Nature-Positive Farming
& Wholesome Foods Foundation (N+3F)

Resource Book on Do-It-Yourself (DIY) Bioformulations in Agriculture

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a. **To support farming communities, farmers organizations (FOs), NGOs, and other agencies** to evolve, establish, and scale-up context-based N+FFS, leading to elimination of the use of synthetic chemical pesticides.
b. **To facilitate the development of regional/territorial and national value/supply chains** for safe, pesticide-free wholesome foods.
c. **To build a knowledge base, serve as a resource organization, and create an enabling environment** for nature-positive farming and wholesome food systems.
d. **To promote equality and social inclusion in N+FFS** by engaging with vulnerable sections like small farmers, Dalits, tribals, women, youth, and consumers with low purchasing power.

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Cover page: Maa Ghantasoni PG members of Janamukti Anusthan (JMA) preparing bioformulations in one of the small-scale Bio Resource Centre supported by N+3F

Chapter 1:

Introduction to Do-It-Yourselves Bioformulations in Agriculture

Bioformulations are an integral part of alternate agricultural methods, including organic farming, natural farming and Non-Pesticidal Management (NPM) of agriculture. A considerable number of Do-It-Yourself (DIY) bioformulations are being promoted in India. Some of the bioformulations like *Panchakavya, Sasyakavya and Kunapajala* were in vogue many few centuries ago, and are have reached us through ancient documents like Vrikshayurveda. There are few, other bioformulations which were used as part of traditional agriculture. These old bioformulations are being revived or reintroduced among the farming community by various agencies realising their relevance and value for sustainable agriculture. Further, many new formulations were developed recently by various actors, including pioneers of alternate agriculture like Dabholkar (Natueco farming), Subash Palekar (Zero Budget Natural Farming), and Deshpande (Rishi Krishi), research institutions (like waster decomposer) and innovative farmers (like CVR technology). Some bioformulations developed in other countries, like the bioformulations that are part of Korean Natural Farming promoted by Cho Han Kyu and Jadam Natural Farming developed by Youngsang Cho, are also being promoted by some of the actors.

These DIY bioformulations can be broadly classified into biostimulants and biopesticides. According to gazette notification S.O. 882 (E) on 23 February 2021 “biostimulant” means a substance or microorganism or a combination of both whose primary function when applied to plants, seeds, or rhizosphere is to stimulate physiological processes in plants and to enhance their nutrient uptake, growth, yield, nutrition efficiency, crop quality, and tolerance to stress, regardless of their nutrient content, but does not include pesticides or plant growth regulators (Suresh K Malhotra, 2022). While this definition is more suitable for biostimulants of industrial origin, the primary function mentioned applies to DIY biostimulants as well. With the user perspective in mind, this document further classifies the DIY biostimulants into i) Soil fertility enhancers, ii) Formulations for seed treatment, iii) Growth promoters, and iv) broad-spectrum formulations. Biopesticides refer to products containing biocontrol agents, natural entities or chemicals produced from natural materials (such as animals, plants, bacteria, or specific minerals). These agents may also include their genes or metabolites. The FAO defines biopesticides as passive biocontrol agents compared to those that actively seek out the pest, such as parasitoids, predators, and numerous types of entomopathogenic nematodes. In this document, biopesticides are classified into a) Botanicals and b) Non-botanicals based on their ingredients.

Given the multiple ways in which these DIY bioformulations have proven to contribute to crop growth, they need to be promoted for wider adoption by a large number of farmers. Besides individual farmers, these bioformulations can be easily produced and marketed by SHGs and local entrepreneurs in rural areas, creating space for the development of the local economy.

It was observed that while considerable efforts have been taken by NGOs and other development agencies to promote these DIY bioformulations, their adoption has been limited, indicating the need for large-scale efforts. Even when adopted by the farmers, only a few bioformulations are adopted, and that too with a limited understanding of their mode of action and suitability. There is a need to

build the knowledge and capacity of farmers and the staff of promoting agencies on the different categories of DIY bioformulations, their main ingredients, the mode of action of the ingredients or formulations, and effective ways to use them. In the last two decades, considerable research has been taken up on the prominent bioformulations that shed light on the mode of action and effects on crop growth, including the suppression of pests and diseases. Farmers, and NGOs and other agencies working with farmers need to be aware of the results of these research initiatives so that they can use bioformulations more effectively. This resource document developed by Nature-Positive Farming and Wholesome Foods Foundation (N+3F) attempt to fill these gaps.

This document builds on the experience of N+3F in promoting wider adoption of DIY bioformulations and small-scale Bio Resource Centres among the small holder farmers in the remote rural locations in Central, Eastern and Southern India. It was developed to give a broader understanding of DIY bioformulations in terms of their major ingredients and how they work by pooling the available research results and knowledge and offering them to stakeholders in an easy-to-understand way. This document also attempts to help the readers get a specific understanding in terms of details of preparation, storage, uses, and application methods. It is organised into two sections. The Chapter 2 offers an overview of ingredients, preparation methods, mode of action and utilisation of different types of DIY bioformulations (DBFs). The Chapter 3 describes the production, handling, application methods, and research results pertaining to specific bioformulations.

We expect that this document will be useful to staff of FPOs and NGOs/CSOs, individual farmers, and entrepreneurs involved in the production and utilisation/marketing of bioformulations in getting to know the basic details and research results of important bioformulations in one place. We also expect that the details given in this document will help them improve the methods of preparation of these bioformulations and the ways in which they are utilized. We will be updating this document periodically. We welcome your suggestions and additional details for improving this document.

