SOIL REMINERALISATION WITH BASALTIC ROCK DUST IN AUSTRALIA

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Abstract

Following an extensive worldwide literature search and discussions with experts in the field from Europe, USA and Australia, greenhouse trials have been carried out using basaltic rock dust to assess the impact on plant growth and health and soils improvements. Rock dust contains a large range of trace elements and improves the soil pH, water retention, microbial activity, in general the plant growth and the soil structure. Basaltic rock dust with higher paramagnetic intensity is very beneficial for the improvement of soil quality and in turn plant growth and health. Field trials are being undertaken to verify the positive results from the greenhouse trials. Additional investigations recommended are microbial treatments, assessment of compost behaviour and issues related to blending, pelletising, minerals addition etc.
Keywords: Rock dust, trace elements, paramagnetism, microbial activity, pelletising, soil remineralisation, greenhouse.

1 Introduction

Rock dusts contain an extensive range of trace elements beneficial for plant growth. In the late nineteenth century, Julius Hensel in his discussions with the proponents of artificial fertilisers, advocated the use of rock dust to improve soil quality and the crop health (Thompkins & Bird, 1989).

Extensive worldwide literature search for the rock dust has been conducted and discussions took place with some of the leaders in this field in Europe, USA and

Australia. For the purpose of this study it was concluded that basaltic rock dust contains the most suitable range of trace elements when applied to the soil. Also, the basaltic rock dust could improve the soil pH, moisture retention, microbial activity, soil structure and in turn the humus complex. The improved soil using basaltic rock dust has been found to improve plant growth and health.

There are different types of basaltic rock dust in geological terms. (Ehlers & Blatt, 1982). The variety of names include tholeiite, olivine tholeiite, high aluminium basalt, alkali basalt, etc.

In selecting the type of basaltic rock dusts used in trials and presented in this paper, the mineralogical composition and in particular the presence of larger quantities of the trace elements which are required in a good soil and in turn giving good plant growth (Peavy & Peary, 1993) has been considered. However, other criteria of selection was the paramagnetic level of such basalts and of course, proximity to a potential market.

Literature search show that rock dust with high paramagnetic levels are thought to favourably affect both the composting process and plant growth.

According to Phillip Callahan, "stones have a secret life that involves two equal and opposing magnetic forces, the plus and the minus of nature, the yin and yang of the Chinese" (Thompkins & Bird, 1989). These are the forces called paramagnetism and diamagnetism, the former attracted by a magnetic field, the latter repelled. Details of paramagnetism and diamagnetism levels were considered and their intensity is being measured in centimetres per gram per second (Callahan, 1995).

2 Greenhouse trials

Pot trials mixes have been assessed in order to determine the impact of basaltic rock dust on plant growth. A large greenhouse specially constructed with heating and cooling systems has been installed to provide an ideal environment for plant growth. The aim of the project was to scientifically assess, within a controlled environment, the potential impact of basaltic rock dust at different levels of applications on plant growth.

The growing media chosen for the trials consist of a mixture of coconut peat, perlite and river sand. These components provide the structural material in which the plant grows and are inert, with a negligible amount of nutrients.

2.1 Experimental design

2.1.1 Application rates

The basaltic rock dust was added to the inert growing medium at 5 experimental rates. These rates of application reflect broad acre application rates ranging from 0 tonnes to approximately 40 tonnes per hectare, as presented in Table 1. Combining the five rates application of basaltic rock dust with five applications of artificial fertilisers and carrying out the program in 15 replicates, has resulted in 375 pots for all 25 treatments. Statistical analysis (ANOVA-analysis of variance) has been used to assess the data.

		Basaltic Rock Dust	
Level	Particle Size	Grams per pot (g/125mm pot)	Tonnes per hectare equivalent (t/ha)
0	-	0.00	0
1	75 microns	6.14	5
2	75 microns	12.28	10
4	75 microns	24.55	20
8	75 microns	49.11	40

Table 1 - Application rates for the pot trial program in the greenhouse

2.1.2 Plant physical and tissues analysis

The following assessment has been carried out for each trial.

