Wood Vinegar and Biochar in Agriculture

How to Improve Crop Quality While Reducing Dependence on Agricultural Chemicals

From

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Literature Review
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Introduction

Mr Hirowaka could you please let the readers know about the history of this publication

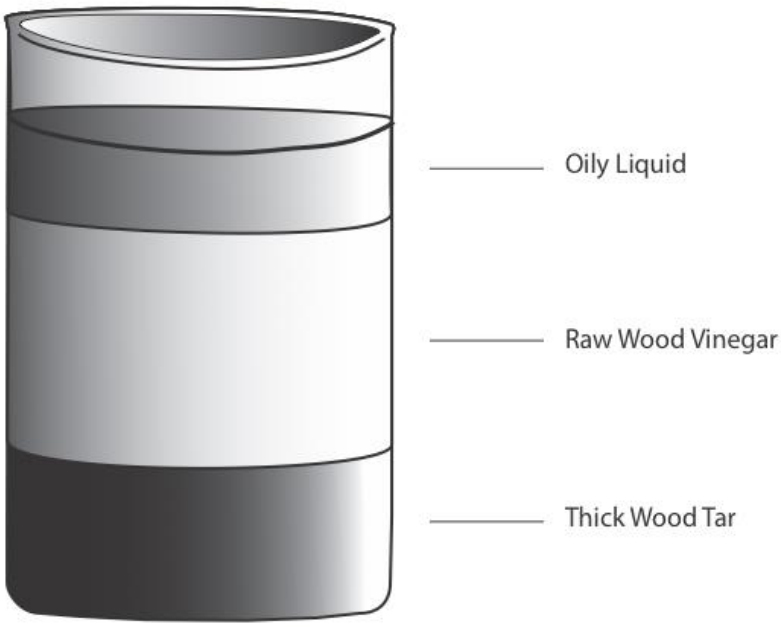
Why was this publication produced, who produced it eyc.

Literature Review

To be completed

CHARCOAL AND WOOD VINEGAR: Overview

When wood is burnt in the open air, it is reduced to ash. However, if it is heated in a closed vessel or air-tight environment, it is pyrolysed, or transformed through the action of the heat, leaving behind charcoal. During this process of carbonization, smoke is emitted. If this smoke is cooled, a liquid can be collected. This liquid, if left to sit, will separate into three distinct layers as shown in Figures 1 and 2. An oily liquid occupies the top layer while thick wood tar settles on the bottom. The middle layer consists of a transparent, yellowish-brown liquid which is commonly called raw wood vinegar.



Until recently, charcoal and wood vinegar have been used principally in areas other than agriculture. Charcoal has been used as a fuel, of course, as well as in sewage treatment and metal polishing. Wood vinegar has been used in a variety of ways, including as an ingredient in medicines, an additive to animal feeds, a deodoriser, a mordant in the dyeing process, a facilitator in the fermentation process, a filter in sewage treatment and a raw material in various other industries.

However, recently farmers and agricultural researchers have been looking into the use of charcoal and wood vinegar as alternatives to chemicals in improving crop yields and controlling pests. According to recent research and field trials, the following are some of the benefits of using charcoal and wood vinegar in agriculture.

Benefits of charcoal use

1. Due to the fact that charcoal is very porous, it is an efficient filter of air and water, and absorbs and easily

retains moisture. It therefore also improves the physical characteristics of soil such as its water permeability and water retention.

2. If charcoal is applied to the soil, it increases the quantity of useful microbes such as Vesicular-Arbuscular mycorrhiza. As a result, plants develop stronger root systems and damage by blights and insects is decreased.

3. In greenhouses, charcoal absorbs ammonia and other harmful chemicals that build up over time.

4. Charcoal consists of a well-balanced variety of minerals including calcium and boron. Due to the carbonization process, these minerals exist in a form which plants can easily absorb.

5. Mixing charcoal with manure reduces offensive odours and facilitates the composting process.

Benefits of wood vinegar

Wood vinegar has a variety of beneficial effects stemming from the fact that it is made up of a variety of minerals, compounds and acids. Researchers have found that wood vinegar consists of more than 200 different ingredients. Tables 1 and 2 show the main ingredients found in raw and refined wood vinegar.

The most common component in wood vinegar, except for water, is acetic acid, which accounts for 3 to 7% of the total ingredients and 50-70% of the organic matter. In addition to acetic acid and other organic vinegars, raw wood vinegar also consists of roughly 5% phenols

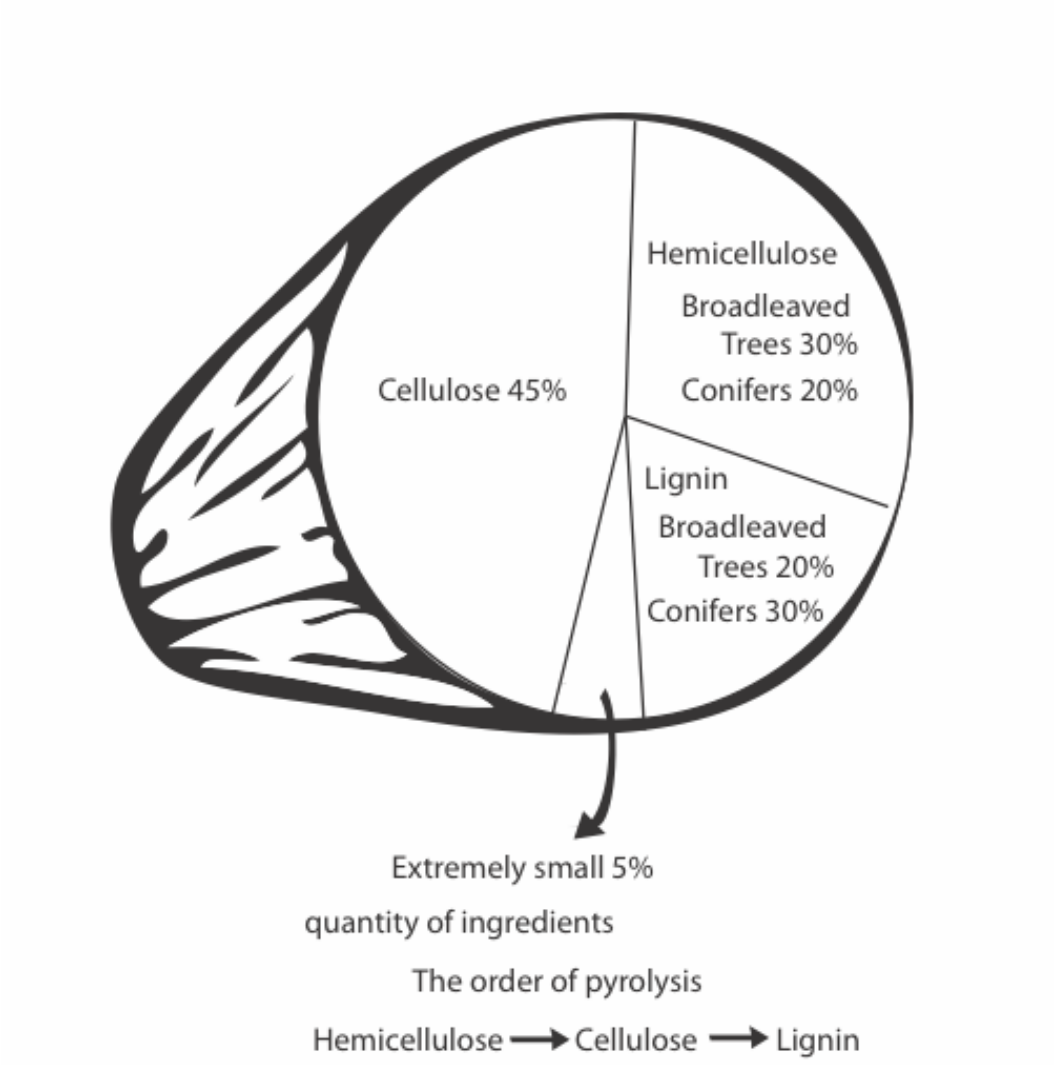
and several percents of various types of alcohol including methanol and ethanol.
Researchers have found that the beneficial effects of wood vinegar in agricultural applications include:

