A Practical Guide on Production and Application of Biochar and Bokashi to Rejuvenate Soil Health

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ICAC
INTERNATIONAL COTTON ADVISORY COMMITTEE

A practical Guide on Production and Application of Biochar and Bokashi to Rejuvenate Soil Health First Edition: June 2024.

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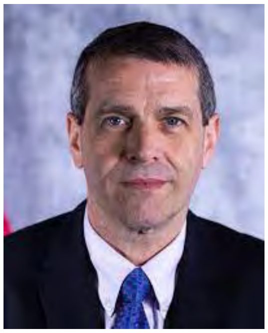

Foreword

Healthy soils play a central role in supporting plant, animal, and human life. The effects of poor soil health can gravely undermine the sustainability of agriculture, especially aggravated by other rising environmental stresses such as erratic water supplies. As land degradation accelerates in many vital agricultural producing regions, it is increasingly important to find effective ways not only to slow deterioration - but to begin the recovery of soils.

Fortunately, there are practical ways to address the soil quality challenge. In recent years, biochar and Bokashi have emerged as two highly effective methods available to rejuvenate soils. This manual, "A Practical Guide on Production and Application of Biochar and Bokashi to Rejuvenate Soil Health," is a comprehensive resource designed to equip farmers with the knowledge and techniques needed to harness these remarkable soil enhancements.

Biochar and Bokashi stand out due to their complementary roles in improving soil vitality. Biochar, a stable form of carbon, provides a hospitable environment for beneficial microorganisms, creating a thriving soil ecosystem while Bokashi serves as a rich source of these microorganisms and essential plant nutrients. This complementarity has another dimension: biochar's alkaline properties balance Bokashi's acidity, making them versatile and complementary tools for soil remediation. Farmers can use biochar to neutralize acidic soils, Bokashi to improve alkaline soils, or a mixture of both for soils with neutral or variable pH levels.

The methods discussed in this guide — particularly the open-earth-cone-pit method for biochar and the Bokashi techniques adapted for Africa by the International Cotton Advisory Committee (ICAC) — are not only effective but also implementable by smallholder farmers. These approaches are simple, easy to adopt, and can result in rapid improvements in soil health. By utilizing these techniques, farmers can expect improved yields and the added benefit of sequestering carbon in the soil, opening possibilities for possible future carbon credits by contributing to global climate resilience.

I congratulate Dr. Keshav Kranthi and Dr. Sandhya Kranthi for producing this valuable manual on behalf of the ICAC and believe it will be a valuable tool for farmers striving to adopt and maintain sustainable agricultural practices. By embracing biochar and Bokashi, we can restore the health of our soils, boost productivity, and secure a more sustainable and prosperous future for all.

-Eric Trachtenberg
Executive Director, ICAC

June 2024
Washington DC

Preface

Climate change poses a severe threat to agriculture, directly impacting our livelihoods and survival. Erratic rainfall patterns and global warming, consequences of climate change, make rainfed farming highly vulnerable to the risks of crop failures. The relentless increase in greenhouse gas emissions and our limited ability to enhance carbon sequestration have exacerbated these climate impacts, making the situation more dire with each passing day.

Over the past few decades, scientists have emphasized the urgent need for sustainable agriculture, focusing on strategies that reduce anthropogenic emissions and enhance carbon sequestration. These strategies aim to build climate resilience without compromising crop productivity. Among the various approaches, 'regenerative agriculture' has recently emerged as a promising concept. It encapsulates the core elements of sustainable farming, offering the potential to improve soil health and ecological biodiversity while fostering climate resilience.

The principles of regenerative agriculture lead to climate-smart practices that boost biodiversity and strengthen the symbiotic relationship between crops and beneficial soil organisms. These strategies enable soil biodiversity to thrive, which supports crop health and resilience, ultimately creating self-regenerative agricultural ecosystems. A vibrant biodiversity both above and below ground is crucial for self-sustaining agriculture, significantly reducing dependence on external inputs such as agrochemicals and machinery reliant on fossil fuels. This reduction in external inputs decreases anthropogenic emissions and enhances carbon sequestration through soil conservation practices like no-till farming, cover cropping, mulching, and organic amendments. Scientific evidence supports that practices such as zero-tillage or minimum tillage, cover crops, and biochar technology lead to enhanced soil carbon sequestration and improved soil health by fostering soil microbial life.

Biochar, a form of recalcitrant carbon produced by regulated pyrolysis of farm waste, offers numerous benefits. When added to soil, biochar reduces greenhouse gas emissions, improves soil structure, increases water retention, regulates soil pH, reduces erosion, enhances fertility and nutrient retention, and provides a habitat for soil microorganisms, thereby boosting crop yields. Fortifying biochar with compost further enhances soil health by inoculating the soil with microbial life and providing a balanced diet for crops and soil organisms.

Bokashi, an anaerobic fermentation method, rapidly converts farm waste into nutrient-rich compost in just 3-4 weeks, making it one of the fastest composting methods available. The application of biochar and Bokashi to soil holds immense potential for rejuvenating soil health and establishing a self-sustaining system that promotes long-term agricultural resilience.

