Soil Air

Soil air is a continuation of the atmospheric air. Unlike the other components, it is constant state of motion from the soil pores into the atmosphere and from the atmosphere into the pore space. This constant movement or circulation of air in the soil mass resulting in the renewal of its component gases is known as soil aeration.

Composition of Soil Air: The soil air contains a number of gases of which nitrogen, oxygen, carbon dioxide and water vapour are the most important. Soil air constantly moves from the soil pores into the atmosphere and from the atmosphere into the pore space. Soil air and atmospheric air differ in the compositions. Soil air contains a much greater proportion of carbon dioxide and a lesser amount of oxygen than atmospheric air. At the same time, soil air contains a far great amount of water vapour than atmospheric air. The amount of nitrogen in soil air is almost the same as in the atmosphere.

Composition of soil and atmospheric air

	Percentage by volume		
	Nitrogen	**Oxygen**	**Carbon dioxide**
Soil Air	79.2	20.6	0.3
Atmospheric Air	79.9	20.97	0.03

Factors Affecting the Composition of Soil Air:

1. Nature and condition of soil: The quantity of oxygen in soil air is less than that in atmospheric air. The amount of oxygen also depends upon the soil depth. The oxygen content of the air in lower layer is usually less than that of the surface soil. This is possibly due to more readily diffusion of the oxygen from the atmosphere into the surface soil than in the subsoil. Light texture soil or sandy soil contains much higher percentage than heavy soil. The concentration of CO2 is usually greater in subsoil probably due to more sluggish aeration in lower layer than in the surface soil.

2. Type of crop: Plant roots require oxygen, which they take from the soil air and deplete the concentration of oxygen in the soil air. Soils on which crops are grown contain more CO_2 than fallow lands. The amount of CO_2 is usually much greater near the roots of plants than further away. It may be due to respiration by roots.

3. Microbial activity: The microorganisms in soil require oxygen for respiration and they take it from the soil air and thus deplete its concentration in the soil air. Decomposition of organic matter produces CO_2 because of increased microbial activity. Hence, soils rich in organic matter contain higher percentage of CO_2.

4. Seasonal variation: The quantity of oxygen is usually higher in dry season than during the monsoon. Because soils are normally drier during the summer months, opportunity for gaseous exchange is greater during this period. This results in relatively high O_2 and low CO_2 levels. Temperature also influences the CO_2 content in the soil air. High temperature during summer season encourages microorganism activity which results in higher production of CO_2.

Aeration Can Improve The Physical properties of soil

Texture

Soil texture refers to the relative amounts of inorganic particles i.e. Sand, Silt and Clay. Sand grains are large and coarse, clay particles are vary fine and smooth, and silt particles intermediate.

Structure

The way in which soil particles are grouped or bound together to form lumps or aggregates is known as soil structure. There are two main types of soil structure, (10) single grained and (2) compound structure. Soil structure can be modified by adopting various soil management practices including aeration, tillage, crop rotation, irrigation, drainage etc.

Density

The density of soil can be expressed in two ways. (1) The density of solid (particle density), particles of the soil and (2) the density of the whole (Bulk density) soil that is inclusive of pore space. Generally soils with low bulk density have better physical condition than those with higher bulk densities. Texture and structure of a soil, its total pore space and organic matter content are all related to bulk densities. Soil density can be modified with aeration.

Porosity

Between the soil particles there are empty spaces which are occupied by air and water and are termed as pore spaces. Pore spaces between the aggregates of soil particles are macro pores and those between the individual particles of the aggregates are micro pores. Sandy soils have a higher percentage of macro pores. Typically, sandy soils never become water logged and allow water to percolate downward more rapidly than clay soils. Typically, moisture content in sandy soils is relatively low when compared to clay soils.

Clay soils contain a higher percentage micro pores when compared to sandy soils. Clay soils are more susceptible to water logging which can adversely effect root respiration and microbial activity. A proper balance between the macro and micro pores can be maintain by timely aeration.