- germination rate and final germination percentage
- pH
- electrical conductivity (EC)
- plant height
- plant dry weight (shoots and roots)
- plant fresh weight (shoots and roots)
- plant leaf counting

Other assessment included shoot/root and root/shoot ratios together with plant mortality, deficiency of toxicity symptoms etc.

2.1.3 Plant species

Plant species cultivated include:

- Radish (Raphanus sativus), currently used in the Australian Standard for potting mix for toxicity determination.
- Red clover
- Turf grass for warm season (couch grass) and cool season (bent grass).
- Tomatoes
- Australian native species (outside greenhouse).

2.2 Plant measurements from greenhouse trials

More results are still to become available, however, some results to date are as follows:

2.2.1 Germination rate

Germination rate seven days after sowing shows treatments of basaltic rock dust of l0t/ha as being the optimum application, as shown in Figure 1.

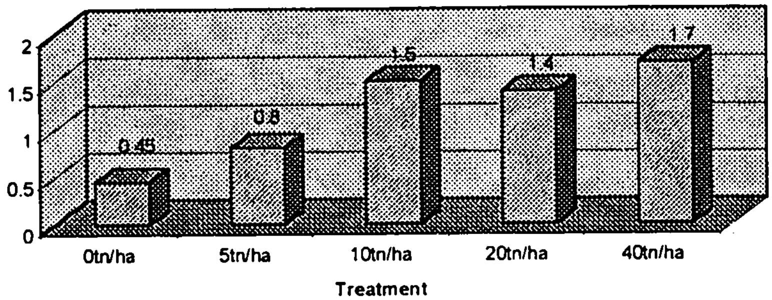

Figure 1 – Germination rate of seeds 7 days after sowing.

2.2.2 Plant height

Plant height six weeks after sowing shows an application rate of basaltic rock dust of 10t/ha as being the optimum rate as illustrated in Figure 2.

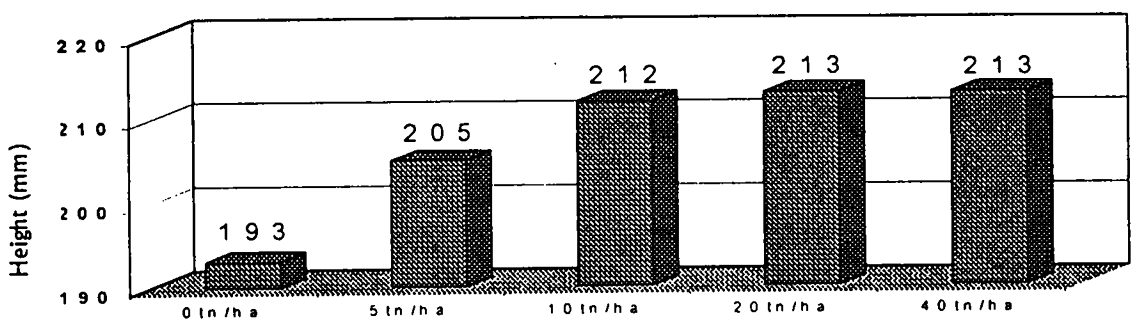

Figure 2 – Plant heights (mm) 6 weeks after sowing.

2.2.3 Plant fresh weight

Eight weeks after sowing, rates of 10t/ha are considered the optimum application. Rates of 20 and 40t/ha also show good results.

2.2.4 pH of growing media

Data available shows that, four weeks after commencement of experiment, the larger the quantity of basaltic rock dust the higher the pH of the growing media. A quantity of 40t/ha basaltic rock dust shows a pH of 7.5 against a control with 0t/ha which is only 6.2

Some very interesting data on pH of basaltic rock dust and lime and dolomitic lime over time in laboratory experiments are presented in Figure 3.