With over 33 years of experience as agricultural scientists working closely with smallholder farmers—the most vulnerable to climate change—we have found biochar and Bokashi to be among the most accessible and effective solutions. These methods are simple, practical, feasible for small farms, and immensely powerful in rejuvenating soil health and increasing carbon sequestration. We have been training smallholder farmers worldwide on techniques to produce biochar and Bokashi from farm waste and applying them to fields to boost soil health. However, it is crucial to note that freshly produced biochar is highly alkaline, and freshly produced Bokashi is highly acidic. Therefore, their application must be managed *carefully to balance soil pH and rejuvenate soil health without causing adverse effects. While conducting training sessions, we always felt the need for an illustrative practical guide to assist farmers and trainees.*

With these considerations in mind, we have crafted this practical guide on the production and application of biochar and Bokashi to rejuvenate soil health. The guide includes numerous illustrations to facilitate understanding, particularly for practitioners in smallholder farms across India, Africa, Bangladesh, and many other developing and least-developed countries. We earnestly hope that farmers worldwide will enrich their soil health and increase crop yields through biochar and Bokashi composting, combat climate change, and contribute to carbon sequestration to mitigate its impact.

Keshav R. Kranthi
Sandhya Kranthi

June 2024. Washington DC.

ABOUT THE AUTHORS

Dr. Keshav R. Kranthi, Ph.D *is the Chief Scientist at the International Cotton Advisory Committee (ICAC), Washington, DC. Before joining the ICAC, he served as the Director of the Central Institute for Cotton Research (CICR) in Nagpur, India, from 2008 to 2017. Dr. Kranthi has thirty-three years of experience as a cotton scientist. He received a gold medal in his Ph.D. in 1991 and has been honored with more than a dozen awards, including the Best CPP Program Award for Research Leadership by the Renewable Natural Resources Research International, UK; the ICAC Researcher of the Year Award in 2009; the Vasantrao Naik Smruti Pratisthan Award in 2004; the ICAR National Award for Leader of Best Team Research in 2006; Fellow of the National Academy of Agricultural Sciences in 2009; the ISCI Recognition Award in 2010; Krishi Gaurav Award in 2010; Bhumi Nirman Award in 2011; ISCI Fellow in 2017; the Plant Protection Recognition Award in 2016 by the National Academy of Agricultural Sciences; and Suresh Kotak Global Cotton Award in 2023.*

Dr. Kranthi has four patents granted in South Africa, Mexico, China, and Uzbekistan, and six patent applications in India. He has published more than 100 peer-reviewed research papers, 15 books/handbooks/manuals, 17 book chapters, and more than 50 popular articles. Dr. Kranthi has presented invited talks, and conducted training sessions in more than 35 countries. His research citations exceeded 5,450 as of May 2024. As the chief principal investigator, he coordinated and led more than 30 externally funded research projects.

Dr. Sandhya Kranthi, *PhD, is an agricultural scientist with 33 years of experience in cotton research, technology development, and extension outreach programs. She began her career at the Central Institute for Cotton Research (CICR) in Nagpur, India, eventually becoming Principal Scientist and Head of the Crop Protection Division. In 2017, she moved to Washington, DC, to serve as Projects Consultant for the International Cotton Advisory Committee (ICAC), a position she held until June 2023.*

Dr. Kranthi's has extensive experience in insect physiology, molecular biology and integrated pest management (IPM). She has developed training curricula, manuals, field diaries, and digital training tools like virtual reality applications and mobile apps for scientists, students, extension workers, professional trainers, consultants, and farmers.

Dr. Kranthi has received numerous prestigious awards, including the Outstanding Woman Scientist Award from the Indian Council of Agricultural Research in 2008, an International Fellowship from the Japan International Cooperation Agency in 1996, the IARI Senior Research Fellowship for her PhD in 1987, and the Validandla Gold Medal and Hexamar Gold Medal for the highest OGPA during her Master's program in 1987. As a consultant and manager, Dr. Kranthi has trained trainers in eight African countries using both conventional and digital tools. Contracted by the International Trade Centre, she conducted training sessions in Zambia in March and April 2024, focusing on doubling cotton yields and promoting regenerative agriculture.

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INTRODUCTION

Soil health is fundamental to sustainable agriculture, and biochar and Bokashi have recently become prominent methods for enhancing it. This manual, "A Practical Guide on Production and Application of Biochar and Bokashi to Rejuvenate Soil Health," serves as an essential resource for farmers seeking to leverage these powerful soil amendments.

Biochar and Bokashi play unique yet complementary roles in soil improvement. Biochar, a stable carbon-rich material, fosters a supportive environment for beneficial microorganisms, creating a robust soil ecosystem. Bokashi, on the other hand, is a rich source of these microorganisms and essential nutrients for plants. Their combined use offers a balanced approach to soil remediation: biochar's alkalinity can neutralize acidic soils, while Bokashi's acidity can amend alkaline soils. Together, or in various proportions, they can be tailored to address soils with neutral or variable pH levels.

This guide details practical methods, such as the open-earth-cone-pit technique for biochar and Bokashi practices adapted for Africa by the International Cotton Advisory Committee (ICAC). These methods are not only effective but also accessible for smallholder farmers, promising rapid improvements in soil health. The use of these amendments can lead to increased crop yields and the added advantage of long-term carbon sequestration, opening avenues for carbon credit rewards and contributing to global climate resilience.