Chapter 2:

Overview of ingredients, preparation methods, mode of action and utilisation of DIY bioformulations (DBFs)

The contribution of bioformulations to crop performance is to a large extent determined by the constituents, mode of action and potential uses of their major ingredients, and method of preparation. Therefore, in this chapter, an attempt has been made to pool information from various published studies on the major ingredients used for preparing DIY bioformulations listed in Chapter 3. The pooled information is presented in three tables. In Table 1, the classification of DIY bioformulations based on their purpose, the ingredients used for preparing them and the method of preparation are presented. In Table 2, salient features of various ingredients pooled from various studies are presented. The details shared include the constituents of these ingredients, their mode of action and contributions to crop performance, the bioformulations made with them, and the studies referred to. In Table 3, elaborate details about the plants used for making plant-based biopesticides are presented. Table 3 is a supplementary document for Table 2, as it gives expanded details for a category of ingredients mentioned in Table 2. Going through this information together, the reader can get an idea of why certain sets of ingredients are used and why a particular method of preparation is deployed for a specific bioformulation, given its main purpose. Besides helping in understanding the functional features of DBFs listed in Chapter 3, this information on the salient features of ingredients will aid a farmer, field worker or entrepreneur in getting to know which bioformulations can be used for meeting specific crop needs and how need-based bioformulations can be made. The reader can also get a glimpse of the 'One health' perspective[1], as many of the ingredients used in the bioformulations are also used for the improvement of animal and human health.

While only brief information is given about the ingredients in this Chapter 2, readers can access more information on them by going through the ingredientwise references. The information given in this chapter is limited by the set of studies referred to as there could be many more studies on the ingredients considered. Furthermore, in Chapter 2, only ingredients that are used in the bioformulations listed in Chapter 3 are covered. There could be many other DIY bioformulations that are not listed in Chapter 3 and correspondingly, there could be many other ingredients that are not covered here. We look forward to the readers contributing to the addition of any left out relevant information on the ingredients covered and the addition of new DIY bioformulations and their ingredients. The information given in this chapter will be updated periodically.

1. Ingredients in bioformulations

It can be seen from Table 1 that the bioformulations are prepared using commonly available ingredients relevant to their function or use, namely, *seed treatment, soil fertility enhancement, growth promoters, biopesticides, etc*. These ingredients can be broadly classified into two categories, namely I. Ingredients that contribute to crop performance and II. Ingredients used for the preparation of bioformulations. More focus in this chapter is given to the first category. The first category can be further classified into the following sub-categories: 1) Products sourced or derived from domesticated

[1] One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes that the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent.

animals (cattle, sheep, goats and poultry), 2) Products derived from plants, 3) Plants and plant parts, 4) Dead animal

Photo: Sorting raw materials required for preparation of Bioformulations

Table 1: Details of ingredients of DIY bioformulations and their method of preparation

S.No.	Type and name of bioformulations	I. Ingredients that contribute to crop performance																						II. Ingredients that aid in preparation of bioformulations						Method of preparation								
		1. Products derived from domesticated animals										2. Products derived from plants						3. Plants and plant parts			4. Dead animal parts		5. Composts		6. Products other than those from plants and animals							Fermentation						Extraction using extractant		
		Cowdung	Cow urine	Cow milk	Curd	Ghee	Cowdung manure	Cowdung cake	Goat manure	Poultry manure	Egg	Oilseed or Mahua cake	Turmeric powder	Asafoetida	Ash	Neem/ Pongamia oil	Castor/ cooking oil	Plants with nutrients	Plants with biopesticidal properties	Plant parts rich in metabolites	Flesh and bone marrow of animals with horn	Fish	Compost	Vermicompost		Jaggery	Pulse/Basan powder	Banana/fruits	Boiled smashed	Cooked rice	Detergent	Aerobic	Anaerobic	Solid state	Mixing	Sprouting & grinding	Decoction-Boil and extract	E with cattle urine	E with water	E with alcohol
1	**Biostimulants**																																					
1.1	**Soil fertility enhancers**																																					
	Sanjeevak/Amrithpani	■	■																							■						■								
	Ghanajeevamruth	■	■																							■	■							■						
	Bakramruth								■			■			■																			■						
	Pranamruth									■		■			■																			■						
	Gajaramrith		■															Parthenium							Alum, Rocksalt												■		
	Fermented liquid plant fertiliser																	Available plants								■							■						
	Jadam Microbial Solution																								Soil, salt				■				■						
1.2	**Formulations for seed treatment**																																					
	Beejamruth	■	■				■	■					■		■										Soil, Lime								■						
	Beejraksha		■										■	■	■										Soil								■						
	Seed coating for bold seeded crops	■	■				■								■										Termite mound soil	■							■						
	Cow urine		■																																			
	Cow milk			■																																			
1.3	**Growth promoters**																																					
	Shri Amrith/ Saptadanyankur tonic																								Pulses, wheat, black sesame										■			
	Fish amino acid																					■				■						■						
	Fermented Plant Juice																			Mugwart/ water amaranth/ Bamboo shoot						■						■						
	Oriental Herbal Nutrient (OHN)																		Ginger, Garlic	Cinnamon, Licorice, Angelica						■						■						■
	Uplamrith/Gibberlic acid							■																									■						
	Egg amino acid										■								Lemon							■					■								

1.4	**Broad spectrum biostimulants**			
	Jeevamrutha			Soil
	Panchagavya		Tender coconut	
	IMO (Here or soil fer enhancer?)			
	Kunapajala			Honey
	Dasagavya	Neem, Vitex, Leucus asper, Lantana, Datura, Calotropis, Jatropa, Adanthoda	Tender coconut	
	Compost tea			
	Vermiwash			
2	**Bio-pesticides**			
2.1	**Botanicals**			
2.1.1	**Primarily bio insecticides**			
	Single plant product			
	Neemastra	Neem leaves		
	Neem bioenzyme	Neem leaves		
	Neem seed kernal extract	Neem kernals		
	Vitex decoction	Vitex		
	Tobacco decocction	Tobacco		
	Mahuastra	Mahua		
	Onion kashayam	Onion		
	Datura leaf extract	Datura		
	Thutikada Kashayam (ipomea solution)	Ipomea		
	Ocimum kashayam	Ocimum		
	Lantana preparation	Lantana		
	Turmeric extract			
	Chunastra			Lime, Kerosene
	Asafoetida formulation			

