 1000 1000	1000 1000 1000 1000
Salvia	Fury	1		
Marigold	Disco	1	625	625
Dahlia	Red Shades	1	500	500

Germination Details

Plant Name	Sowing Date	Chitting	First Emergence	Full Emergence	Pricking off date	Days from sowing to pricking off
Marigold	04.04.98	05.04.98	06.04.98	07.04.98	10.04.98	6 days
Dahlia	04.04.98	06.04.98	07.04.98	08.04.98	10.04.98	6 days
Salvia	04.04.98	08.04.98	09.04.98	10.04.98	15.04.98	11 days
Impatiens	04.04.98	09.04.98	10.04.98	11.04.98	16.04.98	12 days

Pricking off Details
Treatment 1 Previcur drench and College Water

Plant Name	Number of seeds sown	Number pricked off	% Pricked-off
Dahlia Yellow Shades	1000	502	50%
Marigold Disco	625	366	59%
Salvia Fury	2 trade packets	1044	100%
Impatiens Rose	1000	948	94.8%
Impatiens Lavender Blue	1000	936	93.6%
Impatiens Burgundy	1000	960	96%
Impatiens Pink	1000	877	87.7%

Treatment 2 College Water only

Plant Name	Number of seeds sown	Number pricked off	% Pricked-off
Dahlia Yellow Shaded	1000	472	47.2%
Marigold Disco	625	432	69%
Salvia Fury	2 trade packets	1044	100%
Impatiens Salmon Picotee	1000	984	98.4%
Impatiens Coral	1000	780	78%
Impatiens Violet	1000	924	92.4%

Impatiens Burgundy	**1000**	**960**	**96%**

Treatment 3 Previcur drench and Treated Water

Plant Name	**Number of seeds sown**	**Number pricked-off**	**% Pricked-off**
Dahlia Red Shades	**1000**	**588**	**58.8%**
Marigold Disco	**625**	**408**	**65%**
Salvia Fury	**2 trade packets**	**1073**	**100%**
Impatiens Lilac	**1000**	**979**	**97.9%**
Impatiens Apricot	**1000**	**948**	**94.8%**
Impatiens Carmine	**1000**	**912**	**91.2%**
Impatiens Cranberry	**1000**	**900**	**90%**

Treatment 4 Treated Water only

Plant Name	**Number of seeds sown**	**Number pricked-off**	**% Pricked-off**
Dahlia Red Shades	**1000**	**648**	**64.8%**
Marigold Disco	**625**	**432**	**69%**
Salvia Fury	**2 trade packets**	**1068**	**100%**
Impatiens White	**1000**	**960**	**96%**
Impatiens Pink	**1000**	**864**	**86.4%**
Impatiens Salmon	**1000**	**828**	**82.8%**
Impatiens Red	**1000**	**948**	**94.8%**

Experiment 2

To observe the growth and development of plug plants from a range of bedding plants.

The purpose of this observation was to see if the apparent improvement of plants with the treated water would continue and be manifested until sale.

METHODS AND MATERIALS

Before any plants were transferred a dry matter analysis was taken of the 4 plant species for both water treatment types to confirm observations of the plant development to this stage. This involved selecting two rows (24 plants) at random from a plug tray (216 cells) for each plant species in the trial. The plants were harvested by cutting the stem as close to compost level as possible and placing them in breathable containers for transportation to the laboratory for dry matter analysis (Appendix Table 1). None of the seedlings treated with a Previcur drench was used in this experiment. This left only two treatments, namely plants irrigated with (a) College Water and (b) Treated Water. Plants were transferred from the plug tray into 12 pack trays containing peat moss to which 2.5kg Dolomitic limestone and 3 kg of Osmocote Plus (3-4month) were added per cubic meter of peat. 720 plants (60x 12 pack trays) was transferred for each of the plant species in the 2 treatments on 14th May, 1998 as follows:

Treatment	Plant Name	No. of Trays	Plants/Tray	Total Plant Number
College Water	Impatiens Pink	60	12	720
	Salvia Fury	60	12	720
	Dahlia Yellow Shades	60	12	720
	Marigold Disco	60	12	720
Treated Water	Impatiens Pink	60	12	720
	Salvia Fury	60	12	720

	Dahlia Red Shades	60	12	720
	Marigold Disco	60	12	720

In all a total of 5760 plants was transferred from the cell trays into the 12 packs with 2880 plants for each treatment.

After transferring from cell trays into 12 packs all plants were placed directly on timber pallets in a polythene tunnel. Plants were watered every second day. After 10 days the plants irrigated with the treated water began to show chlorotic symptoms on the leaves which eventually stunted the plants. The pattern of symptoms indicated that something was released from the timber pallets that was causing the damage. All plants were raised off the pallets using empty cell trays. A liquid feed was given to all plants in both treatments and recovery was quick with the affected plants regaining their normal colour and size.