This manual is a vital tool for farmers dedicated to sustainable agriculture. By integrating biochar and Bokashi, we can revitalize soil health, enhance productivity, and pave the way for a more sustainable and prosperous future.

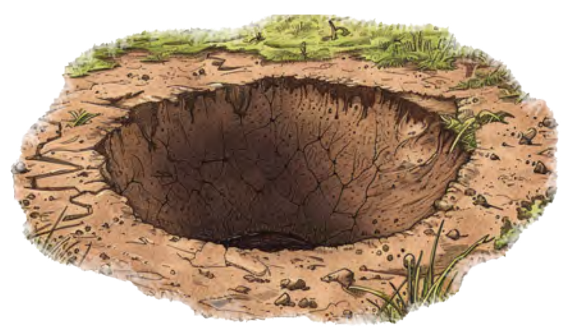
BIOCHAR

Biochar is a form of charcoal produced from organic materials through pyrolysis, a process that involves heating the biomass in the absence of oxygen. It is renowned for its ability to improve soil health by enhancing soil structure, increasing water retention, and promoting microbial activity. Additionally, biochar can sequester carbon, thus contributing to climate change mitigation.

Benefits of Biochar for Soil Health:

- Biochar improves soil fertility by providing a stable habitat for beneficial soil microorganisms thereby leading to improved crop yields and healthier plant growth.
- Biochar enhances nutrient availability for plants.
- Addition of biochar to soils increases the soil Cation Exchange Capacity (CEC)
- Biochar increases soil pH levels in acidic soils.
- The porous structure of biochar aids in retaining moisture and nutrients, making them more accessible to plants.

The ICAC Open Earth Cone Pit Method: The open earth cone pit method standardized by the ICAC is a simple and cost-effective technique for producing biochar, especially in small holder farms. This method involves digging a cone-shaped pit into the ground, filling it with dry organic material, and then igniting it. The shape of the pit promotes efficient pyrolysis by facilitating a steady flow of oxygen at the top while restricting it at the base, ensuring a thorough and even conversion of biomass to biochar.



Advantages of the Cone Pit Method: The cone pit method is advantageous over other biochar production techniques due to its low cost and simplicity, requiring no specialized equipment. Additionally, it minimizes the release of smoke and greenhouse gases compared to traditional open burning methods, making it a more environmentally friendly option.

Biochar Production Instructions

Materials

1

Shovel

2

Cone-pit

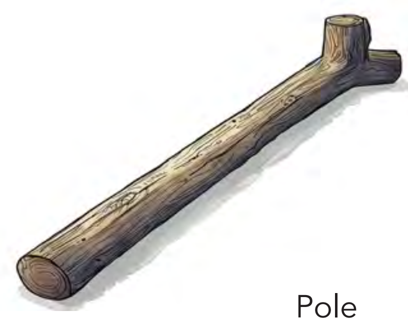
3

stalks

4

Matchbox

5



Pole

6,7

Water & drums

1. Shovel
2. Circular Cone-pit: 2 meters in diameter and 1.5 meters deep
3. Cotton stalks or dry stalks from any crop or weeds: Approximately 500 kg
4. Matchbox
5. Long thick pole: 2 meters long and 2-3 cm in girth
6. Water: 100-200 liters
7. Plastic drums: One or two (20 liters each) and two mugs

1. Digging the pit:

- Dig a circular conical pit, 2.0m in diameter and 1.5m deep.
- The area near the outer circumference of the pit should be bare and free of any organic matter that could catch fire. Lining the outer edge of the pit with stones is preferable to prevent the fire from spreading.

- Collect and pile 500 kg of dry stalks from crops like cotton, pigeon-pea, maize, sunflower or similar with stalks about 1.0cm to 2.0cm in girth.

- Place the pile of stalks about 2.0m away from the pit to prevent them from catching fire accidentally.

2. Stick Preparation:

- Break a few stalks into 30-40 small sticks, each about 30cm in length.
- Break the remaining stalks into medium-sized sticks, 50-60cm in length.

3. Building the Chimney:

- Arrange the small sticks in 7-8 layers at the bottom of the pit in a criss-cross manner to form a square chimney about 20-30cm high.

- Add dry hay, paper, dry maize leaves, or any dry organic material below the top layer of sticks in the chimney.

4. Ignition:

- Ignite the dry material from the top to minimize smoke.

- Avoid ignition from the bottom, which produces more smoke.

- Allow the chimney to burn until the topmost sticks turn red and the outer bark becomes grey ash.

5. Layer Addition:

- Gradually add sticks to the pit, covering the chimney fire completely with a fresh layer (first layer) of approximately 10-15cm.

- Push unburnt sticks from the outer edges to the center to ensure uniform burning.

- Wait until the first layer burns, with the topmost sticks turning red and with bark turning ash colored.
- Repeat the process, adding sticks to create subsequent layers (10-15cm each) and ensuring each layer burns properly until the topmost sticks turn red with outer bark turning ash colored before adding the next.