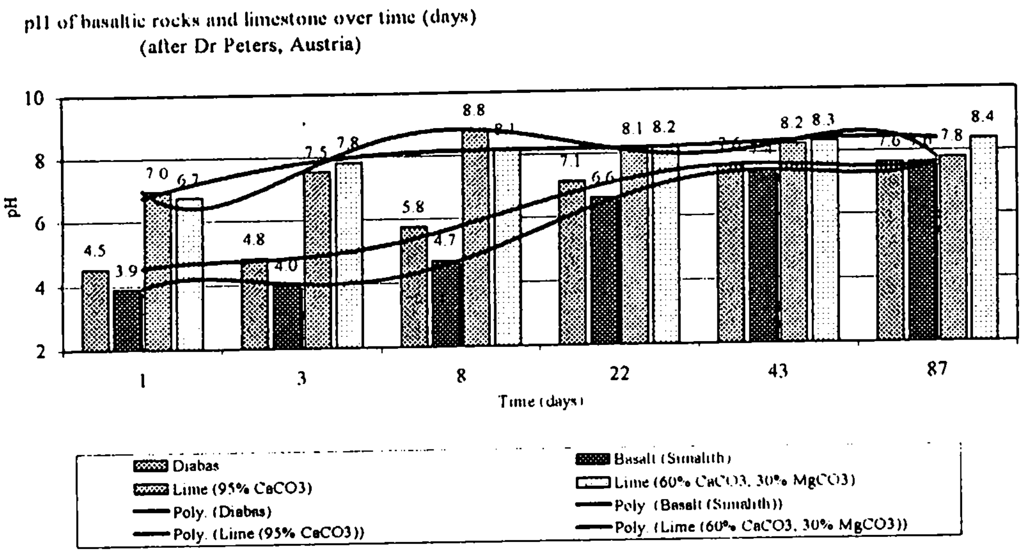

Figure 3 – pH of basaltic rocks and lime over time (after Dr Peters, Austria)

It was observed that initially the pH of soil with lime and dolomitic lime will increase almost instantly when compared to basalts. However, it was found that after 87 days, the pH of the soil where basalts and lime were used was almost identical. Ideally, the changes of the pH in soil should take place in a manner to prevent plant growth from being subjected to excessive stresses. It is very important to highlight that the application of basaltic rock dust slowly increases the soil pH to the same level as lime, except over a larger period of time, but it generates far less stress on the plant growth. Furthermore, the basaltic rock dust forms a symbiotic relationship with the microbial activity within the soil which is crucial for the ongoing development of the humus complex.

2.2.5 Moisture retention

The experimental trial was designed to investigate moisture retention by minus 75 micron basaltic rock dust. The trial involved pots containing the inert growing medium with no plants and no added artificial fertilisers.

An increase in moisture retention was obtained with increased level of basaltic rock dust. Applying more than the equivalent of 10 tonnes per hectare per pot, increased moisture retention by up to 5% daily for the duration of the experiment. Details of this experiment are presented in Figure 4.

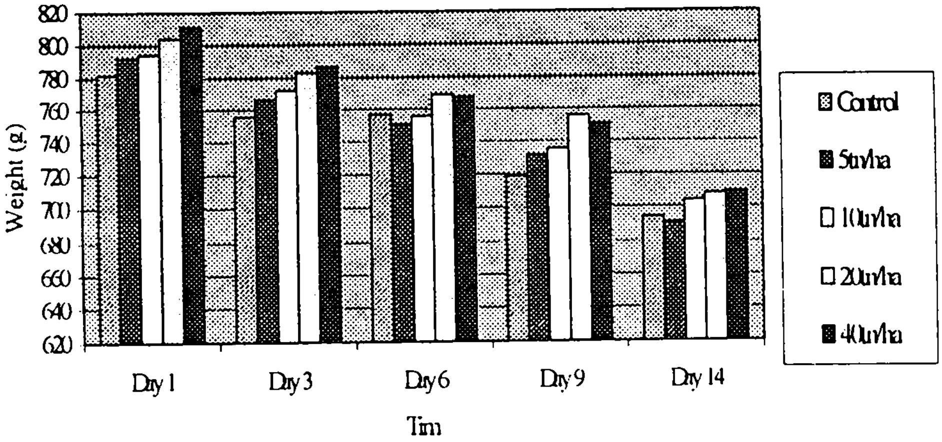

Figure 4 – Growing media moisture retention.