	Multiplant products			
	Agniastra		Neem Tobacco Chilly Garlic	
	Brahmastra		Neem, Datura, Pongamia, castor, custard apple,	
	Dashparni ark		Tobacco, Chilli, Garlic, Ginger, Neem, Pongamia, Datura, Castor, Vitex, Lantana, Nerium, Casia, Hibiscus, Mahua	
	Handi katha		Neem, Pongamia, Calotropis	
	Sarva Keetanashi	Parthenium	Neem, Calotropis, Ipomea, Ocimum, Custard, Chilly, Garlic	
	Panch patti kada		Neem, Pongamia, Datura, Calatropis, Sapota	
	Chilli Garlic solution		Chilli Garlic	Kerosene
	Char chatni		Ginger, Chilli, Garlic, Onion	
2.1.2	**Primarily antimicrobials (manages diseases)**			
	Sothastra		Ginger	
	Stone apple leaf extract		Stoneapple leaves	
2.2	**Non botanicals**			
2.2.1	**Primarily bio-insecticides**			
	CVR technique			Soil
2.2.2	**Primarily antimicrobials (manage diseases)**			
	Katta matta (spoiled buttermilk)			
	COY			

parts, 5) Composts, and 6) Products other than those from plants and animals. It can be seen that while many Indian bioformulations use cattle-based ingredients, many of the bioformulations used in Korean Natural Farming do not use cattle-based products. While some of these ingredients contribute in multiple ways to crop performance (like cow dung and cow urine), a few others contribute in one or two specific ways (like the anti-viral properties of asafoetida). Let us try to understand the salient features of these ingredients in the following paragraphs.

Ingredients that contribute to crop performance

1) Products sourced/derived from domesticated animals

In this sub-category, cattle-based products are the most commonly used ones. It is observed from Table 2 that many studies indicate that cattle dung contributes in an impressive variety of ways to crop performance, given its chemical components and large consortia of microbes. These include: i) nutrient supply, ii) increasing the availability of soil nutrients to the plants, iii) biocontrol, iv) immunity boosting, and v) growth promotion. The wide variety of microbes present in the dung helps in the replenishment of soil and plant microbiomes, which in turn contribute to crop performance in terms of building soil fertility, biocontrol and boosting immunity. So, many bioformulations that focus on soil fertility enhancement, like *Sanjeevak, Jeevamruth*, etc., exploit this potential.[2] Some of the products derived from dung, namely manure and dung cake, are also used in some of the preparations (*Uplamirth*). Cattle dung cake serves as a substrate for solid state fermentation by microbes that results in the production of gibberellic acid, a growth promoter very useful for crops.

Cattle urine is also widely used for the preparation of various types of bioformulations, as it contributes in multiple ways to crop performance, given its chemical components and broad anti-pathogenic activity. It supplies minerals, enzymes and trace elements, besides major nutrients. It serves as a disinfectant and prophylactic, aiding in preventing major crop diseases. Besides being an ingredient useful for crop performance, it also helps in preparing plant-based bioformulations as it aids in extracting the bioactive primary and secondary metabolites from the plant parts.

While cattle dung and urine are the most commonly used ingredients, other cattle-based products like milk, curd and ghee are also used in some of the preparations. Milk is used for seed treatment as it helps in inducing early germination, breaking dormancy and increasing seedling vigour. It also helps in controlling some diseases, like vein clearing disease and powdery mildew. While curd contributes in multiple ways to crop growth as it has a wide range of nutrients, various species of lactic acid bacteria and anti-microbial compounds, it is mainly used for its ability to promote growth and control diseases. Cow ghee had been used in ancient and medieval times (Kautilya 321-296 BC and Someshwara Deve 1126 AD) for managing seedling health. The ghee contains vitamin A, vitamin B, calcium, fat and glycosides. It is a wonder how these cattle-based products offer a wider array of benefits for crop performance when bioformulations blend all of them together, as evidenced in the case of *Panchagavya* and *Dasagavya*. It is also a wonder how materials with contrasting characteristics, like cow dung which is rich in microbes and cow urine which has anti-pathogenic properties, when combined, result in bioformulations useful in many ways rather than offsetting each other's effectiveness.

[2] The presence of common microbes as part of soil, plant and cattle microbiomes in a way demonstrates the 'One health' principle.

Table 2: Major ingredients of DIY bioformulations and their contributions to crop performance

S. No.	Major ingredients	Constituents	Modes of action and contributions to crop growth	References	Agricultural use and the related bioformulations
1	**Products derived from domesticated animals (cattle, sheep, goat and poultry)**				
1.1	**Dung**	Cowdung has a consortium of beneficial microorganisms (almost 60 species of bacteria (i.e. Bacillus sp., Lactobacillus spp., Corynebacterium spp.), fungi (i.e. Aspergillus, Trichoderma), 100 species of protozoa and yeasts (i.e. Saccharomyces and Candida)) which helps in inoculation of the soil; This enhances the population of beneficial microbes in the soil and crop spheres; Has macro and micro nutrients	**1) Nutrient supply**- CD based bioformulations has a high amount of macro-and micro-nutrients which helps meeting the nutrient requirments of crops; **2) Increasing the availability of soil nutrients to the plants**- Phosphorus(P) solubilization, zinc mobilization and sulphur oxidation were documented; **3) Biocontrol**- counteracting the fungal and bacterial pathogens and some insects; **4) Immunity booster; 5) Growth promotion**- The microbiota of CD promote plant growth by regulating nutritional and hormonal balance, produce plant growth regulators/phytohormones - IAA, cytokinin, Gibberellin, kinetin; which results in enhanced growth of roots and shoots, leaf area, chlorophyll content and photosynthetic activity.	Sudhanshu and Ray, 2021 Kartikey et al., 2016 Shinde and Malshe., 2015 Thanuja et al., 2019 Shakuntala et al. 2012 Srinivas et al., 2009	**1) Seed treatment-** Bijamrutha, Bijaraksha **2) Soil fertility enhancer:** Ghanajeevamruth **3) Growth promoter:** Umplamurth **4) Broadspectrum use:** Jeevamruth, Sanjeevak, Panchakavya, Dasakvya, Handikhata