6. Completion:

- Continue adding layers until the pit is filled.
- Push any unburnt sticks to the center. Once the topmost sticks turn red with the outer bark turning ash colored,
- Douse the fire with 50-100 liters of water to fully extinguish it, converting the sticks to biochar.
- The fire can also be extinguished with soil in areas where water is unavailable.

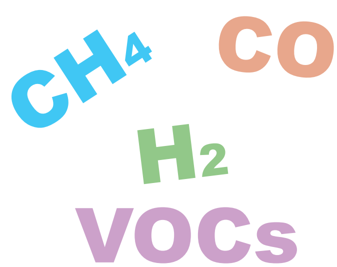
- Scoop out the biochar after 10-15 minutes to ensure no layers are still burning.

Key Principles

- **Conical pit:** The conical shape of the pit enables addition of layers of cotton stalks consequentially one above the other for each of the upper layers to completely cover the respective lower layers to prevent any entry of oxygen into the lower layer to enable incomplete combustion through anaerobic pyrolysis of the lower layers.

- **Top-Down Ignition:** This method of igniting the chimney for the top, reduces smoke by preheating and drying the wood below as the fire progresses downward, promoting more complete combustion. It maintains a steady oxygen supply, resulting in a longer, cleaner burn with less smoke production. Subsequently, as each layer of sticks is added from the top, fire rushes from the underneath layer into the central part of the upper layer first and then spreads to the periphery, thus creating a top-down ignition for each fresh layer.

- **Combustion:** Igniting sticks initiates complex chemical reactions, starting with water evaporation, followed by pyrolysis, where organic compounds decompose, releasing flammable gases such as methane (CH_4), carbon monoxide (CO), hydrogen (H_2), and volatile organic compounds (VOCs). These gases mix with oxygen and ignite, producing heat and light.



- **Layering:** Adding sticks in layers ensures the lower layers are deprived of oxygen, slowing pyrolysis and preventing complete burning to ash. This process retains most of the carbon in the stalks, forming biochar.

- **Pyrolysis:** The freshly added upper layer catches fire and burns in the presence of oxygen, which heats the stalks in the layer to release pyrolytic gases which burn thus generating more heat. This process of burning is allowed only to a point when the bark of the stalks in the upper layer is just about to turn into ash, but the inner part of the stem has released gases due the heat, but with most of the carbon still being intact.

JEEVAMRIT

Introduction

Jeevamrit is a traditional Indian bio-fertilizer. This natural concoction helps to multiply soil microorganisms by incubating an inoculum of forest soil in a solution containing molasses/jaggery, cattle urine, cattle dung, legume flour and water.

1

Cattle urine

2

Cattle dung

3

Healthy soil

4

Jaggery or Molasses

5

Legume flour

6

Water

Ingredients

1. Cow/cattle urine: 500ml
2. Cow/cattle dung: 1-2Kg
3. Forest soil (healthy soil): 100g
4. Jaggery (200g) or Molasses (400ml)
5. Legume flour: 200g
6. Water: 20 litres in a bucket/drum

Mixing Ingredients:

Add 20 litres of water

- Start by filling the container with 20 liters of water.
  - Add 1.0Kg of fresh cow dung to the water.
  - Stir the mixture thoroughly to ensure the dung is well-dissolved.

Add 1.0 Kg dung

Stir well

Pour 500ml of cow urine.

Add 400ml of molasses

Add 200g legume flour

Add handful of healthy soil.

Stir the mixture well

Cover with cloth

- **Pour 500ml of cow urine** into the container. Mix well with the dung solution.
- **Add 200g of jaggery or 400ml of molasses**. Jaggery or molasses act as microbial feed, enhancing the growth of beneficial microorganisms. Stir until the jaggery is completely dissolved.
- **Add 200g of pulse/legume flour** to the mixture. The pulse flour provides additional nutrients necessary for microbial growth.
- **Add a handful of healthy soil** from the farm. This introduces native beneficial microbes to the mixture.
- **Stir the mixture well** to ensure all ingredients are evenly distributed.
- Cover the container with a cloth to prevent debris from falling in while allowing air exchange.
- **Place the container in a shaded area to ferment for 48 hours**. Stir the mixture at least twice daily to aerate it and promote microbial activity.
- After 48 hours, your Jeevamrit is ready for use
- **Storage:** Use the prepared Jeevamrit within 7 days to ensure microbial activity remains high. Store it in a shaded, cool place if not used immediately.
- **Safety Precautions:** Wear gloves and protective clothing while handling cow dung and urine. Wash hands thoroughly after preparation and application.

BOKASHI COMPONENTS

Bokashi is a method of anaerobic fermentation to convert organic biomass waste into excellent compost in the shortest possible time of about 2-4 weeks. Bokashi composting utilizes a blend of microorganisms called 'Effective Microorganisms (EM1) developed by Dr Teruo Higa, for converting various farm wastes, including green leaves, weeds, and cattle dung, into nutrient-rich compost. These microorganisms are used to accelerate the composting process, enhance soil fertility, and promote plant health. This manual provides a step-by-step guide for multiplying EM-1 and preparing 'EM-1 Bokashi bran' which can then be used to prepare Bokashi compost.