2.2.6 Comparison between four basaltic rock dusts

Four types of basaltic rock dust with different chemical composition and paramagnetic intensity were used to assess the impact on the growth of radish plants. Details of chemical composition and paramagnetic intensity are presented in Table 2.

Chemical Analysis	Prospect	Peats	Kiama	Byrock
pH	9.7	8.0	9.7	8.4
SiO_2 (%)	43.99	45.37	54.53	45.1
Al_2O_3 (%)	12.22	14.62	16.60	9.0
Fe_2O_3 (%)	13.62	12.87	7.80	11.3
CaO (%)	9.89	10.53	7.78	7.5
MgO (%)	12.17	9.05	2.90	8.40
Na_2O (%)	2.10	2.82	3.35	1.0
K_2O (%)	0.64	0.82	3.88	7.1
TiO_2 (%)	1.49	1.89	0.89	5.44
Mn_2O_3 (%)	0.18	0.19	0.18	0.16
V (%)	ND	ND	ND	<0.05
Cr (%)	0.05	0.02	0.01	0.04
Cu (%)	0.01	0.01	0.03	0.01
Co (%)	ND	<0.01	ND	0.01
Pb (%)	ND	ND	ND	<0.01
ZnO (%)	0.01	0.01	0.01	0.02
L.O.I.	2.55	0.91	1.72	2.6
Total (%)	99.09	99.26	99.91	97.7
Total Nitrogen (mg/kg)	200	200	100	59
Total Phosphorous (mg/kg)	1500	1300	2200	2950
CEC (meq/100g)	9.7		14.2	7.6
Exchange Na (meq/100g)	3.8		0.5	0.40
Exchange K (meq/100g)	0.19		0.06	0.50
Exchange Ca (meq/100g)	4.05		8.9	3.20
Exchange Mg (meq/100g	0.42		5	3.45
Paramagnetic intensity *	1960-3280	270-330	4830-6090	940-1350