1. Spraying diluted wood vinegar on plant leaves increases their vitality and improves crop quality.
2. Spraying also helps control harmful insects and some kinds of plant diseases.
3. Wood vinegar and agricultural chemicals are complementary. The efficacy of using them together is greater than using either one alone.
4. If wood vinegar is applied to the soil or mixed into it in high concentrations, it inhibits eelworms and soil diseases. In low concentrations or while it is in th process of being broken down in the soil it increases the quantity of useful microbes.
5. Wood vinegar helps plants develop stronger roots.
6. Mixing wood vinegar with manure reduces odours and facilitates composting.

Wood vinegar has a variety of other benefits. For example, if it is mixed with animal feed, it improves the meat quality. Table 1 lists some specific uses of wood vinegar in combating blight and insects.

How wood vinegar is formed

In order to better understand the components of wood vinegar ad how it works, it may be helpful to know how it is formed. The main ingredients in wood are the fibres cellulose, hemicellulose and lignin (Figure 3). In addition there are small quantities of compounds such as tannin.



When these compounds are pyrolysed, ie in an air-tight environment, new compounds are formed. The types of compounds formed depends on the temperature of the fire. During the wood carbonization process, cellulose first pyrolyses at about 275 degrees centigrade. Later, lignin pyrolysis begins at 375 degrees, becoming most intense at 400 degrees (Figure 4). (The same type of process occurs when compost is made from straw where decomposition by microbes first occurs in the cellulose and later in the harder lignin).

The stages in the carbonisation process can be observed by monitoring the smoke as it leaves the charcoal kiln. Initially, white water vapour is emitted as most of the moisture in the

wood is driven off. Next, an acrid smoke is produced, a result of the pyrolysis of hemicellulose. Later, as cellulose pyrolysis begins, a pungent smoke is emitted. Finally, as lignin pyrolysis begins, smoke leaving the kiln turns a bluish-purple colour, like the smoke of a cigarette.

When collecting wood vinegar, the first, white-vapour, stage and the last, purple smoke, stage, should both be avoided. The first stage contains too much water, and the smoke emitted during the high temperature, last stage, contains large quantities of tar. Therefore, vinegar from both stages is inappropriate for agriculture.

The different ingredients in wood produce different compounds in wood vinegar. For example organic acids such as acetic acid and various kinds of alcohol, result from the pyrolysis of cellulose and hemicellulose. The pyrolysis of lignin produces phenols.

The major difference between wood vinegar and edible vinegar is that wood vinegar includes ingredients resulting from lignin pyrolysis. Among these ingredients is a compound used in medicine, ethyl gualacol.

Also included are the suspected carcinogens, 3.4-benzopyrene and 1.2.5.6-dibenzanthracene methylcholinsrene. However, these compounds will not be produced if the carbonization temperature is kept under 425 degrees. For this reason, the temperature of the kiln must be carefully monitored when collecting wood vinegar. In addition, it is comparatively easy to remove these potentially harmful substances in the distillation process, although excessive distillation will also remove many tars useful in agricultural applications.

The Multiple Beneficial Effects of Wood Vinegar

As mentioned above, wood vinegar consists of a variety of ingredients resulting from pyrolysis. This mix of ingredients is what makes wood vinegar effective. Unlike agricultural chemicals which rely on one or two "active ingredients", in wood vinegar, various ingredients are interweaved with each other. If wood vinegar were to be compared to a medicine, it could be called a herbal medicine. Its strength does not come from a single ingredient, but from the multiple effects of various ingredients. It is this combination of ingredients that gives wood vinegar its multiple beneficial effects, including the ability to control diseases and pests, to increase microbes, and to facilitate root growth.

However, details about how the various substances in wood vinegar work together, are scant. For example, although acetic acid, a major component of wood vinegar, does have a beneficial germicidal effect when sprayed on plants, wood vinegar itself is more effective than acetic acid on its own. Also the beneficial effects of wood vinegar on soils cannot be explained simply by the temporary lowering of pH.

Wood vinegar appears to facilitate cell growth and especially to serve as a catalyst for the growth of the various enzymes and microbes that surround the processes of photosynthesis, nutrient absorption and cell growth.

Moreover, because wood vinegar has small quantities of various kinds of permeable ingredients such as alcohol, ketone and aldehyde, it is easily absorbed into plants. It also dissolves agricultural chemicals, making them easier to absorb.

Used in Moderation is Best

It is important that wood vinegar not be used in too concentrated a form. In this sense, wood vinegar is like vitamins for humans: repeated use of concentrated doses is not more effective, and may even be more harmful, than using the prescribed amount.

An example of this is Japanese horseradish. Because of the wood vinegar in smoke emitted by charcoal kilns, these plants grow well at some distance downstream of the kilns, but do not grow well closer to them. Horseradish growth is poor within 100m of the kiln, but is very good within the 100-1000m range. No effect is found further than 1000m from the kiln.

HOW WOOD VINEGAR WORKS

As shown in Fig. 5, the degree of concentration determines whether wood vinegar destroys soil microbes or facilitates their growth.

In high concentrations, wood vinegar has a strong germicidal effect due to its high acidity and the presence of germicidal ingredients such as methanol and phenol.

The microbes first killed by wood vinegar are bacilli which have no spores, and some hyphomycetes which are weak in acid.

However, when wood vinegar is diluted 20 times, it greatly increases the concentration of microbes. It is believed that this is primarily due to the effects of the acetic acid in wood vinegar. As shown in Fig. 6, plants and microbes produce a substance named acetyl coenzyme from acetic aid. Acetyl coenzyme itself is then converted into various substances which facilitate the growth of plants and microbes.

Bacilli with spores (including actinomyces) and many kinds of moulds grow rapidly as they feed on the nutrients in wood vinegar. Within a week of spraying wood vinegar on soil, the surface and inside of the soil are covered with white moulds.

http://watchingtheworldwakeup.blogspot.com.au/2009/10/real-problem-with-rim-brakes-and-true.html

Some germs and useful microbes (antibacterial microbes) are resistant to acids, others are not. Spraying wood vinegar on soil generally tends to raise the density of useful microbes such as bacilli and actinomyces. Trichoderma also increases greatly. These are antibacterial microbes which are parasitic to Corticium rolfsii Curzi, seedling damping-off bacillus (Rhizoctonia, Pythium), Sclerotinia, and so on.