1.2	**Urine**	Cattle urine contains nitrogen, sulphur, phosphate, sodium, manganese, iron, silicon, chlorine, magnesium, maleic, citric, tartaric and calcium salts, vitamin A, B, C, D, E, minerals, lactose, enzymes, creatinine, hormones and gold acids.	**1) Nutrient supply-** Supplies 1.0 per cent nitrogen traces of P2O5 and 1.0 per cent of K2O; **2) Growth promoter:** Cow urine spray resulted in improvement in the growth and productivity. The protein and carbohydrate content found in seedlings sprayed with cow urine was more; **3) Seed growth enhancement:** Significant early germination and increase in germination percentage observed when seeds are soaked in cow urine; **4) Disease suppression and control:** It serves as a disinfectant and prophylactic; It helps in killing the pathogens; Inhibits seed borne disease like fruit rot and die back	Bakang and Modiri, 2020 Shinde and Malshe, 2015 Yawalker et al., 1996 Kamalam and Rajappan, 1989 Chawla, 1986 Ramani, et al., 2012 Aniket and Rahul, 2017 tnau.ac.in Savita et al., 2015 Ambika et al., 2014	**1) Seed treatment**-Bijamrutha, Bijaraksha, Seed coating **2) Soil fertility enhancer:** Ghanajeevamruth **3) Broadspectrum use:** Jeevamruth, Sanjeevak, Panchakavya, Dasagavya, Handikhata
1.3	**Milk**	Amino acids, fat, proteins and salts (such as oxalate, sodium bicarbonate and tribasic or dibasic potassium phosphate); lactoperoxidase and lactoferrin which play a role in controlling powdery mildew	**1) Seed growth enhancement:** Early germination, Increases seedling vigour, Harmones present in milk helps relieves Photo, thermo and physiological dormancy in seeds; **2) Disease control:** Reduces vein clearing disease, Milk had protective and curative properties against powdery mildew	Adelani and Bello, 2016 Sadiqur et al., 2021 Sreelakshmi and Manoj, 2023 https://agritech.tnau.ac.in/ Al-Naseri et al., 2014 Kamel and Afifi., 2020	**1) Seed treatment:** Raw cow milk **2) Broadspectrum biostimulants:** Panchakavya, Dasagavya, Kunapajala **3) Biopesticides:** Sothastra

1. 4	**Curd**	Curd contains several nutrients and micronutrients, including water, proteins, vitamins like A, B, D, and E; minerals like calcium, phosphorous, magnesium, zinc, etc. Various species of lactic acid bacteria (LAB) such as Lactobacillus spp Anti-microbial compounds and effective substances such as lactic acid, bacteriocins, hydrogen peroxide and carbon dioxide were produced by LAB	**1) Seed growth enhancement:** Diluted curd helps to maintain the neutral pH for seed germination **2) Induces nitrogen fixation** when pulses are treated with curd **3) Growth promoter:** LAB produces metabolites which promote plant growth and stimulate shoot and root growth **4) Disease control:** LAB has antagonistic effect against phytopathogens, inhibiting fungal and bacterial populations in the rhizosphere and phyllosphere **5) Induces fermentation**	Vanavil 2021 Raman et al., 2022 Sumit and Neelam, 2020 Bajaj et al., 2022	**1) Broadspectrum use:** Panchagavya, Dasagavya **2) Biopesticides:** Katta matta
1.5	**Ghee**	Vitamins: A D E & K Essential fatty acids: Omega 3 and Omega 9 Calcium and glycosides	**Seed and seedling growth:** Cow dung was used with ghee and honey in ancient times for treating seeds; Ghee was used for inducing seedling growth	Bajaj et al., 2022 Shivakumar, 2014 Rakesh et al., 2013	**1) Broadspectrum use:** Panchagavya, Dasagavya
1.6	**Dung cake**		Solid state fermenting cowdung produce gibberlic acid which stimulates the growth of plant effectively	El Sheikh et al., 2020	**1) Growth promoter:** Uplamruth
1.7	**Goat manure**	Has 3% N, 1% P2O5 and 2% K2O, small amounts of Zn, Cu, Mo, Co, B, Mn and Fe	**Nutrient supply-** both macro and micro nutrients	Batubara et al., 2021 Awodun et al., 2007	**1) Soil fertility enhancer:** Bakramruth
1.8	**Poultry manure**	Has Nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo)	**Nutrient supply-** both macro and micro nutrients	Amanullah et al., 2010 Renu Kumari et al., 2022 https://agritech.tnau.ac.in/org_farm/orgfarm_poultry.html	**1) Soil fertility enhancer:** Pranamrutha

1.9	**Egg**	Protein: Albumin (Ovalbumin, Conalbumin, Ovamucoid, Ovomucin, Avidin), Yolk (Lipoproteins, Iron and Zinc) Enzyme: Lysozyme Vitamins: A B C and D Nutrients: phosphorus, calcium, potassium, and contains moderate amounts of sodium Trace elements: copper, iron, magnesium, manganese, selenium, and zinc	**1) Nutrient supply:** P, Ca and K **2) Disease control:** triggers permeabilization and bacterial death (lysozyme, avian beta-defensins, etc.); Lyzozyme in egg acts against bacteria, fungi and viruses; Cystatin in egg acts against bacteria, fungi, viruses and parasites **3) Induces flowering**	Godbert et al., 2019 Aishwarya R Nair, 2022 Karthika et al., 2017	**1) Growth promoter:** Egg amino acid **2) Biopesticide:** Cooking oil and Yolk
2	**Products derived from plants**				
2.1	**Oil cakes (edible)**	Nutrients, Aminoacids and minerals	**Nutrient supply:** Supplies Nitrogen, Phosphorus, potassium, protiens and aminoacids,		**1) Soil fertility enhancer:** Bakramruth, Pranamurth
2.2	**Oil cakes (non-edible)**	Bioactive compounds depending on the plant like Neem oil cake; Pongamia oil cake	**Insect and disease suppression and control:** Supress soil borne pests and diseases and plant based pests and diseases		**1) Biopesticides:** Pongamia cake, Neem cake, Castor cake
2.2	**Asefoetida**	Typical asafoetida contains about 40–64% resin, 25% endogeneous gum, 10–17% volatile oil, and 1.5–10% ash. The resin portion contains asaresinotannols A and B, ferulic acid, umbelliferone and four unidentified compounds. The volatile oil component is rich in various organosulphide compounds, such as 2-butyl-propenyl-disulphide, diallyl sulphide, diallyl disulphide (also present in garlic) and dimethyl trisulphide. The organosulphides are primarily responsible for the odour and flavour of asafoetida.	**1) Disease control- Antibacterial, anti-fungal and anti viral:** Protect the crop from blight, effectively control leaf curl in tomato and chilli; Presence of Sulphur (Di-sulphide) in Asafoetida makes this solution as a fungicide as well as bactericide **2) Insect control**: White fly reduction in cotton	agritech.tnau.ac.in GKVKs.com, 2021 Abdul et al., 2016 https://keralaagriculture.gov.in/ https://en.wikipedia.org/wiki/Asafoetida	**1) Seed treatement:** Beejaraksha **2) Biopesticide:** Cow Dung, Cow Urine & Asafoetida Mixture