* Measured as cm/g/sec x 10^{-6}

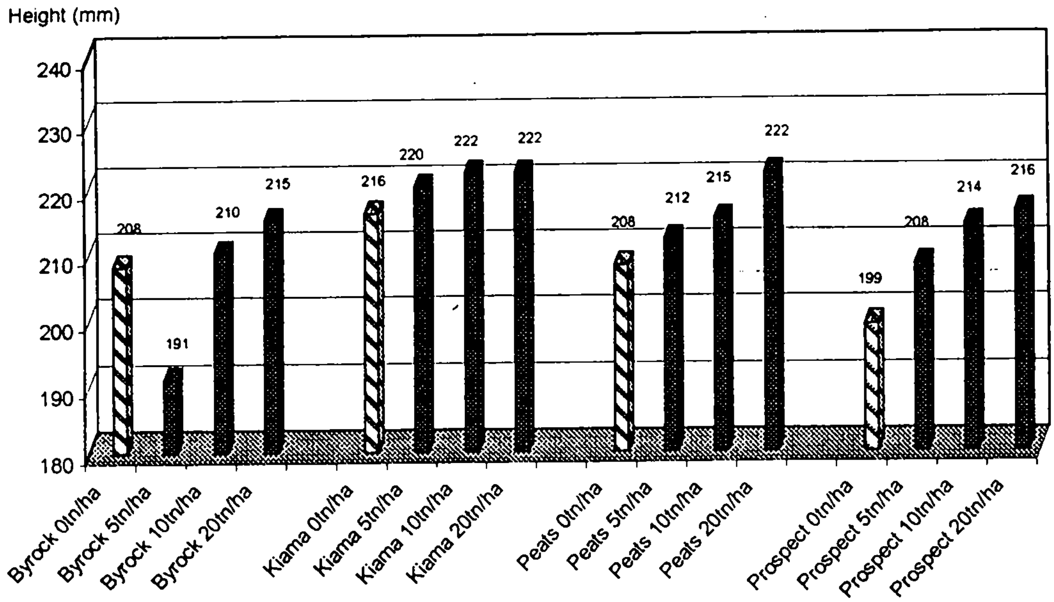

Figure 5 - Average radish plant height 8 weeks after sowing.

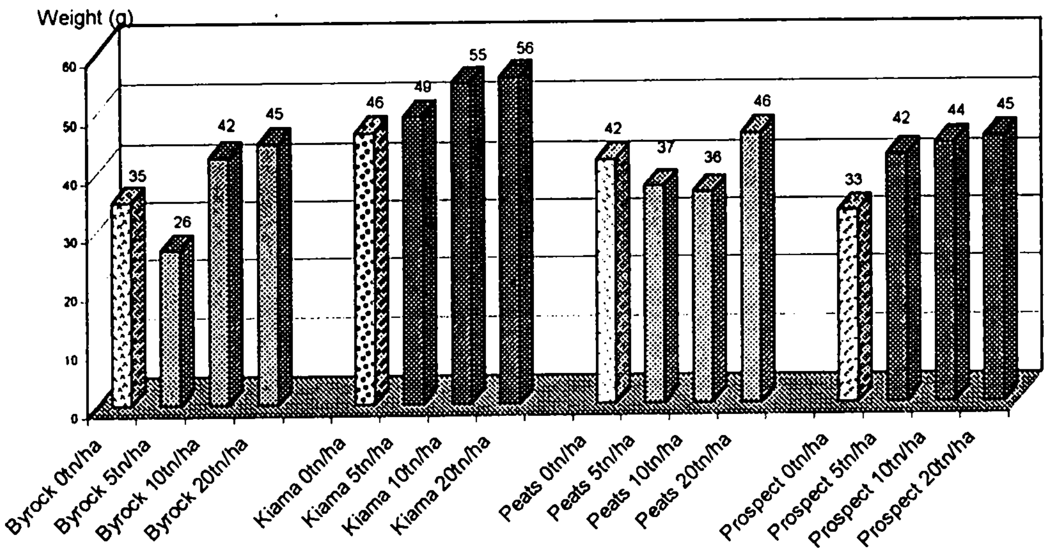

Figure 6 - Average radish total fresh weight 9 weeks after sowing.