Colour

Soil color is helpful in determining soil properties. A dark brown or black colored soil indicates its high organic matter content and fertility. A red or yellowish soil shows good aeration and proper drainage. A white color, resulting from the accumulation of salts of alkali indicates deterioration of soil fertility and its unsuitability for normal growth of many crops

Soil temperature and plant growth:

Soil micro-organisms show maximum growth and activity at optimum soil temperature range. All crops practically slow down their growth below the temperature of about 9^0C and above the temperature of about 50^0 C. The biological processes for nutrient transformations and nutrient availability are controlled by soil temperature and soil moisture. Soil temperature has a profound influence on seed germination, root and shoot growth, and nutrient uptake and crop growth. Seeds do not germinate below or above a certain range of temperature but Micro-organisms functioning in the soil are very active while a certain range of temperature, which is about 27^0 to 32^0C. It is necessary to know whether the soil temperature is helpful to the activities of plants and micro-organisms and the temperature could be suitably controlled and modified. The various factors that control the soil temperature are soil moisture, soil colour, slope of the land, vegetative cover and general soil tilth. **Aeration** can be used to control soil temperature, regulate soil moisture, improve drainage, stimulate microbial activity and improve overall soil tilth.

Biological properties of soil:

A variety of organisms inhabit the soil. They decompose organic matter, fix atmospheric nitrogen, cause denitrification etc. Specific groups of organisms are responsible for specific activities in the soil. Such activities may be beneficial or harmful to the crop or its yield potential.

Bacteria

Bacteria are generally confined to the 20 to 30 cm. layer and work best when there is (1) good aeration, a neutral reaction, soil moisture content at about half of the soil's water holding capacity and temperature between 25^0 c and 38^0 c

Fungi

These organisms produce microscopic threads called mycelia and are found in the organic matter of plant roots. Fungi help in breaking down the somewhat resistant parts of the organic matter like cellulose, lignin, gums etc. A large part of slowly decomposing soil humus is made up of the dead remains of fungi.

Actinomycetes

They can grow in deeper layers even under dry conditions. Their main function lies in decomposing the resistant parts of organic matter like cellulose.

Algae

They are microscopic or very minute sized plants having chlorophyll and are usually found on the surface of wet soils. They help in adding organic matter to soil, improving the soil aeration and fixing atmospheric nitrogen.

Texture and other soil properties and plant growth

Many of the important soil properties are related to texture. Clayey soils show high water holding capacity, high plasticity, and stickiness and swelling whereas sandy soils are conspicuous by the absence of these properties. The most important way in which soil texture affects plant growth is water and with it the nutrient supply. The available water holding capacity of soil is related to soil texture. Timely **aeration** can improve Soil texture improved water holding capacity.

Soil structure and plant growth

Soil structure influences plant growth rather indirectly. The pores are the controlling factors governing water, air and temperature in soil, which in turn, govern plant growth. One of the best e.g. of the effect of soil structure on plant growth is the emergence of seedlings in the seedbed. The seedlings are very sensitive to soil physical condition so that there should not be any hindrance to the emergence of tender seedlings and there should be optimum soil water and soil aeration. The soil in the seedbed should have a crumb structure so that the roots of the seedling can penetrate it easily. The hard compact layer impedes root growth.

Soil water

Water is essential for plant growth. Soil is capable of being a storehouse of water and becoming the main source of water for land plants. Soil water plays a significant role in several natural processes- evaporation, infiltration and drainage of water, diffusion of gases, conduction of heat, and movement of salts and nutrients are all dependent upon the amount of water present in soil. Plants meet their water requirement from water stored in soil. Soil moisture can be improved with aeration.

Soil Aeration and plant growth

Oxygen is required by microbe and plants for respiration. Oxygen taken up and carbon dioxide evolved are stoichiometric. Under anaerobic conditions, gaseous carbon compounds other than carbon dioxide are evolved. Root elongation is particularly sensitive to aeration. Oxygen deficiency disturbs metabolic processes in plants, resulting in the accumulation of toxic substances in plants and low uptake of nutrients.

Soil compaction

Soil compaction is the process of increasing dry bulk density of soil and reducing pore space by expulsion of air through applied pressure on a soil body. Soil compaction is a limiting factor in seed germination, water transmission and aeration. Timely aeration and the incorporation of biologicals can prevent soil compaction.

Start

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311-3 Cranberry Response to Soil Aeration and Soil Matric Potential.