Although wood vinegar usually is able to reduce soil diseases through its ability to destroy harmful nicrobes and encourage the growth of helpful ones, occasionally there are not sufficient useful microbes or there are too many acid proof germs in the original soil. In these cases it is important to apply compost along with the wood vinegar. The compost introduces such useful micrbes.

Such changes in the biota or microbes not only inhibits diseases of the soil, but also helps plants take root well and grow strong.

Wood vinegar also kills clubroot eelworms. Though the reason is not clear, it is presumed that wood vinegar not only has a toxic effect on the eelworms themselves, but also increases the numbers of the eelworms' predators.

Wood Vinegar Complements Agricultural Chemicals

With respect to diseases of stems and leaves, many researchers claim that wood vinegar both has a direct germicidal effect, and an indirect, prophylactic effect through changing the biota on the leaf surface. When leaves are temporarily acidified, it prevents the increase of germs.

However, the most conspicuous benefit of spraying wood vinegar on leaves, is the vinegar's ability to strengthen plants' natural resistances to diseases and to increase the permeability of agricultural chemicals.

Many researchers point out that leaves on which wood vinegar is sprayed turn glossier and greener. They postulate that this is because certain kinds of esters in wood vinegar increase the levels of chlorophyll and stimulate photosynthesis. It is also presumed that they assist in the synthesis of sugars and amino acids. As a result, in addition to increasing leaf vitality and thus resistance to disease,

wood vinegar can also actually improve the taste of agricultural produce.

In addition, wood vinegar increases the permeability of agricultural chemicals into leaves. Such chemical usually dissolve most easily in acids with pH value of 4 to 5. Therefore, when they are sprayed together with wood vinegar, they become more effective. In this way, the quantity of agricultural chemicals used, and the frequency with which they are used, can often be reduced by half. However, alkaline agricultural chemicals cannot be mixed with wood vinegar because they react negatively with the acids in the vinegar.

Increased Sugar Levels and Growth Stimulation

Another major benefit of wood vinegar is that it appears to assist the enzymes and microbes which facilitate plant cell growth and other useful reactions. While this mechanism is unclear scientifically, many researchers claim that spraying wood vinegar makes plants take root more firmly, helps leaves grow larger and fuller, counteracts excessive nitrogen, stimulated the metabolism of plants and raises sugar levels. It is assumed that plants are favourably affected by trace elements in the wood vinegar, or other substances produced when wood vinegar is decomposed through the photosynthetic process.

Spraying wood vinegar diluted 500 to 1000 times an improve the taste of fruits that are not very sweet due to weak photosynthesis resulting from a lack of sun or poor soil. This effect is assumed to be due to wood vinegar's role as a coenzyme. It is also thought to be related to the presence of esters in wood vinegar. Valerianic acid ethyl, for example, benefits the growth of radish and of Chinese cabbage. Such esters in wood vinegar as methyl acetate and

methyl formate also have a strong growth acceleration effect on plants.

Wood Vinegar helps Fertiliser

Just as wood vinegar increases the effectiveness of pesticides and herbicides, it also increases the effectiveness of fertilizer. This is due to the fact that wood vinegar complements both the fertilizer and the existing soil nutrients. For example, it has been recorded in applications of wood vinegar in the growing of tea, that it increases by three times the level of useable phosphoric acid. The roots of plants secrete organic acids which dissolve and absorb phosphoric acid in the soil, and it is thought that organic acids in wood vinegar have the same effect.

Composting with Wood Vinegar

Wood vinegar can accelerate the fermentation of organic matter during composting and in many cases can halve the fermentation period. Although too much wood vinegar can be harmful because of its fungicidal effect, low concentrations actually increase the amounts of useful moulds, bacilli and actinomyces actionmyces and accelerates the breaking down of tougher fibres. In this way the compost is not only fermented faster but it also becomes better in quality.

Research has shown that certain ingredients in wood vinegar increase the concentrations of microbes that produce or complement the enzyme Cellulase. The ingredients which appear to most benefit Cellulase are acids, phenols and especially carbonyls. Thus wood vinegar acts as a facilitator and catalyst for the growth of enzymes.

As a Deodorant for Manure

Because it counteracts the production of ammonia, wood vinegar can be sprayed on manure to reduce odours in cattle sheds and the like. In addition, wood vinegar can be used to repel dogs, cats and insects, especially centipedes. It is unclear why it has such an effect, but there is an opinion that animals associate the smell of wood vinegar with fire and tend to avoid it instinctively. For these purposes, raw wood vinegar is preferable to…. Because it contains more dissolved tar, lipids and resin.

CHARACTERISTICS AND EFFECT OF CHARCOAL

Charcoal has a large surface area and increases useful microbes

Charcoal is the remainder of the pyrolysis of cellulose, lignin and other substances and consists of 80-90% solid carbons. Fig. 7 shows a magnified picture of a section of charcoal. It has a high pH value of between 8.0 and 9.0.