2.3	**Turmeric powder**	Turmeric powder is about 60–70% carbohydrates, 6–13% water, 6–8% protein, 5–10% fat, 3–7% dietary minerals, 3–7% essential oils, 2–7% dietary fiber, and 1–6% curcuminoids. Phytochemical components of turmeric include diarylheptanoids, a class including numerous curcuminoids, such as curcumin, demethoxycurcumin, and bisdemethoxycurcumin. Some 34 essential oils are present in turmeric, among which turmerone, germacrone, atlantone, and zingiberene are major constituents.	**1) Disease control**- Antimicrobial: Extracts used for treating fungi in maize seeds; Protection against fungal rot and wilt; induces immunity; extracts of C. longa (Murthy et al., 2015) and C. amada inhibited bacterial wilt caused by Ralstonia solanacearum in tomato; inhibit the growth of Xanthomonas axonopodis pv. manihotis, which causes cassava spot disease **2) Storage pest management:** Found effective against many storage Storing seeds	Alsahli et al., 2018 Technical Bulletin-4 organic farming https://en.wikipedia.org/wiki/Turmeric Pandey et al., 2021 Alka Rani, 2017	**1) Seed treatement:** Beejaraksha **2) Biopesticide:** Onion Kasayam, Turmeric extract
2.4	**Ash**	Wood ash is composed of many major and minor elements that plansts need for growth. Calcium is the most abundant element in wood ash and gives ash properties similar to agricultural lime. Ash is also a good source of potassium, phosphorus, and magnesium. In terms of commercial fertilizer, average wood ash would be about 0-1-3 (N-P-K). In addition to these macro-nutrients, wood ash is a good source of many micronutrients needed in trace amounts for adequate plant growth.	**1) Nutrient supply:** Both macro and micronutrients; Since most of these elements are extracted from the soil and atmosphere during the plant's growth, they are common in our environment and are also essential in production of crops and forages. **2) Disease control:** Reduces the moisture content preventing growth of fungi; **3) Insect control:** Desicates the insects by absorbing water; Inhibits ovi-position of insects directly on the seeds	Martin et al., 2022 Kuba et al. , 2008 Bougnom et al., 2020 Sreelakshmi and Manoj, 2023 Mark Risse, 2013	**1) Seed treatment:** Beejaraksha, Seed coating **2) Soil fertility enhancer:** Bakramruth, Pranamruth

2.5	**Neem oil**	Azadirachtin (Azadirachtin A), Nimbidiol, 3-tigloylazadirachtol (Azadirachtin B), Salannol, Salannin, Nimbinin, Nimbin, Nimbidin, and 1-tigloyl-3- acetyl-11-hydroxymeliacarpin (Azadirachtin D) non volatile compounds are the major once. Further, sulfur modified fatty substance like loeic acid (50–60%), palmitic acid (13–15%), stearic acid (14–19%), linoleic acid (8–16%) and arachidic acid (1–3%) are present in neem seed oil.	**1) Insect control:** Antifeedent, Anti repellent, supress ovulation **2) Disease control:** Antifungal: against powdery mildew **3) Nematode control:** Acts against Root knot nematode **4) Storage pest control**	Bond et al., 2012 Campos et al., 2016 Swapna sonale et al., 2018 Nature neem	**Biopesticide:**Chunastra
2.6	**Pongamia oil**	Oil has a high content of triglycerides, and its disagreeable taste and odor are due to bitter flavonoid constituents including pongamol, karanjin, karanjachromene and tannin.	**1) Nutrient supply:** Rich Source of NPK **2) Insect control:** Insecticidal and Larvacidal activities	Purkait et al., 2021 Kumar and Singh, 2002 Usharani et al., 2019	**Biopesticide:**Chunastra
2.6	**Cooking Oil**	Saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), palmitic acid (C16:0; 4.6%–20.0%), oleic acid (C18:1; 6.2%–71.1%) and linoleic acid (C18:2; 1.6%–79%), respectively, were found predominant. phospholipids, free sterols, tocopherols, and tocotrienols, triterpene alcohols, hydrocarbons, and fat-soluble vitamins in small amounts Micro and macro nutrients such are S, Zn, B,, N: 5.1- 5.2%, P: 1.8, -1.9% and K: 1.1-1.3%	**1)vNutrient supply:** good growth and higher yield with better quality in some of the fruit crops **2) Disease control:** controls powdery mildew and aphid transmitted viruses. Sigatoka disease of banana caused by Mycosphaerella musicola **3) Insect control:** oils block the air holes (spiracles) through which insects breathe, causing them to die from asphyxiation. Spider mites, whiteflies and young stages of scales are common pests that can be controlled by oils during the growing season **4) Storage insect control:** vegetable oils effect egg laying as well as	Jin jee et al., 2009 Jana Orsavova et al., 2015 Guidoni et al., 2019 Dayeswari et al., 2019 Cranshaw and Baxendale, 2013 Anurag Singh et al., 2012	**Biopesticide:** COY