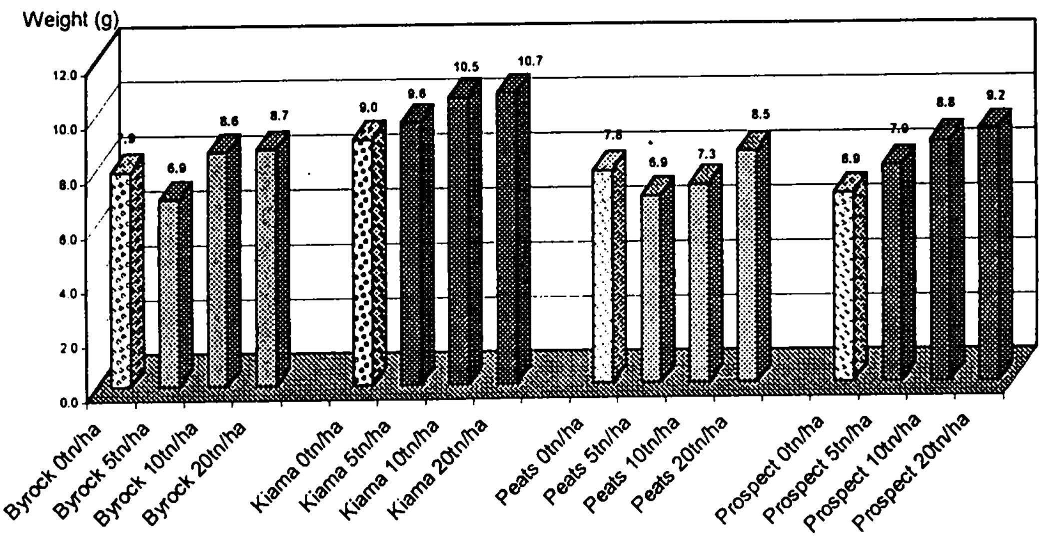

Figure 7 - Average radish total dry weight 9 weeks after sowing.

Table 2 The chemical composition and paramagnetic intensity of basaltic rocks

An experimental design with a specific monitoring program was developed. The pot trial program was divided into several treatments. Four treatments utilised only basaltic rock dust with different application rates and the other four treatments utilised only artificial fertilisers with different application rates. Additional treatments utilised a combination of both the basaltic rock dust and the artificial fertilisers to assess the impact on plant growth. From data available and presented in Figures 5, 6 and 7 it is obvious that the basaltic rock dust with the highest paramagnetic intensity recorded (up to 6000cm/g/sec) consistently exhibited the most advanced plant growth.

It should be noted that every aspect of this trial was identical, except for the four different types of basaltic rock dust. There are no major differences in the mineralogical and chemical composition of the basalts.

The paramagnetic intensity was the most significant difference between each of the four types of basalts and it was the basaltic dust with the highest paramagnetic intensity which quite significantly improved plant growth in comparison to each of the other three types of basaltic rock dust.

2.2.7 Basaltic rock dust as natural sand replacement in potting mix.

The results clearly show that basaltic rock dust has significant potential to act as a replacement for natural sands in horticultural growing media and to improve plant growth. In the vast majority of treatments, the root fresh weight was significantly increased above the control. Although shoot fresh weight did not show results as favourable as the root fresh weight, the results are still positive.

A summary of benefits of basaltic rock dust treatments on different plants in a greenhouse environment is presented in Table 3.

3 Field trials

A number of field trials are currently undertaken covering areas such as:

- open space turf/lawn using couch grass
- open space potted Australian native trees (bottle brush and eucalyptus)
- golf courses
- olive tree plantation
- vineyards
- dairy farms
- remediation of very acidic soils

Most of the field trials have only recently been commenced and field trial results are being collected and data processed. For example, after approximately six months the results on the golf course show a slight increase in the soil pH with an increase in the rate of the basaltic rock dust applied. Also, measurements of the soil EC were consistently higher than levels recorded at the start of the trial. The increase in EC suggests a release of trace elements in soil from the basaltic rock dust. This increase does not pose a risk to plant growth as the plant growth is only affected when EC is greater than 0.75 ∂S/m (Handreck & Black, 1994), the results being well below this figure.

4 Future directions

Based on existing data it is intended to continue some of the greenhouse trials in order to evaluate cereal crops (barley, oats or wheat) and potted colour (flowers). Additional assessments include treatment with various microbes, two types of fish emulsion, compost, etc. Considering the spreading costs and farming techniques, issues such as pelletising and adding minerals and some nutrients are to be assessed.