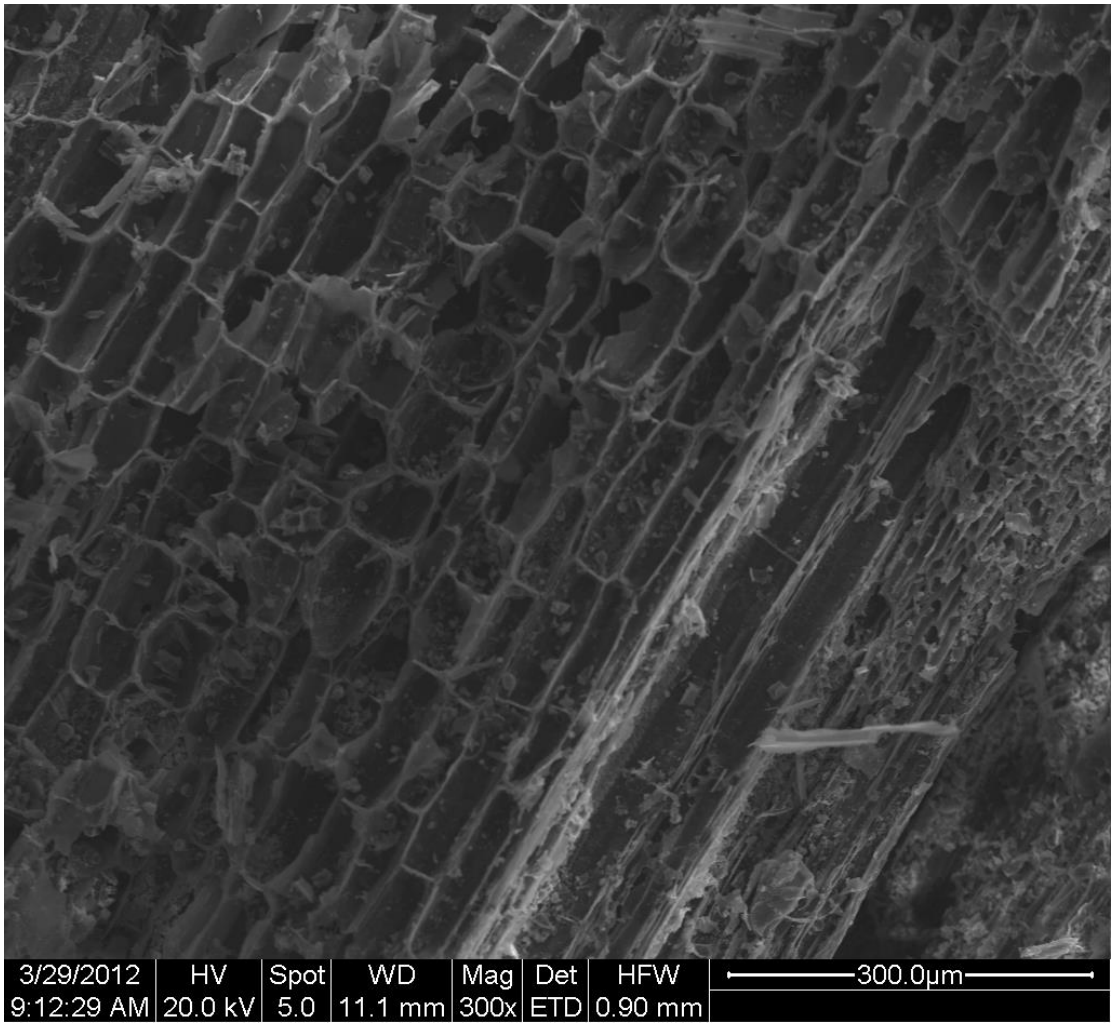


Photo: Stephen Joseph University of NSW

Charcoal is very porous and has a large internal surface area. Surface area per gram is no less than 200 to 400 square metres! The pores of charcoal range from several microns to 100 microns in width. Because of charcoal's high porosity and its extremely large surface area, it has a high capacity to absorb gas and moisture. For this reason, charcoal has traditionally been used as a deodoriser, filter or purifier in applications ranging from cigarettes to water treatment.

In the case of agriculture, charcoal has many benefits. When applied to soil, it absorbs harmful gases. It also keeps in the soil nitrogen which would otherwise be emitted as ammonia gas.

Charcoal also provides a home for many useful microbes. Since charcoal contains no organic matter, saprophytes – which feed on organic matter and which are the dominant type of bacteria in the soil – cannot live in it. It is difficult for moulds to enter charcoal because their spawn are too big. However, actionmyces actinomyces and bacilli can enter easily.

Although charcoal itself contains only very small quantities of minerals and no nitrogen, the microbes that usually enter it first are those such as azotobacter, that produce their own nutrients by fixing nitrogen. Charcoal therefore leads to an increase in nitrogen-fixing bacteria.

As nitrogen accumulates in charcoal, plants take root in it and there is an increase in bacteria such as Vesicular-Arbuscular mycorrhiza which live in symbiosis with roots. Vesicular-Arbuscular mycorrhiza bacteria get its nutrients from roots, and at the same time absorbs phosphoric acid and minerals from the soil by dispersing its spawn. This then makes those substances more readily available to roots. In addition, soil diseases appear to be reduced in the presence of Vesicular-Arbuscular mycorrhiza bacteria and other mycorrhiza microbes.

Therefore, like wood vinegar, charcoal is neither a fertiliser nor an agricultural chemical. Howeer, it creates a favourable environment for growth, complements the effects of fertilisers, and reduces diseases.

Charcoal and Wood Vinegar

Soaking charcoal in wood vinegar before applying it to the soil has a multiplier effect on the effectiveness of the charcoal. This is especially true of vinegar and charcoal made from the same wood. Charcoal has extremely small quantities of minerals which are highly reactive (that is, they

ionize easily) making charcoal highly alkaline (8 – 9 pH). Soaking charcoal in vinegar, which is acidic, lowers the pH to around 5.5 which makes the charcoal a better home for useful microbes.

Many researchers claim that the same "softening" of charcoal can be achieved by leaving it exposed to rain for a year or so.

In any case, the combination of charcoal, which provides a favourable environment for useful microbes, and wood vinegar, which supports their growth both directly as a nutrient and indirectly as a catalyst, dramatically enhances the quality of the soil.

http://pinagoutama.en.ec21.com/Wood_Vinegar--5156628.html

Comparing Wood Vinegars

Nowadays, various kinds of wood vinegar are sold together and it can be confusing as to what kind of wood vinegar should be used. Some are high quality, produced in the

traditional way from charcoal kilns; others are produced through short-cut methods without kilns. One major problem with low quality wood vinegar, is that it may be made from inferior wood and may contain inorganic substances such as pain, insecticide, preservatives or residues from sea water. The following is a guide to distinguishing good wood vinegar from those of lesser quality.

Wood Vinegar with Tar can cause Problems

Depending on the intended use of the wood vinegar, the user should determine whether raw wood vinegar, with its tars and resins, is preferable to distilled wood vinegar. As mentioned above, if raw wood vinegar coming out of the kiln is left to sit, it separates into three layers: at the top is a light oil such as terpen; on the bottom is the sticky wood tar; and in between lies the refined wood vinegar.

These layers are divided into water-soluble and oil-soluble solutions. The water-soluble liquid is wood vinegar. The light oil and wood tar are both oil-soluble but are separated because the former is lighter than the vinegar, the latter heavier.

The wood vinegar also contains small quantities of tar, but since this tar often contains useful ingredients and is difficult to remove, it is usually not filtered out. However, wood vinegar which contains a lot of such tar is not good for agriculture. This is because, when sprayed on leaves, tar sticks to and coats them, blocking normal growth processes. Because it is oily, tar weakens leaves and roots, restrains the differentiation of roots, and may kill them by forming a membrane over them. It is important, therefore, that only wood vinegar which has had most of its tar resins removed, be used for agriculture.

Wood vinegar continues to change over time. Formaldehydes contained in wood vinegar form resins by polymerizing with phenols. They then form tar, the majority of which sinks to the bottom of the vessel. However, this process of resinification continues for over a month after the vinegar is collected. For this reason, high quality, stabilized wood vinegar is usually left to sit for about a year before it is separated and, at the bare minimum, wood vinegar should be left to sit for at least one month.

If you collect wood vinegar by yourself, you should separate out the tar by keeping it still for several months and using only the yellow-brown transparent liquid in the middle layer. Alternatively, as will be explained later, you can eliminate tar by mixing in charcoal powder.

In general, when buying wood vinegar on the market, you should choose a transparent one. Vinegar that contains more than 1% tar is not transparent.

The Contents of the Tar depends on the Type of Wood and the Method of Making Charcoal

There are many kinds of charcoal. However, as is shown in Fig. 8, they can be roughly divided into those made in the mountains and those made in the towns. In the former, traditional charcoal kilns and used and the material is primarily broadleaf trees. Wood vinegar from such systems can be easily separated and refined. Wood vinegar made from charcoal kilns in the mountains is relatively safe.

How to clarify the content of tar

Wood vinegar made in cities often contains a lot of tar due to the fact that much bark and sawdust if used. It is also often made by the low quality dry distillation method, which uses external heat rather than heat produced by the

carbonization of wood itself. The tar in such vinegar cannot be eliminated simply by being kept still and filtering, but must be separated out using a higher-grade refining technique in order to leave the useful ingredients behind.

One way to clarify how much tar is in the wood vinegar, is to see whether it is transparent or not.