Poster Number 1813

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***Thomas Laurent**, Laval University, QuÃ©bec, QC, CANADA, Suzanne Allaire, Laval University, Ste-Foy, QC, Canada and Jean Caron, Pavillon Envirotron, Université Laval, Quebec, QC, Canada*

Cranberry yields have increased about 10% over the last decade in Quebec. New irrigation methods contributed to this increase and some of this increase has been attributed to poor aeration conditions.

The objective of this study was to to determine the threshold at which soil aeration becomes insufficient and affects cranberry yield and photosynthesis.

To highlight the impact of groundwater and subsequent level on the plants, six treatments were imposed randomly and replicated four times to 24 soil blocks (26 cm width x 26 long x 42 cm high) column sampled in cranberry fields with limited disturbance. They were later brought to a growth cabinet and imposed a controlled environment. Water levels associated to matric potential of -0.25, -0.5, -1, -2, -3 and -5 kPa were imposed for the duration of the experiment. Matric potential, water contents and oxygen concentrations were measured every 30 minutes at the 5 to 15 cm depths using respectively pressure sensors, T.D.R. and Apogee probes connected to dataloggers while transpiration, stomatal conductance, and photosynthesis were measured as plant physiological indicators. Correlations are established between air porosity and diffusive flux of oxygen with indicators of the plant activity.

Measurements indicated that at a matric potential threshold of about -3 kPa, a decrease in photosynthesis rate was observed and was associated to insufficient oxygen diffusion to the roots. Plant activity decreased significantly by 30% after one week in the wettest treatments (-0.25, -0.5, -1 kPa). This indicates a high sensitivity of cranberry to excess water, contrarily to the common belief for this crop.

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See more from this Session: Soil & Water Management & Conservation: II

Degradation and sorption in subsurface and aquifers of the herbicide metabolite BAM (2,6-dichlorobenzamide) after non-point contamination

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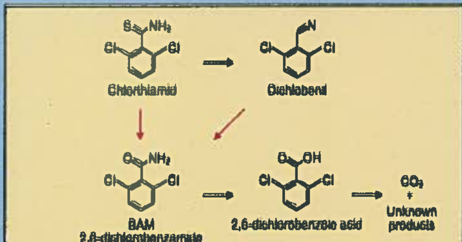
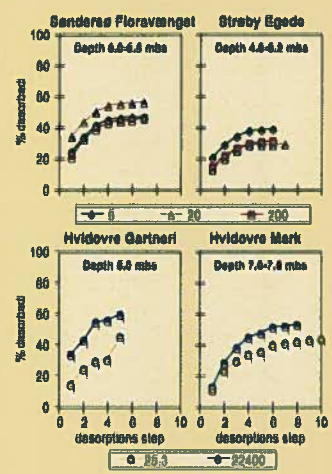
Background

The total weed control herbicide dichlobenil (e.g. Prefix and Casoron) is degraded to the metabolite dichlobenzamid (BAM), which is relatively persistent, and easily transported. Therefore BAM is often found in subsurface and aquifers, e.g. in Denmark, Sweden and Germany, where it is found in 20-44% of the investigated abstraction wells. It is still the most often found pesticide in Danish groundwater, nine years after it was abandoned in Denmark.

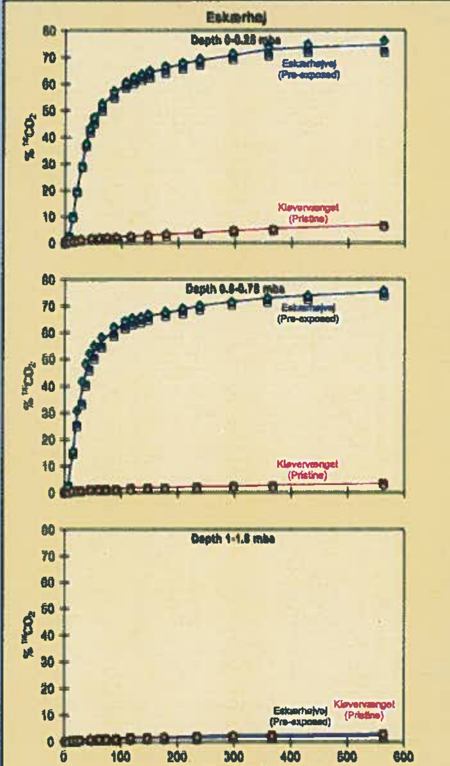
To get insight in the controlling parameters for the persistence of BAM the degradation and sorption of the metabolite BAM was investigated in soil, subsurface and aquifers.