EM-1 Solution

The consortium of effective microorganisms (EM-1) is mainly comprised of beneficial microorganisms such as photosynthetic bacteria, *Rhodopseudomonas* species, lactic acid bacteria, *Lactobacillus* species, Actinomycetes, beneficial bacteria, fermentative fungi and yeasts, *Saccharomyces* species. EM-1 solution can be used for direct soil application, foliar sprays, liquid composting systems, or soaking biochar before its application to the soil or to boost traditional composting processes.

- **Lactic Acid Bacteria:** These bacteria are known for their ability to ferment organic matter and produce lactic acid. They contribute to breaking down complex compounds in the organic material and creating a more acidic environment that helps preserve nutrients and inhibit the growth of harmful pathogens.
- **Yeast:** Yeasts are microorganisms that play a role in fermentation and breakdown of sugars. They contribute to the production of enzymes and organic acids that aid in decomposition.
- **Photosynthetic Bacteria:** These bacteria are capable of photosynthesis, which means they can convert light energy into chemical energy. They contribute to the production of various compounds that benefit plant growth.
- **Actinomycetes:** Actinomycetes are beneficial bacteria that contribute to the decomposition of tough organic materials, such as cellulose and lignin. They produce enzymes that break down complex organic compounds.
- **Fermentative Fungi:** Certain fungi are involved in the fermentation process, helping to break down organic matter and release nutrients.
- **Beneficial Bacteria:** In addition to the specific types mentioned above, EM-1 often contains a mixture of other beneficial bacteria that contribute to the overall health of the composting process and soil ecosystem.

Multiplication of EM-1 solution & Bokashi Bran

Preparing EM-1 Solution

Materials

1. EM-1 (commercially available) -1 part
2. Jaggery or Molasses - 2 parts
3. Water (chlorine-free) - 20 parts
4. Plastic container & measuring cups
5. Stirring stick
6. pH strips

1 EM-1

2 Jaggery or Molasses

3 Water

4,5 Containers, mugs & stick

6 pH papers

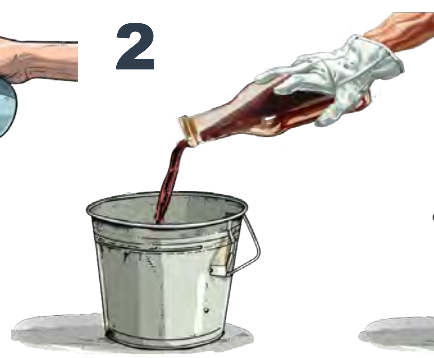
Procedure:

- **Measure the required amounts** of EM-1, molasses, and water based on the ratio 1:2:20. For example, to multiply 100 ml of EM-1, you will need 200 ml of molasses and 2 liters of water.

1

Add water

2



Add molasses

3

Add EM-1

4

Seal the container

1. **Pour the chlorine-free water i**nto the container. Chlorine can harm the beneficial microorganisms, so if using tap water, allow it to sit uncovered for 24 hours to dissipate the chlorine or use filtered water.
2. **Add the molasses to the water.** Stir thoroughly.

3. **Add the EM-1 to the molasses-water mixture**. Stir well to ensure even distribution of the microorganisms.
4. **Seal the container with the lid,** leaving a small gap for gas exchange or use an airlock if available. This prevents the build-up of pressure during fermentation.

- **Place the container in a warm, dark place.** The ideal temperature range is between 20°C to 30°C (68°F to 86°F).
- **Allow the mixture to ferment for 7 to 10 days.** Stir the mixture once daily to promote even fermentation and prevent settling of solids.
- During fermentation, **monitor the pH level** if possible. A pH of around 3.5 to 4.0 indicates successful fermentation.

Storage:

- After the fermentation period, the multiplied EM-1 solution is ready for use. It should have a sweet-sour smell.
- Transfer the solution to smaller containers if necessary, and store it in a cool, dark place. The multiplied EM-1 can be stored for up to 6 months if kept properly.

Preparing EM-1 Bokashi Bran

EM-1 Bokashi bran is best suited for composting of wet organic farm biowaste such as freshly chopped green leaves or weeds, wet cow dung, kitchen waste etc.

Materials

1 EM-1

2 Jaggery or Molasses

3 Bran

1. EM-1 (commercially available) - 1 Litre
2. Jaggery (1 Kg) or Molasses - 2 Litres
3. Bran (rice, wheat, maize or any grain) -28 Kg

Materials

4 Water

5,6 Containers, mugs & stick

7 pH papers

4. Water (chlorine-free) - 20 Litres
5. Clean plastic container with a tight-fitting lid
6. Measuring cups and stirring stick
7. pH strips

Procedure

1

Mix bran with EM-1

2

Ensure that the bran is evenly wet

3

Place the bran in a container

1. **Mixing:** Mix bran (wheat, rice, or other types) with the multiplied EM-1 solution. The ratio is typically 1 liter of EM-1 + 2 liters of EM-1solution + 20 litres of water + 28 kg of bran.
2. **Moisture:** Ensure the bran is evenly moist but not too wet. The above recipe results in an ideal moisture content at around 30% to 40%.
3. **Anaerobic Fermentation:** Place the moistened bran in an airtight container or bag and allow it to ferment for 3 to 4 weeks.