Wood vinegar is sometimes also made artificially by dissolving tar in methanol and mixing it with acetic acid. Such artificial vinegar is identifiable because unlike natural vinegar, it is not transparent. It is ineffective, if not harmful, in agricultural applications, and should be avoided.

Another way to distinguish refined wood vinegar appropriate for agriculture, from low-quality, artificial or raw vinegar, is to observe the change in its pH as it is diluted in water. As fig. 9 shows, the pH of inferior vinegar rises steadily as it is diluted, until it reaches about pH 7 at a dilution of 1000 to 1. On the other hand, the pH of high quality, refined vinegar begins at about 3, but initially rises quickly before increasing more gradually. This is because the pH value of tar tends to rise steadily as it is diluted.

Other Harmful Substances in Wood Vinegar

Harmful substances other than tar may also be mixed with wood vinegar. The following are some of the most problematic:

Terpene

Wood vinegar produced from charcoal made from conifers contains terpene which is harmful to plants and therefore must be eliminated. An exception is terpene from Japanese Cedar which has a different structure from other terpenes and is not harmful to plants.

Terpene, like oil, floats on top of the wood vinegar because it has a light specific gravity. It also has a strong smell. Therefore it is easy to identify and can be skimmed off the top layer of liquid.

Impurities from collecting equipment

In addition to contaminants that originate with wood, impurities can also come from collecting equipment. For example, iron implements should not be used. If an iron drum or pipe is used, the vinegar turns black as it oxidises the metal. It is best to avoid wood vinegar made in metal containers such as iron and zinc, as well as that made in certain kinds of vinyl. If you make your own wood vinegar, be sure to use an acid-resistant vessel or synthetic resin tank such as those used in agriculture.

How to use wood vinegar – spraying

The two main aims of spraying wood vinegar on leaves are:

1. To accelerate the plant's metabolism and raise its overall quality – effects stemming from vinegar's role as a fermentation facilitator and catalyst.
2. To allow agricultural chemicals to better permeate leaves and plant tissues, thereby increasing their effectiveness.

Though wood vinegar has a germicidal and insecticidal effect, it should not be used with the same expectations as agricultural chemicals. Its effectiveness lies in it being a catalyst for fermentation and a soil conditioner. Like agricultural chemicals, however, it is no more effective, and probably more harmful, when used in large quantities than when applied in prescribed dosages.

Guidelines on Use of Wood Vinegar: Frequency

To improve crop quality, the following standards for spraying wood vinegar are being adopted in Japan.

Wood vinegar is applied 2 or 3 times, or once every 15-20 days, during the growing season, up until about 15 days before harvest. By applying before the harvest, the esters in wood vinegar accelerate the fermentation of amino acids and sugar. In the case of tangerines, wood vinegar should be applied to shaded trees or when levels of sugar in the fruits are expected to be low due to cloudy weather. Wood vinegar encourages the production of sugar and amino acids and improves aroma.

For vegetables, spraying before harvest improves taste and quality and may delay wilting.

For fruits and leaf vegetables that are harvested over a long period apply wood vinegar 2 or 3 times every 15-20 days starting just after the beginning of harvest time.

For fruit trees, once the fruits have reached mature size and start ripening – in the case of tangerines, just before they start coloration – apply wood vinegar 1 0r 2 times every 20 days until 15-20 days before harvest.

Guidelines on Use of Wood Vinegar: Concentrations

The generally accepted standard for applying wood vinegar is at a dilution of between 300-to-1 and 1,000-to-1. Concentrations under 300-to-1 can damage plants resulting in the following symptoms:

1. Spots on leaves;
2. Plant growth stops temporarily;
3. Growth is accelerated, delaying the maturing of fruit.

Symptoms 1 and 2 are a result of damage caused by the organic acid in wood vinegar. Symptom 3 is caused by wood vinegar's effect as a catalyst, accelerating metabolism and facilitating root absorption. In any case, wood vinegar should be applied to only a few plants on a trial basis and observed for 3 to 4 days before applying to the entire crop. It should be used with particular care on crops that are sensitive to agricultural chemicals and plants with soft leaves.

Synergism with amino acids, seafood by-products and other ingredients

To increase wood vinegar's crop-improving qualities, it can be mixed with seaweed, fish or shellfish extracts. This is particularly true of fish extract, which is high in amino acids, and is applied before harvesting. As mentioned above in the case of agricultural chemicals, using wood vinegar together with these other ingredients is more effective than using each separately. It is wood vinegar's effect of accelerating absorption through leaves and roots that is the basis for this synergistic relationship.

Other uses of wood vinegar include the following:

1. Soaking Dokudami (a strong-smelling perennial of the family Saururaceae: Houttuynia cordata) or garlic in wood vinegar and then applying it to plants can guard against insects.
2. Dokudami and vinegar can prevent lice infestation.
3. Wood vinegar with garlic can control mildew.
4. Herbs can be soaked in wood vinegar that the liquid used in the preparation of various health foods. This use of wood vinegar in food preparation has a patent in Japan.

How to use with agricultural chemicals

Agricultural chemicals (A.C.) are dissolved most easily and their effectiveness most enhanced if they are mixed into solutions of pH4-5. Therefore, mixing A.C. in solutions of wood vinegar diluted 500-1000 times makes the best use of these chemicals and allows the farmers to lower overall dosages. Many farmers in Japan have halved the amount of A.C. used, in this way. In addition there is no need for 'spreaders' – additives used to make the A.C. adhere better to leaves and plant surfaces – because the sticky tars and resins in wood vinegar serve this purpose. However as mentioned above, wood vinegar can't be used with alkaline A.C. such as lime-sulphur substances or bordeaux mixture.

How to use Wood Vinegar – Application to Soil

As part of soil amelioration:

By applying wood vinegar to soil, the following benefits can be obtained:

1. Damage by soil diseases and insects will be decreased.
2. Wood vinegar enhances the effectiveness of manure and fertilisers by making them easier for the plants to absorb.
3. Wood vinegar diminishes damage from excessive salt.

Of course, except for its effect on eelworm and plant wilt, wood vinegar used along has little immediate effect on soil quality. Rather, it should be used together with other inputs as part of an overall strategy of soil amelioration. This is especially true of soil that has ben degraded by years of bad cultivation techniques and an over-reliance on chemicals. Therefore, wood vinegar should be used together with other high-quality inputs of fertilizer, compost, clay-mineral

mixtures and agricultural chemicals as part of a long-term strategy to maintain soil quality.

Apply Wood Vinegar at least one week before planting

Just after applying wood vinegar to the soil, organic acid in the vinegar reacts with alkaline substances in the soil and generates carbon monoxide. Carbon monoxide is harmfl to organisms, although it has a germicidal effect. In higher quantities, it can damage plant roots, causing them to lose their absorptive capacities and, in the worst case, to lignify (turn to wood) or rot. Over time CO turns into CO2, depriving the soil of some of its oxygen. The influence of the CO remains in the soil for roughly one week, so planting should be postponed till roughly one week after applying wood vinegar. If wood vinegar is applied with 5 parts of charcoal, the damage mentioned above can be avoided.