Degradation pathways



The sorption of BAM is strong - and to some extent irreversible - in anaerobic sediments, which may function as sink. The figure shows the cumulated desorption (in percentage) as function of number of desorption steps after adsorption equilibrium was reached. Data from different initial concentrations (µg/L) at the start of the adsorption.



Effect of pre-exposure: sandy sediments with known history of pre-exposure were adapted and degraded BAM, whereas uncontaminated sediments did not. However, layer below 1 mbs under the pre-exposed site were not adapted. Initial concentration: 100 µg/kg.

Methods

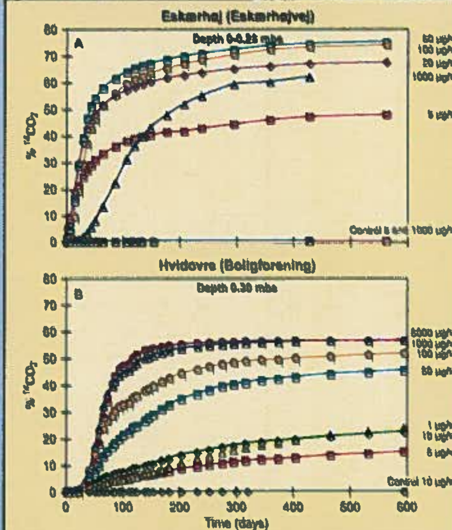
From 10 cores 58 samples were investigated, including topsoil, unsaturated zone and aquifers, clayey till and sandy sediments.

Aerobic degradation of ^{14}C-ring-labeled BAM, with collection of $^{14}CO_2$ in NaOH-traps included uncontaminated and contaminated sediments.

The metabolite 2,6-dichlorobenzoic acid was analysed for by GC-MS.

Sorption was measured by standard procedure with ^{14}C-BAM, 7 days of equilibration time and 5 g of sediment and 5 mL sterile filtered groundwater.

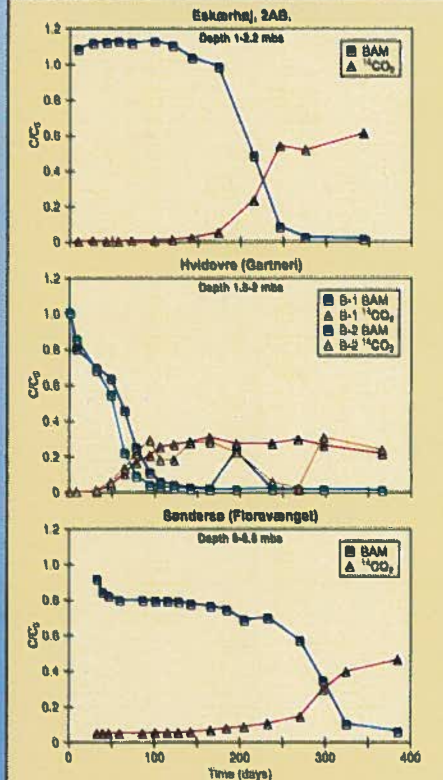
Desorption was measured after 3 days of equilibration after centrifugation and replacement of the water phase. This was repeated up to 8 times.



Effect of initial concentration in pre-exposed sediments. In clayey till (Hvidovre) the degradation rate increased with increased initial concentrations, indicating growth of the degrading population. In sandy sediments (Eskærhøj) BAM was degraded relatively fast at all concentrations.

Results

- BAM was microbially mineralised to CO_2 mainly in the upper meter below surface
- BAM was much easier degraded in contaminated sand (up to 200 µg/kg dichlobenil) than in uncontaminated sand. However, this effect of pre-exposure was not seen in clayey sediments
- Previous exposures have led to adaptation in sandy sediment in the upper meter below surface, but exposure alone did not prompt adaptation
- In contaminated clayey till sediments degradation rates increased with increasing BAM-concentrations in the range 1-5000 µg/kg, indicating growth-controlled kinetics
- In sediments from a contaminated sandy location, degradation rate was relatively high and independent of the initial concentration. This was probably due to higher numbers of specific degraders due to long exposure to dichlobenil and BAM
- 3 exposed aquifers showed BAM degradation at high initial concentrations (100 µg/L) in 4 out of 6 incubations. No degradation was observed in aquifer incubations with low initial concentrations (5 µg/L)
- 2,6-Dichlorobenzoic acid was verified as a metabolite in the pathway to CO_2, and its field detection may thus indicate BAM-degradation
- In reduced clayey till sediments, BAM was relatively strongly adsorbed, since more than 40% of BAM remained sorbed, and only desorbed very slowly