			embryo and larvae development on the surface of the seed. In some cases female insects are able to lay eggs, but the hatching of the larvae is prevented by the oil		
3	**Parts of plants and animals**				
3.1	**Plants rich in nutrients**	Macro nutrient: Nitrogen, Potassium, calcium Micro nutrients: Magnesium, Copper, Zinc, Iron and Manganese	**Nutrient Supply:** Nutrients present in different plant parts of easily available plants	Katarzyna et al., 2021 Jang and Yong., 2019 Sebastián González Amat, 2022	**1) Soil fertility enhancer**: Liquid Plant Fertilizer
3.1.1	**Parthenium**	**Nutrient content;** Nitrogen (2.54%), Phosphorous (0.44%), Potassium (1.23%), Zinc(13.9 ppm), Manganese (161.2 ppm), Iron (528.3 ppm) and Copper (9.0 ppm). **Insecticidal property:** Parthenin, Dehydroleucodine and Rishitin **Weed control:**phenolic compounds (flavonoids, phenols, coumarins, carboxylic acids, benzoic acids)	**1) Nutrient supply:**Supplies higher quantities of N, P, K, Fe, Mn, Cu and Zn for Crop growth **2) Insect control:**Presence of phenolic acids will have tremendous effect on sucking pests; Effective against Spodoptera litura and Aphis craccivora and cowpea weevil (a storage pest) **3) Nematicidal:** Effective against root knot nematode 4**) Weed control**: Dry leaf powder causes wilting and desication of salvinia, water lettuce and water hyacinth	Prem Kishore et al., 2010 Mahesh et al., 2014 Irfan et al., 2022 Seema patil, 2011 Bashar et al., 2021 P.Biradar et al., 2006 Motmainna et al., 2021 Datta and Saxena, 2001 Reddy et al. 2018	**1) Soil fertility enhancer:** Gajaramruth
3.2	**Plant parts with biopesticidal properties**	Active ingredients with biopesticidal properties	More details given in Table 3		

3.3	**Plant parts rich in alkaloids and other metabolites**	Secondary metabolites:Terpenes, Phenolics N & S containing compounds Phytohormones:Auxin, IAA and abscisic acid	**1) Production enhancement:**Growth and development, respiration and photosynthesis, and hormone and protein synthesis **2) Stress control:** Act as signal molecules under stress conditions **3) Immunity**: Induce the plant systematic resistance and plant hormones **4)Microbial control:** Antifungal and anti bacterial **5)Growth regulation:** Growth and reproduction, seed and bud dormancy, abiotic stress response	Hazem et al., 2023 Tasiu Isah, 2019 Imane Naboulsi et al., 2018	**1) Growth promoter:** Fermented Liquid Juice, Oriental Herbal Nutrient
3.3.1	**Germinated seeds**	Amino acids and other bio active compounds that helps in growth promotion Natural growth regulator	**1) Immunity booster**: Increases the immunity in plants **2) Supply enzymes**: Pulse sprouts are a rich source of enzymes viz; α-amylase activity, phytase and other digestive enzymes and protein water soluble vitamins such as Thiamin, Niacin, Vitamin A, B complex and vitamin C, minerals and soluble sugars **3) Growth regulator**:Green bean sprout extract had a concentration of auxin growth regulator of 1.68 ppm, gibberellins 39.94 ppm, and cytokinin 96.26 ppm. Induce early tillering and flowering **4) Nutrient supply**: Peanut sprouts as natural/ green nitrogen source	Vijayalakshmi et al., 2018 Oloyo, 2003 Kokila et al., 2014 Vijayalakshmi et al., 2013 Latunra et al., 2020 Erdi surya et al., 2020	**1) Growth promoter:** Sapthadhanyankura Kashayam
3.3.2	**Coconut water/ Tendor coconut**	Sugars, sugar alcohols, lipids, amino acids, nitrogenous compounds, organic acids and enzymes **vitamins:** Thiamine (B1), Riboflavin	**1) Seed and seedling growth**: Seed germination and root growth of plant cuttings in tissue culture lab. **2) Growth regulator**: increased	Jean et al., 2009 https://en.wikipedia.org/ Sankar et al., 2020	**1) Broad spectrum Biostimulants:** Panchagavya and Dasagavya

		(B2), Niacin (B3), Pantothenic Acid (B5), Vitamin B6, Folate (B9), Choline, Vit-c **Minerals:** Calcium, Copper, Iron, Manganese, Magnesium, Phosphorus, Potassium, Sodium and Zinc **Protein**: TryptophanThroein, Leucine, lysine, Proline, Tyrosine,cystine etc **Plant growth regulators** such asAuxin, gibberellins (GAs), ethylene, cytokinins, and abscisic acid (ABA)	number of pods per pot, grain yield and stover yield of Greengram **3) Microbial action:** Multiplication of micro organism enhanced the soil nutrient availability due to solubalization and uptake of nutrients **4) Microbial medium:** for multiplication of Bacillus Thuringiensis, Trichoderma harzianum and Pseudomonas fluorescens, Trichoderma viride, Metarhiziumanisopliae, PGPRPseudomonas sp. and Bacillus pumilus.	Balcony and garden web, 2023	
4	**Dead animal parts like fish waste**	Complex biomasses of carbohydrates, proteins, lignin, fat and minerals	**1) Nutrient supply:** Rich source of major and micro nutrients are made available through mineralization. **2) Insecticide:** Spraying of Kunapajala on tea bushes controlled the attack of tea mosquito bug (Helopeltis theivora) and loopers (Biston suppressaria) **3) Rodant repellent:** Rat infestation also highly decreased. **4) Growth harmones:** Promote seedling growth, fruiting. Impact on the growth, physiological, biochemical, yield, and quality attributes of medicinal plants	Mukherjee et al., 2022 Nene, 2018 Biswas and Das, 2023 Eric Weinert et al, 2014 Su Su Shwe and Myat Myat Moe, 2018 Chakraborty et al, 2019	**1) Growth promoter:** Fish Amino acid **2) Broad spectrum biostimulant:** Kunapajala
5	**Composts**				