High-quality, traditionally-produced wood vinegar can be used repeatedly with little danger of soil contamination or of acidification due to the build-up of residues. This is because components of wood vinegar generally break down in the soil within a month. Organic acids in wood vinegar, unlike sulphuric or hydrochloric acid, break down easily. As for pH, just after applying wood vinegar reduces pH by about 0.5. However, within a month it recovers to its former levels. Field trials have shown that if 10 litres of undiluted wood vinegar is applied to 1 cubic metre of soil, the following day pH returns to almost its former value, and after 4 or 5 days pH is completely restored.

The standard of concentration of wood vinegar

Compared with the concentration for spraying wood vinegar solution on leaves, the concentration for applying to soil should be higher. In general, the solution should decrease pH by more than 0.5. Higher concentrated solutions which

decrease pH by more than 0.5 should be avoided as they can shock plants and the soil. In Japan, for the purposes of soil amelioration, concentrations of 30-to-1 at quantities of about 6 litres per square meter are typically used. In order to sterilize soil, combat eel worm or soil diseases, or where residues from chemical fertilisers have built up, more concentrated solutions should be used. The general standard for sterilizing soil is that wood vinegar with a pH of 3 and a specific gravity of 1.014 should be diluted by 8 times. This solution should be applied at a rate of 1 liter per square meter. However, for eel worms, which can be particularly resistant to agricultural chemicals and which cause root knot, normally it takes 3-4 years of applying wood vinegar before they are eliminated.

For growing vegetables, spray the solution of 30-to-1 before planting at about 6 litres per square meter. The soil should be soaked to a depth of 50 cm. While this can most easily be done after plowing it may also be done before.

An important point in applying wood vinegar to soil is that for it to be most effective, it should soak well into the soil. The injection method is recommended. The easiest way to do this is to remove the nozzle of a power atomizer (an agricultural implement used to insert and disperse chemicals in the soil), set its pressure at 1-2 kg and insert it into the soil to a depth of 2-3 cm. The intervals between injection points should be 20-30 cm and extend the solution from the point to a 15cm radius.

Wood Vinegar used with Compost as a Soil Disinfectant

When using wood vinegar and compost together, compost should be spread on the soil before applying the wood vinegar. The reason for this is that wood vinegar may kill useful microbes (such as occurs when strong fungicides such as Chloropicrin are used). For this reason, compost should

be distributed first, then wood vinegar applied, and then both should be plowed in together.

Compost and wood vinegar should also be used only after soil disinfectants such as Chloropicrin are used. As wood vinegar improves soil quality after several years of use, soil disinfection will no longer be needed.

On land which is affected with eel worms, soil diseases or the build-up of salts, higher concentration solution, such as 5-10 to 1, should be used.

For fruit trees and potted plants

For fruit trees, irrigate 10 point around the tree where rain falls and many small roots are growing. Wood vinegar should be diluted 30-50 times and 500 litres per 1,000 square meter (10ha) should be applied.

For potted plants, mix wood vinegar with soil and let it sit 10-15 days to let the gas out of the soil before filling the pot. Mixing in 1% charcoal powder also improves oil quality.

Using charcoal soaked in wood vinegar

As mentioned above, using charcoal and wood vinegar produced from the same kind of wood multiplies the vinegar's effectiveness as a soil conditioner and an enzyme catalyst.

In the case of using charcoal and wood vinegar together, dilute the vinegar 5 times, sprinkle it on charcoal and let it soak in well. Since charcoal is very absorptive, in order to make the vinegar soak into it evenly, quite a large quantity is needed. After soaking, a chemical reaction between the charcoal and the vinegar will heat the charcoal and dry it. When the charcoal dries to the point where it leaves no moisture on your hands, it is roughly 20% wood vinegar and ready for use. When soaking vinegar into the charcoal, it is

not necessary to use crushed charcoal, but when applying it to the soil, it should be crushed.

If soaking charcoal with vinegar is too troublesome, charcoal can be spread on the soil alone first, and later sprinkled with wood vinegar. A wood vinegar concentration diluted 5-30 times should be sued. The charcoal/vinegar mixture should then be plowed into the soil.

Utilization for making compost

As mentioned above, wood vinegar accelerates composting, often doubling the rate of fermentation. This is especially true for pig and chicken manure. Due to the fact that fermentation occurs much faster and temperatures are higher, much attention should be paid to stirring, re-piling and watering the compost. This is particularly true for sawdust compost which contains much lignin. In the Japanese summer, for example, compost reaches a temperature of 80 degrees Celsius after 4 days with the help of wood vinegar.

In making compost use wood vinegar diluted 100 times and sprinkle it on the fermenting compost. Be careful not to use concentrations higher than this as it will sterilize the compost. The fermentation of the compost is complete when it acquires the sweet smell of ester.

http://www.dayonedesign.org/bio-char-kiln

Adding charcoal makes re-piling unnecessary

As the fermentation of compost proceeds oxygen is consumed and anaerobic decomposition takes over. However, anaerobic decomposition produces low quality compost. To avoid this, frequent stirring and re-piling is necessary. However, if 30% charcoal is mixed into the compost, such re-piling is unnecessary as the highly porous charcoal contains much oxygen. Additionally, mixing 10% powdered charcoal into compost accelerates the fermentation process.

Compost that has been treated with charcoal and wood vinegar is more able to prevent the propagation of bacteria which cause soil diseases such as fuzarium. At the same time, it accelerates the growth of actinomyces.

On the basis of this wood vinegar can help stimulate growth in plants that are growing poorly or that are developing abnormally with, for example, overly long stems. It can help plants that are not fruiting properly because of an excess of nitrogen or whose roots are damaged by high concentrations of accumulated chemical fertilizers. It can also prevent soil diseases and eel worm damage.

When crops are affected by diseases of the roots, apply wood vinegar diluted 100-200 times at the base of the plant so as to soak the oil to a 50cm depth. For tomato and cucumber, applying 1-2 litres of wood vinegar solution per plant at the base can improve the overall vitality of the plant by accelerating root development. In case of droop due to eel worm which causes root knot, you can see signs of recovery, in the earliest case, several hours after, and at worst, next day.

For potted plants, pour a solution diluted 200 times 2-3 times every 15-20 days after planting, combined with regular watering.

For rice, wood vinegar can counteract White Ear disease??? a disease resulting from excessive nitrogen levels. To apply the wood vinegar drain the paddy field and irrigate the field with 500 litres of a 30-to-1 solution. After two days, reflood the paddy with fresh water. This should be done in midsummer.