PREPARING BOKASHI COMPOST (100 Kg)

Bokashi compost can be created from organic farm waste using heavy-duty plastic trash bags, air-tight plastic drums, or cubical pits lined with plastic. This manual outlines a method utilizing plastic trash bags, which can be adapted to plastic drums or pits depending on container volume.

Mandatory Materials

1 Trash bags

OR

Plastic drums

OR

Cubical shaped pits

2,3 Green leaves & Machete/Axe

4 Straw

5 EM-1

6 Molasses

7 Water

1. Plastic trash bags >100 litres capacity: 2
   or Plastic drums or cubical pits (1 x 1 x 1 Metres)
2. Green Leaves or Weeds: 50 kg (finely chopped)
3. Chopper or Machete: For chopping leaves or weeds
4. Other Biomass (e.g., straw, crop residues): 17 kg
5. EM-1 Solution: 1 liter
6. Molasses: 2 liters
7. Water (chlorine free): 17 liters

Additional, Optional Materials

8. Bokashi Bran: 8 kg (prepared using EM-1)
9. Cattle Dung: 17 kg (fresh)
10. Forest soil (undisturbed healthy soil): 0.5 Kg
11. Plastic Sheet or Tarp: For mixing
12. Shovels or Pitchforks: For mixing compost
13. Measuring Cups: For EM-1 and molasses
14. Buckets / drums: For mixing EM-1 solution
15. pH Meter or Strips

8 Bokashi bran

9 Cattle dung

10 Healthy soil

11 Plastic sheet

12 Shovel

13 Measuring cups

14 Drums & buckets

15 pH papers

Procedure

1 Two layer trash bags

2 Chop the green leaves

3 Mix EM-1+Molasses

4 Add water & stir well

5 Add dung, straw, healthy soil & bokashi bran

6 Mix well

1. Place one trash bag into the other so that the bag becomes two-layered for additional strength.
2. Finely chop 50 kg of green leaves or weeds. The smaller the pieces, the faster the composting process.
3. In a bucket, add 1 liter of EM-1 with 2 liters of molasses.
4. Add 17 liters of chlorine-free water to the mixture. Stir well to ensure the molasses are completely dissolved.
5. Spread the 50 Kg chopped leaves or weeds, 17 kg of cattle dung, 17 kg of other biomass (e.g., straw, crop residues) and 0.5 Kg of forest soil on a plastic sheet or tarp. Sprinkle the 8 kg of Bokashi bran evenly over the mixture.
6. Using a shovel or pitchfork, mix the Bokashi bran thoroughly with the other materials.

7 Add EM-1

8 Check moisture

9 Add biochar at bottom of the 2 layered trash bag

10 Add the organic green mix to the 2 layered bag

10 Cross section of the bokashi bag with biochar as bottom layer

7. Gradually sprinkle the 20 litres EM-1 solution over the mixture of leaves, cattle dung, biomass, and Bokashi bran while continuously turning the material to ensure even distribution.
8. The mixture should be moist but not soaking wet. The ideal moisture content is around 30-40%. To test, take a handful of the mixture and squeeze it. It should hold its shape without dripping excess water.
9. Add 5-6 Kg biochar at the bottom of the 2-layered plastic bag or any container that will be used for Bokashi composting. The biochar soaks excess water that will be released during the process of Bokashi fermentation.
10. Pack the thoroughly mixed organic material into airtight containers or bags. Compress the material to remove as much air as possible, as anaerobic conditions are essential for Bokashi composting.

11 Press the contents & seal the plastic bag tightly

12 Store the bag under shade

11. Seal the containers or bags tightly to prevent air from entering.
12. Store the containers or bags in a shaded, cool place for 3-4 weeks to ferment. During this period, beneficial microorganisms will break down the organic material. After 3-4 weeks, the Bokashi compost is ready for use. It may have a sweet-sour smell and should appear well-decomposed.
13. Optionally, monitor the pH of the compost. A pH around 3.5-4.0 indicates successful fermentation.

Application of Jeevamrit, EM-1, Bokashi and Biochar

- **Jeevamrit:** Freshly produced Jeevamrit has a pH of about 6.5 to 7.0.
- **Bokashi and EM-1:** Freshly produced Bokashi and EM-1 are acidic, with a pH of 3.5 to 4.0.
- **Biochar:** Freshly produced Biochar is alkaline, with a pH of 8.0 to 11.0.
- **Soil pH Range:** Soil pH can range from acidic (3.5) to alkaline (10.0)

Application Recommendations:

- **Jeevamrit** can be directly applied to the soil or used as a microbial inoculum in either aerated composting or in Bokashi.
- **EM-1 & Bokashi:** Unless the soil is alkaline, direct application of freshly produced EM-1 and Bokashi compost to the soil, especially near the root zone, can harm plants due to their extreme acidity.
- **Biochar:** Similarly, unless the soil is highly acidic, direct application of freshly produced biochar to the soil can harm plants due to its extreme alkalinity.
- **Biochar-Compost:** Therefore, it is important to neutralize the pH of these materials by preparing biochar-compost before applying them to the soil. Biochar-compost can be applied either before sowing, at sowing time, or near the root zone of plants at the seedling stage.