The Salvia plants from the treated water grew extremely fast in the cell trays before transferring into the 12 pack trays. The inter-nodal length was excessive resulting in the need to pinch out the growing point on these plants immediately after transferring to encourage bushier plants. It was decided to pinch out the growing points on the Salvia in the college water treatment for a valid comparison. The Salvia plants should have been transferred earlier or treated with a dwarfing chemical to avoid this unacceptable inter-nodal extension.

The tip flower on all Marigold plants was removed to encourage bushier plants. No such treatment was given or required to either Impatiens or Dahlia.

Plants in both treatments were irrigated three times per week from transferring to sale.

At all times the Impatiens receiving the treated water looked greener, bushier and more advanced compared to the control treatment. The Impatiens variety was Pink for both treatments.

Dahlia Red Shades looked greener and darker than Dahlia Yellow Shades and this may be partly due to the fact that two different varieties were used as well as to the irrigation water.

The Salvia plants finished well in both treatments even after pinching. The Salvia plants receiving the treated water, even though much taller at the transferring stage, finished slightly better than the control plants.

It was very difficult to see any noticeable difference in the Marigold plants from either treatment at sale time. Both treatments looked equally well.

It is good commercial practice to ensure plants are not soft when sold in the market place and simple turgidity tests that can be carried out to check their softness. The simplest test is to place the weight of the hand on the foliage and see how long it takes to recover its former position. The second test involves turning the tray upside down, and allowing the foliage to support it for one minute. The plants irrigated with college water suffered badly with all shoots bending under the weight of the compost in the tray and some shoots were broken. However, the plants irrigated with treated water showed no discernable damage or compaction of shoots as a result of this test. Both these two tests were carried out on 2nd June 1998.

Then one tray of Impatiens from each water treatment was dropped from one metre above ground level to observe their transportability. Again the college water irrigated plants were severely shaken and would take two days to recover from this test. The plants irrigated from the treated water maintained their shape in the tray. On investigation it was evident that the stems on the plants irrigated with the treated water were firmed and stronger than those of the college water treatment.

On Friday, 5th June plants were harvested from all plant types and both treatments for dry matter analysis (Appendix Table 2). Trays were selected at random and all plants from these trays were harvested by cutting the plants as close to compost level as possible. The harvested samples were coded and sent to the laboratory for analysis. At the same time compost samples were taken for Impatiens Pink from both treatments for complete and residual analysis.

APPENDIX.

Ambient conditions

The Meteorological service provided detailed information relating to the Climatic Conditions which prevailed during the period of the study at Grange Research Centre. It showed the hours of bright Sunshine were significantly lower than the historical average for the Months of May, June and July. July 1998 having only 77.7% of the mean average daily sunshine hours recorded over a thirty-year period in the month of July. For a process, which appears to have an effect on photosynthesis, this lack of sunshine would be expected to be less conducive to the synthesis of carbohydrate in grass in the time of the experiment.

In the six days prior to the first harvesting of the grass on July 10th the average hours of sunshine recorded per day was 1.47 hrs. This was only 33.34% of the average July hours of sunshine of 4.53 hours.

The Mean Average Maximum Air Temperature was only below normal on three of the seventeen days in May during which the project ran. In June the temperature fell below normal average Maximum values on 12 days, while in July the number of days when mean average maximum daytime temperatures were not reached were 22.

Rainfall recorded for Grange Research Centre

The experiment started on May 15th .1998 when the seeds were planted. The first crop of grass was cut on July 10th 1998. The second cut was made on July 28th 1998.

From 15 - 23 of May rainfall was 0.0-mm.

From 24 – 31 of May rainfall was 8.9-mm.

Total rainfall for the month of May was 25mm.

Average Rainfall for May over 30 years is 63mm.

May therefore was a month of below average rainfall. It was particularly dry during the first two weeks after sowing the seeds – no rainfall was recorded. The total rainfall for the month was less than 50% of the normal average expected.

From 1-30 of June the rainfall was 132+ mm.

Average rainfall for June over 30 years period is 61 mm.

June was a very wet month with 79.9-mm falling between 15th and 28th of the month followed by another period to the 10th of July when a total of only 3.7-mm of rain fell. After a very dry start to July 46.83-mm. fell between the 10th July and 28th July.

From 1 – 28 of July rainfall was 52.7 mm.

The Average rainfall in July over a 30-year period is 54 mm.

So although the monthly cumulative rainfall was about average the distribution of the rainfall amounts could have resulted in episodes of over saturation causing an anoxic effect on more vigorously growing plants.

In summary the prevailing Climatic conditions in May, June and July of 1998 were not favourable for Grass Growth.