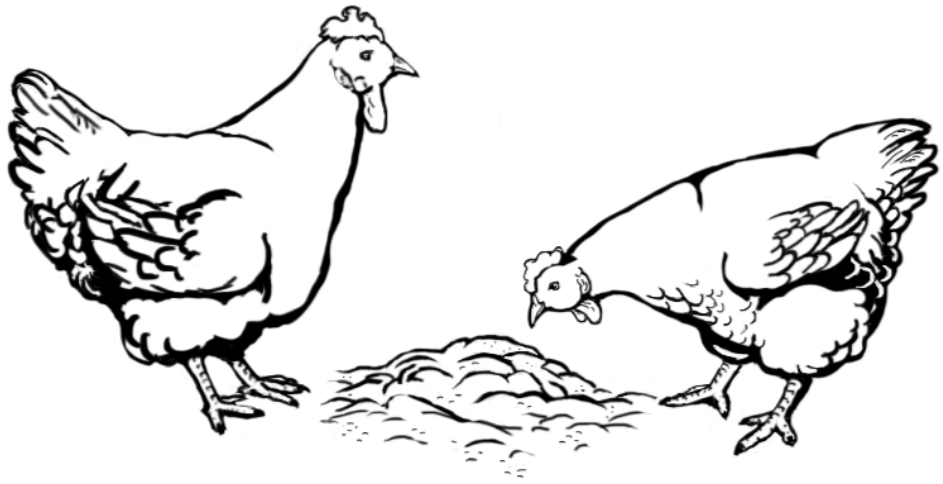
Wood vinegar as a Deodorizer or Livestock Feed Additive

Deodorizing manure

Wood vinegar has a strong deodorizing effect that can help cattle growers or dairy farmers troubled by complaints from neighbours about strong odours. Sprinkle a solution diluted 50 times on the manure and on the floor of the cowshed. Repeat as often as necessary.

As an additive to livestock and poultry feed

Wood vinegar can be used as an additive to feed. It has the effect of adjusting the bacteria in the intestines and facilitating absorption of nutrients. Experience in Japan has shown that adding wood vinegar to feed gives chicken meat a clear pink colour and lowers its water content to 3%, increasing the overall quality of the meat. In milk cows, wood vinegar helps prevent mastitis.



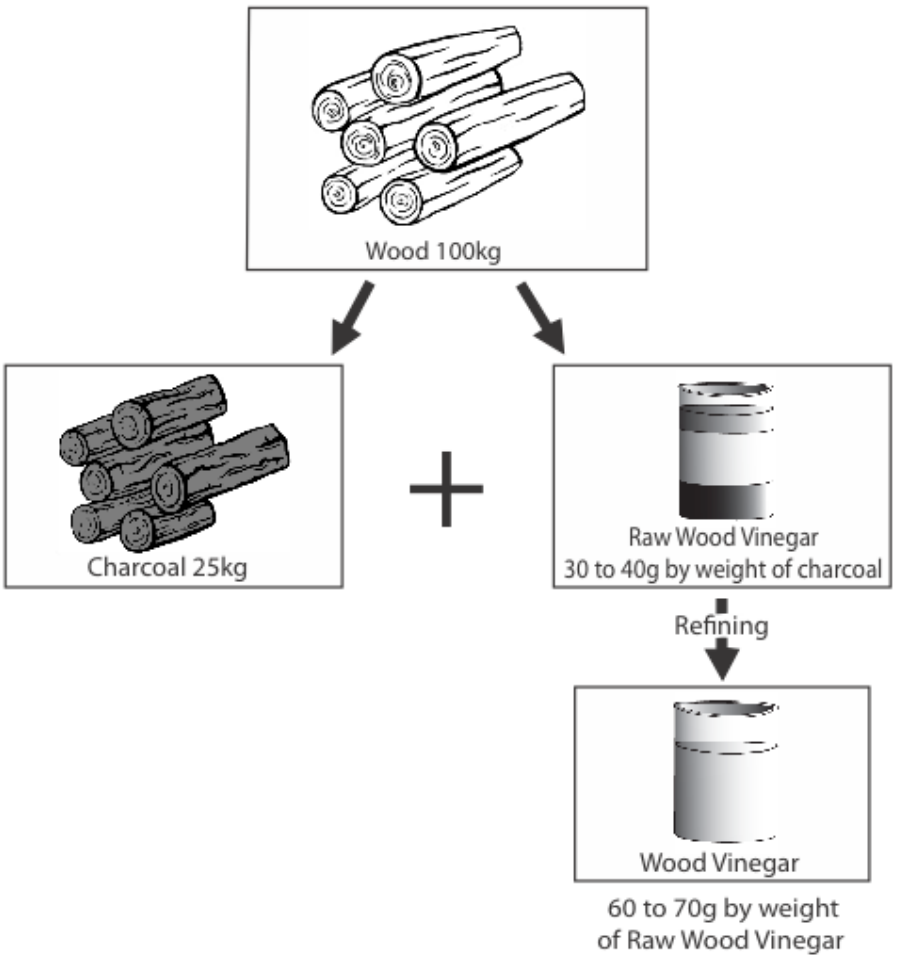
Only high-quality, refined wood vinegar collected from charcoal kilns should be used as an additive to animal feed. To mix it into the feed, let the wood vinegar soak into de-fatted rice bran or rapeseed oil residue. Then add it to the feed at the ratio of 99-to-1. This mixture is useful for most kinds of livestock.

AN EASY METHOD OF COLLECTING WOOD VINEGAR

How much Wood Vinegar can be Collected?

Fig. 10 shows how much wood vinegar can be collected in the carbonization process. Although the quantity depends on the water content of the wood and on the method of

collecting, generally the weight of charcoal is about 25% that of the original wood and the weight of the raw wood vinegar is about 30-40% that of the charcoal. After refining and removing tar and other impurities, the raw vinegar is reduced by another 30-40%



For example, 100kg of wood yields 25kg charcoal, about 8kg raw wood vinegar and 5 kg useable, refined vinegar. Given its specific gravity of nearly 1, this results in about 5 litres volume. In other words, if 200 litres of wood vinegar is needed, 400 kg wood must be used.

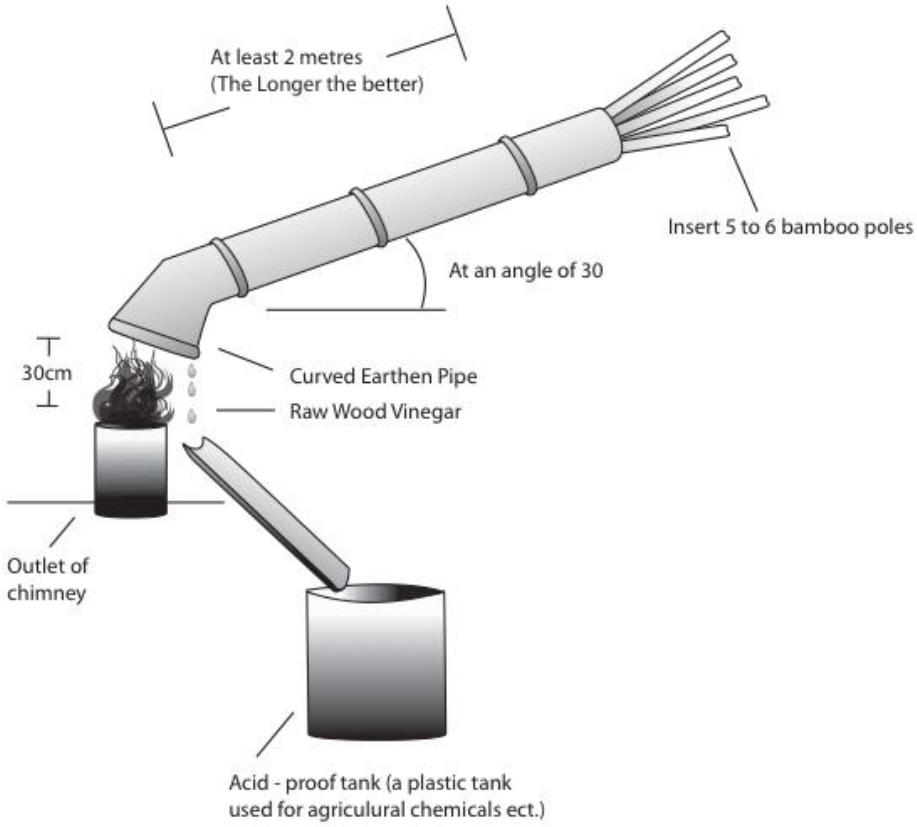
The easiest way to collect wood vinegar is by making charcoal in a drum can (which will be explained later). One firing, which needs about 60 kg wood and produces 15kg charcoal, will produce roughly 3kg, or 3 litres, of refined

vinegar. So 20 firings are needed to produce 60 litres wood vinegar.