MEASURING pH

Soil Acidity and Alkalinity Testing

Soil pH plays an important role in nutrient availability to crops. It is crucial to know the pH of the soil and materials such as Jeevamrit, EM-1, Bokashi, or biochar that are proposed to be used for soil amendment. A simple pH test can bedone using pH litmus papers. However, if pH papers are unavailable, household materials such as white vinegar and baking soda can be used to get an idea of the soil's acidity or alkalinity.

Measuring pH Using pH Paper strips

Measuring the pH of soil, Bokashi compost, EM-1, and biochar helps to calculate the proper ratios of these materials before they are mixed and applied into the soil to achieve a desired pH of 6.5, which is suitable for crops such as cotton, soybean, maize, and beans.

Soil Sampling: Collect 8 to 10 soil samples in a zigzag pattern from different locations in the field, digging a small conical 'V' shaped pit 15 cm below the soil surface.

Spread the soil on a clean surface and remove any stones, pebbles, roots, grass, and organic debris. Mix each sample well and spread it over a newspaper, allowing it to dry for at least 24 hours.

Measuring pH of soil, biochar and Bokashi: Add 2 to 3 spoonfuls of the sample (soil or biochar or Bokashi) into a teacup. Add water approximately equivalent to the volume of the soil sample. Crush the sample in the water using clean fingers. Stir the mixture well with a spoon, mixing about 8 times at 3-4 minute intervals. Let the sample stand for 3-4 minutes. Dip a litmus pH paper into the still liquid and compare the color of the strip with the standard chart to determine the pH of each sample. Calculate the average pH of the soil samples by adding their pH values and dividing the total by the number of samples.

Measuring pH of EM-1 or Jeevamrit: Pour 4 to 5 drops of jeevamrit or EM-1 liquid into a plastic lid. Dip a litmus pH paper into the liquid and compare the color of the strip with the standard chart to determine the pH of the sample.

PH test using Household Materials

It is possible to get an idea of the soil's acidity or alkalinity using white vinegar and baking soda. This method will provide an indication of whether the soil is acidic, neutral, or alkaline.

Testing for Alkalinity: Add 2 to 3 spoonfuls of soil into a teacup. Add half a cup of white vinegar to the soil sample. If you observe bubbles in the sample, it means that the soil is alkaline. The more it fizzes, the higher the alkalinity of the soil.

Testing for Acidity: Add 2 to 3 spoonfuls of soil into a teacup. Add 2 to 3 spoonfuls of baking soda into a separate teacup. Add half a cup of water to the baking soda and mix well to dissolve. Add the baking soda solution to the soil. If you observe bubbles in the sample, it means that the soil is acidic. More bubbles or fizz means higher acidity of the soil.

Preferred soil pH: Cotton prefers a soil pH range of 6.0 to 7.0. Crops such as beans, maize, and soybean prefer a soil pH of 5.5 to 7.0. Thus, a slightly acidic pH of 6.5 is considered ideal to ensure optimal nutrient availability and uptake, promoting healthy growth and high yields.

Formula for Estimating Quantities:

$$\text{Desired resultant pH of the soil (6.5)} \quad \frac{P1xQ1 + P2xQ2 + P3xQ3}{Q1+Q2+Q3}$$

Where:
P1 = pH of biochar (obtained from pH paper test)
P2 = pH of Bokashi (obtained from pH paper test)
P3 = pH of the soil (obtained from pH paper test)
Q1 = Proportion of biochar
Q2 = Proportion of Bokashi
Q3 = Proportion of soil

To estimate the relative proportions of the materials to be mixed with biochar, keep the proportion of biochar as Q = 1 and estimate the relative proportions of the other materials required to achieve the desired pH of the biochar-compost.

Mix the materials in the relative proportions obtained from the calculation. For example, if the results show that Q1=1.0, Q2=2.5 and Q3=3.0, mix the materials in the proportions of one part of biochar with 2.5 parts of Bokashi and 3 parts of soil.

BIOCHAR-COMPOST

Freshly prepared biochar is highly alkaline (pH 8.0 to 11.0) and freshly prepared Bokashi is highly acidic (pH 3.5 to 4.0).

Direct application of freshly prepared biochar or Bokashi compost to the soil without understanding the soil pH may result in undesirable effects.

Therefore, these materials must be neutralized before they are applied to the soil.

It is recommended to mix Bokashi compost with biochar and soil in proportions depending on the pH of the soil and the ingredients such as biochar and Bokashi biochar before application to the soil.

Materials to prepare biochar-compost

1. pH Test
2. Bokashi and biochar
3. Jeevamrit solution
4. EM-1 Solution
5. Labourers

1 pH test

2 Bokashi and biochar

3 Jeevamrit

4 EM-1

5 Labourers

Preparation of Biochar-Compost based on Soil pH

Estimating the pH of the soil, Bokashi compost, and biochar makes it possible to calculate the relative proportions of these materials to be mixed to create a desirable pH of 6.5 of biochar-compost before the mixture is applied to the soil.