5.1	**Compost**	Minerals Major nutrient: 0.5 per cent N, 0.15 per cent P2O5and 0.5 per cent K2O. Trace elements: copper (Cu), zinc (Zn), iron (Fe), manganese (Mn), boron (B), and molybdenum (Mb)	**1) Nutrient supply:**Source of major and micro nutrients **2) Growth promotor:** Provides active agents, such as growth substances **3) Soil health management:** Buffers the soil against rapid changes due to acidity, alkalinity, salinity, pesticides, and toxic heavy metals. Supplies food and encourages the growth of beneficial microorganisms and earthworms	agritech.tnau.ac. in/org_farm	**1) Broad spectrum biostimulant:** Compost tea
5.2	**Vermicompost**	Contains combination of macro- and micro-nutrients High amount of humus Microbial population Growth promoting harmone: Auxin, Cytokinins and Gibberellins	**1) Nutrient supply:** Uptake of the nutrients has a positive effect on plant nutrition, growth, photosynthesis and chlorophyll content of the leaves. **2) Growth promoter:** Plant growth enhancer **3) Disease control:** actinomycetes increases the disease resistance	Rekha et al., 2018 agritech.tnau.ac.in/org_farm Satapathy et al., 2020 Vijayalakshmi and Karthiyayini, 2018	**1) Broad spectrum biostimulant:** Vermiwash
6	**Products other than those from plants and animals**				
6.1	**Soil**	Source of native microorganisms, organic matter and Minerals	**Starter culture of beneficial microorganism:** A teaspoon of rich soil can contain one billion bacteria. These micro organisms are involved in cycling plant nutrients, suppressing plant pests and diseases.	Tom DeGomez, 2019 Needelman, 2013 Thangavel et al, 2019 Laura Kaminsky et al., 2021 Jacoby et al., 2017	**1) Soil fertility enhancers:** Jadam microbial solution **2) Seed treatment:** Beejamrutha, Beejaraksha **3)Broad spectrum Biostimulant:** Jeevamrutha **4)Bio insecticide:** CVR technique
6.2	**Termite mound soil**	Source of native microorganisms Source of nutrients and enzymes	**Nutrient supply:** Serves N P and K along with organic matter. Supplies enzymes like cellulase, protease, urease and phosphatase necessary for mineralization	Turay, et al ., 2022 Chisanga et al., 2017 Chisanga et al., 2020	**1) Seed treatment:** Beejaraksha, Seed coating

6.3	**Alum**	Minerals: Potassium, Aluminium, sulphur	Reduce volatilization of Ammonia and runoff losses of soluble P by precipitation **Antimicrobial:** alum is prepared into aqueous solution with mass concentration of 4-5.9% for preventing and controlling plant disease caused by Pythium aphanidernatum (Fusarium wilt, root rot and damping off) **Insect control:** 10-20% concentrain against aphids, whiteflies and mealy bugs **Soil amendment:** For alkaline soil adding alum hepls in reducing the pH towards neutral	Gilmour et al., 2004 Lefcourt and Meisinger,2001 Delaune et al., 2004 Li Yonggang Han Lanlan Wen Jingzhi, 2011 Admin, 2021	**1) Soil fertility enhancer:** Gajaramruth
6.4	**Rock salt**	Elements include sodium, chloride, calcium, magnesium, potassium, and sulfate	**Nutrient supply:** Sodium, chloride, calcium Mg, K and sulfate	Robert and Paul	**1) Soil fertility enhancer:** Gajaramruth
6.5	**Common salt**	Sodium chloride	**1) Nutrient supply:** Fertilizer **2) Anifungal:**Stem rust fungus in wheat **3) Soil management:** Breaking up the soil and setting its constituents free to nourish the roots of plants; it absorbs moisture from the atmosphere and retains it in the soil, it purifies and decomposes all inert matter **4) Weedicide:** lowering of water potential, direct toxicity of Na+ and Cl– ions, and interference with the uptake of essential nutrients	Spennemann, 2021 Dibyendu et al., 2016	**1) Soil fertility enhancer:** Jadam Microbial Solution

6.6	**Honey**	Carbohydrates:Fructose, glucose, surcrose Amino acid and protein Aroma compound and phenolics Minerals and trace elements:potassium, chlorine, sulfur, calcium, sodium, phosphorus, magnesium, silicon, iron, manganese and copper Enzymes: Invertase, Amylase, Glucose oxidase Vitamins: B vitamins riboflavin, niacin, folic acid, pantothenic acid and vitamin B6 Organic acids such as acetic, butanoic, formic, citric, succinic, lactic, malic, pyroglutamic and gluconic acids	**Disease control (Antimicrobial):** Antibacterial effect depends on the concentration used	Dessie Ashagrie Tafere, 2021 https://www.chm.bris.ac.uk/webprojects2001/loveridge/index-page3.html Buelga and Paramas, 2017 Shahid Ullah Khan et al 2018	**1) Broad spectrum biostimulant:** Kunapajala
6.7	**Lime**	Calcium carbonate	**1) Seed growth:**Heat produced by the lime triggers germination **2) pH balance:** balance the acidic nature of cow urine and maintains the pH of the solution **3) Soil amendment:** applied to acidic soils	agritech.tnau.ac.in Aditya: Agriculture review Anonymous 2022	**1) Seed treatment:** Beejamrutha **2) Biopesticide:** Chunastra
6.8	**Kerosene**	Paraffins (55.2%), naphthenes (40.9%), and aromatic hydrocarbons (3.9%)	**Insecticide:** Kerosene emulsifiable concentrate: contact insecticide for piercing and sucking insects. Pod sucking bugs in cowpea **Insect attractant**	Britannica, 2023 Energy education ECHO Staff 1998. Aliyu et al., 2007 Patnaik, 2017 Abubakar et al., 2022 Sarodee Boruah et al., 2020	**1) Biopesticide:** Chilli garlic solution, Chunastra

As cattle dung and urine by themselves contribute in multiple ways to crop performance, any preparations that combine them serve as a broad-spectrum formulation useful for multiple agricultural purposes (e.g., *Jeevamruth*). This is also the case with bioformulations that involve adding them with other constituents like plant parts (e.g., *Handikhata*).

While dung and urine from cows are generally recommended as ingredients for bioformulations, it is observed that dung and urine from bulls, buffalos, sheep and goats can also be used for the preparation of bioformulations with limited variations in efficacy.

Goat and poultry manure are used mainly for their macro- and micronutrient contents. Eggs are used for their ability to promote growth and induce flowering, given their rich nutrients, including amino acids and minerals, and for their ability to control some diseases. Further egg yolk also serves as a surfactant[3] in the case of Cooking Oil and Yolk (COY), an emulsion-based non-botanical biopesticide.

2) Products derived from plants

It can be understood from Table 2 that products derived from plants are used in the bioformulations for their specific uses. Edible oil cakes are mainly used as they offer a balanced set of macro- and micronutrients. Non-edible oil cakes, like neem cake, are used mainly for their bioactive compounds that help suppress pathogens and insects. Asafoetida is directly used to improve the health of crops in general. It is applied by placing it in the irrigation channel in a gunny bag. It is also used in biopesticides due to its significant antibacterial, antifungal, anti-viral and insecticidal properties. Turmeric powder is used mainly for its anti-microbial and insecticidal properties. It is used for controlling both field pests and storage pests. Ash is used for its various benefits, including the supply of minerals, repelling and suppressing insects, and desiccating ability. Neem oil is used for its wide range of biopesticidal properties (insecticidal, antimicrobial and nematicidal) for controlling field and storage pests. Pongamia oil is used mainly for its insecticidal properties. Cooking oils are used for controlling crop pests given their ability to spread over the surface of plants and seeds, which inhibits the infestation by insect pests and disease-causing microorganisms. For example, cooking oils affect egg laying as well as embryo and larval development on the surface of the seed. They cause asphyxiation, making it difficult for the insects to breathe.