Removal of BAM due to degradation (production of $^{14}CO_2$) in 3 pre-exposed aquifers at initial concentrations of 100 µg/L.

Conclusion

Despite degradable, the metabolite BAM remains quite persistent when it has reached the subsurface. Even though degradation in pre-exposed aquifers was seen, degradation only took place at high initial concentrations (100 µg/L) and not in all incubations (4 out of 6).

Acknowledgement

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References:

Ludvigsen, L., Clausen, L., Jørgensen, P.R., Hoffmann, M., Fredriksen, G.S., Nygaard, B., Albrechtsen, H.-J. & Jensen, T.F. 2005: Fate of BAM in aquifers (In Danish), Danish Environmental Agency, Copenhagen. Miljøprojekt, 1000. pp. 1-222.

Casoron
Dichlobenil (DBN)

Jac Eussen
Crompton Corporation
Crop Protection

Mode of Action

Dichlobenil (DBN) inhibits the formation of cellulose in the plant cell walls. Cells loose their elasticity. They do not elongate but swell in all directions and then burst. At higher doses cell walls are not formed anymore. Dichobenil therefore will only affect growing plant tissue not already established tissue.

DBN-soil characteristics

- The Casoron granule disintegrate when in contact with water, and DBN is released
- DBN is volatile, thus should be watered in after application
- The Casoron granule protect DBN to a certain extend from evaporation
- Volatility is temperature dependent and it is not recommended to apply Casoron above 65/70 F
- In soil DBN will partition between: soil water – soil air – soil particles
- Uptake of DBN by plants from soil occurs through the soil water
- DBN has the property to co-distill with water. Thus as water evaporates from soil DBN will go along with it. 1.4 gram of DBN can disappear in this way with 100 ml of soil water
- DBN also will disappear from soil through soil air
- The partition coefficient of DBN between water and air is 4000. This means that DBN will be forced into the water as long as it is in the soil air space. The solubility of DBN in water however is limited to a maximum of 18 ppm
- Adsorption to the soil strongly dependent on the soil OM content. K=1.0(OM) + 0.5; Maximal adsorption occurs at 10% OM; DBN will desorb from the soil according to the same equation. Adsorption is independent from clay content and CACO3
- Although in organic soils a greater part of DBN will be adsorbed to soil, as a result of its solubility DBN is still regarded as mobile in soil.
- The combined characteristics of DBN will cause DBN not to move much downward as well as laterally in soil. This however will depend on OM. As OM content decreases from 10%, more movement will occur
- Degradation of DBN is a microbial process.
- Half life of DBN is 1.5-12 months
- No effect from light or pH

Consequences for Casoron application.

Peat soils

- Water-in is necessary
- Restricted movement of DBN downward and laterally.
- Co-distillation and evaporation will occur
- Soil will hold a greater part of DBN
- No leaching of DBN.
- 100 lb/a Casoron 4G is adequate for weed control activity and avoiding crop phytotoxicity
- Depending on the weed infestation split applications may be considered

Sand

- Water-in is necessary
- Movement downward and laterally will occur
- Co-distillation and evaporation will occur
- Soil will hold DBN depending on OM
- More DBN is available at greater soil depth than in peat soils.

- Casoron rate should be adapted. Lower than 100 lb/a rate for efficacy and phytotoxicity. Maximum one application rate: ca.: 50lb/a
- Split applications should be considered

Sand soil + OM

- In sandy soil with more or less OM, DBN will behave in between peat soil and sand soil. Rates should be adapted accordingly.
- Small amounts of OM will already hold DBN
- OM may develop gradually during the years of cultivation. Behavior than will gradually change from sand soil to peat soil. Casoron application can be adapted.
- Rates will change from the 50 lb/a maximum to the 100 lb/a maximum