Where pH is known: Where pH can be measured using pH papers, prepare biochar-compost by mixing biochar with Bokashi and soil in proportions as obtained from the equation provided in this manual. Soak the mixture of the biochar-compost heap with a solution of Jeevamrit diluted 1:20 times with water. Incubate the biochar-compost heap for about 7-10 days after which it is ready for use either before or after sowing.

Where soils are acidic: Mix freshly prepared biochar with an equal quantity of topsoil excavated from the top 30 cm anywhere in the field. If available (optional), mix one part of Bokashi to the mixture. Heap the mixture under the shade of a tree. Soak the biochar-compost heap with water, EM-1 solution, or a diluted solution of Jeevamrit (one part of Jeevamrit plus 20 parts of water). Generally, 50 liters of the solution will be adequate to soak a 100 kg mixture of biochar-compost. Incubate the biochar-compost heap for about 7-10 days after which it is ready for use.

Where soils are alkaline or soil pH is unknown: Mix freshly prepared Bokashi with an equal quantity of topsoil excavated from the top 30 cm anywhere in the field. To this mixture, add one part of biochar. Heap the biochar-compost mixture under the shade of a tree. Soak the biochar-compost heap with water, EM-1 solution, or a diluted solution of Jeevamrit (one part of Jeevamrit plus 20 parts of water). Generally, 50 liters of the solution will be adequate to soak a 100 kg mixture of biochar-compost. Incubate the biochar-compost heap for about 7-10 days after which it is ready for use.

Soil Application of Biochar-Compost

Biochar-compost mixed into the top-soil or incorporated into rows before sowing.

Before Sowing: Five tonnes of biochar-compost mixture can be incorporated into the topsoil (15 cm) or incorporated into rows in one quarter of a hectare any time before sowing. This process can be repeated for 5 consecutive years to significantly improve soil health.

Sowing seeds into biochar-compost

Band application of biochar-compost

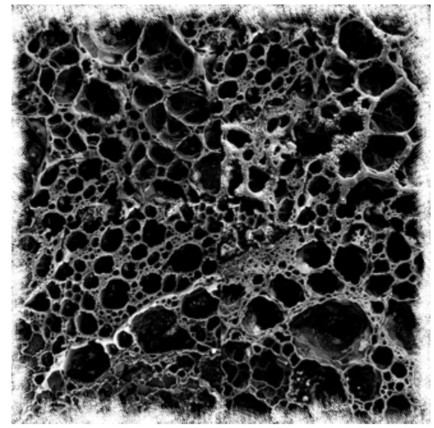
At Sowing Time: Take one tonne of biochar-compost to be applied in one quarter of a hectare. Drop 2-3 fistfuls of the biochar-compost into each seedbed pocket in a row and thrust one or two seeds about 1.5 cm deep into the biochar-compost.

Seedling Stage (5 to 40 days after sowing): Apply one tonne of biochar-compost in a quarter of a hectare as a band incorporated into the soil 8-10 cm away from the base of the plants in a row, near the root zone of seedlings. Additionally, for better results, spray a solution of EM-1 or Jeevamrit on the soil as a band 8-10 cm next to the row of cotton seedlings.

BENEFITS OF BIOCHAR-COMPOST

Adding biochar-compost to soil offers numerous benefits, including:

1. **Improved Soil Structure:** Biochar enhances soil aeration, drainage, and root penetration by improving soil texture.
2. **Increased Water Retention:** The porous nature of biochar retains moisture in the soil, to reduce the impact of drought.
3. **pH Regulation:** Biochar can help neutralize soil pH, making it more suitable for plant growth, especially in acidic soils.
4. **Reduced Soil Erosion:** Biochar helps bind soil particles together, reducing erosion caused by wind and water.
5. **Increased Crop Yields:** The improved soil conditions foster healthier plant growth, often resulting in higher crop yields.
6. **Enhanced Nutrient Retention:** Biochar adsorbs nutrients, preventing them from leaching away and making them available to plants over time.
7. **Microbial Activity Boost:** Biochar-compost provides a habitat for beneficial soil microorganisms, enhancing microbial activity and soil fertility.
8. **Carbon Sequestration:** Biochar sequesters carbon, helping mitigate climate change by storing carbon in a stable form in the soil.
9. **Reduced Greenhouse Gas Emissions:** By promoting soil carbon storage and reducing the need for synthetic fertilizers, biochar helps lower greenhouse gas emissions from agriculture.



Biochar is porous like sponge

Biochar-compost fosters microbial diversity and activity.

10. **Reduction of Soil Contaminants:** Biochar can adsorb heavy metals and other contaminants, reducing their availability to plants.
11. **Enhanced Soil Fertility:** Biochar-compost improves the cation exchange capacity (CEC) of soil, making it easier for plants to access nutrients.
12. **Long-term Soil Health:** Biochar remains stable in soil for long periods, providing ongoing benefits to soil health and fertility.

Utilizing biochar and Bokashi represents the simplest and most effective methods for swiftly remediating soils, bolstering soil health and structure, while also transforming farm waste into high-quality Bokashi-Biochar compost abundant in carbon and nutrients. This approach not only enriches soil but also advocates for sustainable agricultural practices.