Wood Vinegar Collectors

The basis principle for collecting wood vinegar is to use some sort of pipe and container to cool, condense and collect the smoke emitted in the carbonization process.

Fig.11 shows a very simple method for collecting wood vinegar.



1. Prepare an earthen pipe, a stainless steel plate, bamboo and a polyethylene tank such as those used as containers for agricultural chemicals. All of these implements should be acid-proof.
2. Install a large curved earthen pipe (about 24cm diameter, a size commonly sold in Japan) at the end of the kiln's chimney. Be sure to use a glazed pipe as unglazed pipes leak fluids. A stainless steel tube about

the size of a gutter or drainpipe cut length-wise can also be used.

3. Keep the collecting pipe about 30cm from the outlet of the smoke. If it is too near, the smoke will not cool quickly enough. If it is too far, much smoke will be lost.
4. Glazed earthen pipes can be used for the cooling pipe. In Japan “Moso-bamboo”, a thick, durable variety of bamboo, is also used.
5. The longer the cooling pipe, the more wood vinegar is collected, though about 2 meters is usually sufficient.
6. Install the cooling pipe at an angle of about 30 degrees. If the angle is gentler than this, the smoke is not easily drawn through. If it is steeper, smoke passes through too quickly to effectively collect vinegar.
7. Insert 5 to 6 bamboos of 4 meters in length or more into the cooling pipe. These bamboos serve to obstruct the smoke and provide more surface area on which to collect moisture.
8. Raw wood vinegar condenses on the inside surface of the cooling pipe and then flows down the pipe back toward the kiln. A bamboo conduit can be used to guide the liquid, as it drips out of the cooling pipe, into the collecting tank.

http://blog.agriculture.ph/tag/wood-vinegar-benefits

Collecting Time Depends on the Colour of the Smoke

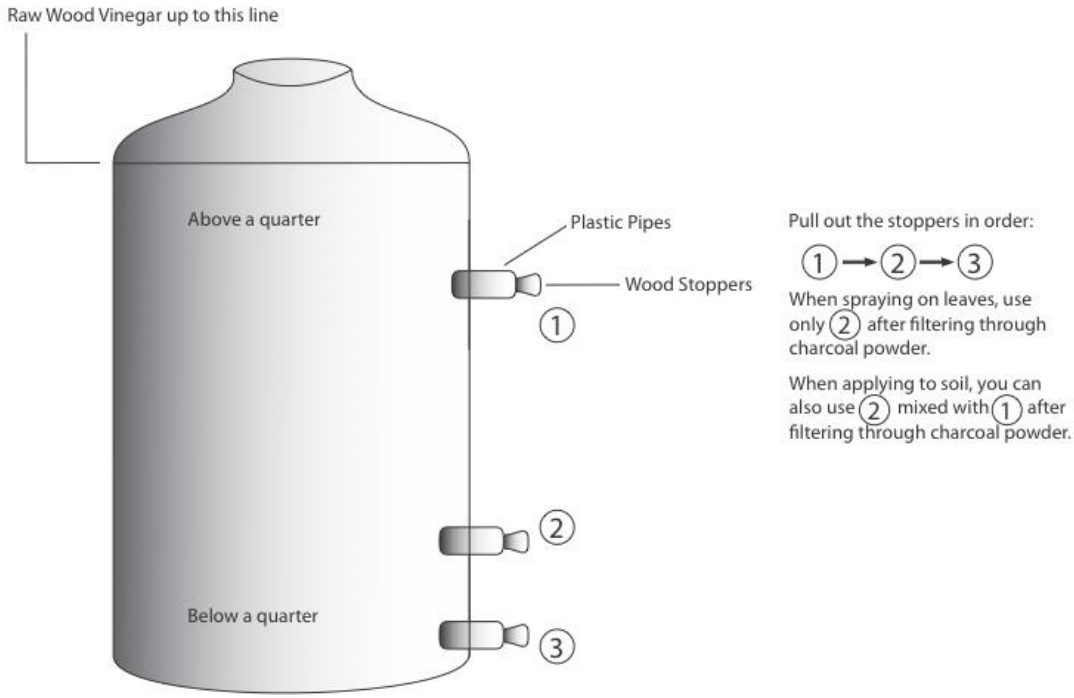
As mentioned above, when collecting wood vinegar it is important to pay attention to the colour of the smoke. As the temperature in the kiln rises, the temperature and colour of the smoke changes.

Collecting should begin when smoke temperature is about 82 degrees centigrade and the smoke is yellow. It should finish when the temperature reaches 150-180 degrees and the smoke turns bluish purple like the smoke of a cigarette. The white smoke emitted immediately after starting the fire should be avoided because of its high

moisture content and the high temperature purple smoke at the end of the carbonization process should not be collected because of its high tar content.

Refining Wood Vinegar

When refining raw wood vinegar, a vessel such as that shown in Fig. 12 is useful. This vessel should be about 100 litres in capacity and, like the other implements and containers use in making wood vinegar, it should be acid-proof. It should also be deep, at least three times the vessel's diameter. Drill holes in the vessel's wall at intervals as shown in the figure and insert acid-proof plastic pipe and stoppers in them.



After collecting, the raw wood vinegar should be kept still for more than one month in this vessel. After that time, it will separate into three layers: a light oil at top, the wood vinegar in the middle, and the wood tar at the bottom.

After the vinegar has separated, first pull out the top stopper and drain the light oil. (In the case of a wide-mouthed vessel, a ladle can be used). Then collect the

refined wood vinegar from the middle tap. Finally, drain the wood tar from the bottom tap.

For spraying directly on leaves, only the middle layer of wood vinegar should be used. However, in the case of applying directly to the soil, the top layer of oil and the vinegar may be used together. In both cases, the oil and the vinegar should be filtered by pouring them through linen or glass wool.

If the wood vinegar is further refined with powdered charcoal, it can be used with even greater assurance. In order to do this, add 2-5% powdered charcoal to the wood vinegar and mix well. At first, the wood vinegar will turn black, but after two days it will become transparent as the tar clings to the charcoal and sinks. Because it firmly traps the tar in its pored, the powdered charcoal can later be applied to the soil without any harmful effects.

How to Utilize the Light Oil and Tar

The easiest way to use the light oil and sticky tar that is left over after refining raw wood vinegar is to use them as a fuel. Both of them burn well because they are oily.

The tar can be filtered, diluted and then used as an odour eater. In addition, it can be used to repel centipedes and slugs by applying it to the ground around the house and covering it with soil. Neither the light oil nor the tar cause pollution because they decompose quickly.