	Germination of seeds	Number of leaves	Plant height	Plant fresh weight	Plant dry weight
Radish	4 days 1.1% ++ 2.2% + 4.4% - 8.8% - 6 days 1.1% + 2.2% +- 4.4% – 8.8% -		3-4 weeks 1.1% ++ 2.2% + 4.4% + 8.8% ++ 5-6 weeks 1.1% + 2.2% ++ 4.4% ++ 8.8% ++	8 weeks Total fr wt 1.1% – 2.2% + 4.4% + 8.8% ++ Shoot fr wt 1.1% - 2.2% + 4.4% + 8.8% ++ Root fr wt 1.1% – 2.2% + 4.4% + 8.8% ++	
Red Clover		4-5 weeks 1.1% + 2.2% ++ 4.4% ++ 8.8% +	4-5 weeks 1.1% +- 2.2% ++ 4.4% + 8.8% - 7 weeks 1.1% +- 2.2% ++ 4.4% + 8.8% – 9-10 weeks 1.1% + 2.2% ++ 4.4% + 8.8% –	10 weeks Total fr wt 1.1% ++ 2.2% ++ 4.4% + 8.8% +- Shoot fr wt 1.1% ++ 2.2% ++ 4.4% + 8.8% +- Root fr wt 1.1% ++ 2.2% ++ 4.4% + 8.8% +-	10 weeks Total dry wt 1.1% + 2.2% ++ 4.4% + 8.8% +-
Tomato	7 days 1.1% + 2.2% ++ 4.4% ++ 8.8% ++	4 weeks 1.1% + 2.2% + 4.4% ++ 8.8% + 8 weeks 1.1% ++ 2.2% + 4.4% +- 8.8% +	4 weeks 1.1% ++ 2.2% + 4.4% + 8.8% - 8 weeks 1.1% ++ 2.2% ++ 4.4% ++ 8.8% +-		

Table 3 Levels of basaltic rock dust that promote plant responses (positive effects) and levels that are detrimental to plant responses (negative effects)

* a comparative scale is used to indicate the effects of different levels of basaltic rock dust in relation to the 0% treatment (the control) within any one set of results (4 basaltic rock dust levels), such that:

++ = much increased (positive effect)
+ = slightly increased (positive effect)
+- = similar to control (no effect)
- = slightly decreased (negative effect)
-- = much decreased (negative effect)

Work is being carried out to determine the spread and amount of trace elements through weathering techniques. In general, basaltic rock dust trials in the greenhouse but in particular in the field, should continue to assess:

- levels of application
- benefits to other plants
- reduction of artificial fertiliser
- supply of some macro-nutrients and several micro-nutrients
- raise the pH of growth media
- mechanism of activity of basaltic rock dust
- improvement in water holding capacity in growth media
- increase the cation exchange capacity (CEC) of growth media
- influence of rock dust to pest attack and insects. Preliminary assessment of nematodes has indicated a positive response.

Work will be necessary to be carried out in order have a better understanding of the paramagnetism and diamagnetism issues.

Liaising with the International Centre for Aggregate Research (ICAR) in the USA and in particular with the Task Force 6 – Remineralization is very important considering research trials to be carried out with the USA Department of Agriculture. Working together and exchanging ideas may prove beneficial to both parties.

5 Conclusions

- Greenhouse trials using different types and application rates of basaltic rock dust show that the treatment of depleted soils has a beneficial impact on soil quality and plants' health and growth.
- Basaltic rock dust with higher paramagnetic intensity has significantly improved plant growth when compared to basaltic rock dust with lower paramagnetic intensity.
- The excellent results obtained and based on statistical analysis using ANOVA techniques in the greenhouse trials are still to be confirmed in the field trials currently undertaken.
- The results to date on greenhouse trials show that some percentages of the artificial fertilisers may possibly be replaced with basaltic rock dust or other rock dust blends without adverse effect on the quality of soil and the plant growth. This should also be confirmed in field trials as no such data are available at this stage.
- Field trials which are still to be carried out are essential in assessing not only the plant growth and health but also the crop yields. The field trials include spreading techniques and costs associated together with other issues such as packaging, pelletising, being of prime importance.

- It is very well known that most of the rock dusts are lacking in some of the essential macronutrients, e.g. nitrogen, phosphorus and to a lesser extent potassium. Blending of different types of rock dust which may include granites or river gravel are considered, together with adding minerals to the final product.

6 References

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