3) Plants and their parts

The use of plants and their parts in bioformulations can be broadly classified into the following categories: 1) for their nutrient and useful metabolite content (e.g., Parthenium in *Gajaramirth* and a mix of plants in Liquid Plant Fertilizer), 2) for their bio-pesticidal properties-, including insecticidal, nematicidal, anti-bacterial, anti-fungal and anti-viral properties (e.g., *Vitex negunda* extract, Tobacco extract and Chilli-Garlic-Ginger extract), and 3) for their energising and growth promoting properties (e.g., use of ginger and cinnamon in Oriental Herbal Nutrient). Some plants fall into more than one category due to their wide range of constituent chemicals. For example, Ginger falls both in the second and third categories, and Parthenium falls in the first and second categories. More details on these uses of plants are shared below.

Plants with nutrients

Some plants are known for their nutrient content. For example, drumstick (Moringa oleifera) extract contains antioxidants and osmoprotectants: phenolics, ascorbic acid, tocopherols, selenium, glutathione, free proline, soluble sugars; phytohormones such as auxins, gibberellins, and zeatin-type cytokinin; micro- (Cu, Fe, Mn, Zn) and macroelements (Ca, Mg, N, P, K, S). The presence of auxins,

[3] A surfactant (aka a surface-active agent) is a substance that, when added to a liquid, reduces its surface tension, thereby increasing its spreading and wetting properties.

cytokinins, gibberellins, and abscisic acid and their metabolites was also observed in young, fully expanded moringa leaves (Katarzyna Godlewska et al., 2021). Similarly, parthenium has Nitrogen (2.54%), Phosphorous (0.44%), Potassium (1.23%), Zinc (13.9 ppm), Manganese (161.2 ppm), Iron (528.3 ppm) and Copper (9.0 ppm). Bioformulations focusing on nutrient supply are made using such nutrient-rich plants. Furthermore, as every plant has some nutrients and as the nutrient content varies between the parts of an individual plant and between plants, some preparations, like Liquid Plant Fertiliser use a mix of plants and plant parts to make a variety of nutrients available to the crops.

Plants with biopesticidal properties

There are a large number of common uncultivated and cultivated trees and herbs that have proven biopesticidal properties. Table 3 shares the relevant details on some of these plants, including the plant parts that have biopesticidal properties, target pests suppressed or controlled, modes of action and the studies referred to. While this list focuses on the commonly available plants used for preparing biopesticides mentioned in Chapter 3, there are many more plants that have biopesticidal properties. Information on them can be accessed from some of the references cited. It can be observed from Table 3 that in most of the plants listed, the biopesticidal properties arise from the presence of active ingredients in a particular part, like leaves, seeds, etc. The target pests suppressed or controlled by these botanicals range from field-based pests like insects, mites, nematodes and pathogens to storage pests. The modes of action of plant-based biopesticides are broadly indicated as insecticidal, anti-bacterial, fungicidal, antiviral, nematicidal, aphicidal and acaricidal based on the target pests. The specific modes of action under insecticidal action include: i) protectant, ii) antifeedant/ feeding deterrence, iii) hormonal (Juvenile Hormonal Agonist), iv) repellence, iv) inhibition of oviposition, egg hatching and moulting, v) binding to acetylcholine receptors, thereby disrupting the nervous system of insects, vi) larvicidal, vi) mimicking the neurotransmitter, vii) induced symptoms of intoxication and necrosis in larva, pupa, and adult, and viii) toxicant. The specific modes of action under antimicrobial action include: a) mycelium growth inhibition, b) delaying and inhibiting spore germination, c) inhibits protein and DNA synthesis, d) inhibits production of mycotoxins, e) hyphal and mycelial modifications, f) cytotoxic inhibiting cellular activities, g) impairing permeability of the plasma membrane, h) denature proteins, i) inhibiting adenosine triphosphate (ATP) production and glucose uptake, j) induce reactive oxygen species (ROS) production, and k) damaging cell membranes.

The biopesticidal properties, mode of action and target pests varied a lot across the botanicals. While plants with insecticidal properties are more common, plants with anti-bacterial and anti-fungal properties are moderately common, and plants with anti-viral and nematicidal properties are relatively less common. Even among the crop insect pests controlled, there are variations across the botanicals, with some of them effective against *sucking pests*, some against *chewers* and some against *borers*. The studies referred to indicated that most of the botanicals are effective against sucking pests and chewers, but only a few of them are effective against borers. One needs to consider these factors while selecting a suitable biopesticide to control specific pests. Wherever needed, botanical biopesticides need to be used in combination with non-botanical pest control measures. Some plants have broad-spectrum biopesticidal properties, like neem. There are many bioformulations that bet on this property of neem. Many botanical biopesticides, like

Table 3: Bio-pesticidal properties of some of the botanicals

S. No.	Common name/ local names/ Scientific name	Plant part used/ preparation	Target pests				Mode of action	Reference
			Target insect pest -*Sucking pests/ Chewers/Borers*	Target nematode	Target pathogen *Bacteria/Fungi/Virus*	Storage pests		
1	Neem (Azardiracta indica)	Leaves and seeds	**Sucking pests:** Whitefly, aphids, Japanese beetles, moth larvae, scale, and spider mites; **Borers:** Sorghum stem borer, Chickpea pod borer, Brinjal fruit and shoot borer, Cotton bollworm and army worm **Chewers:** Tobacco caterpillar		**Fungi:** Black mold (Aspergillus niger), Tinea (Microsporum gypseum), Aspergillus ear rot (Aspergillus flavus); Damping off and Collar rot of Pigeonpea, Wilt disease complex of lentil; **Virus:** Bean common mosaic virus		**Insecticidal**- Hormonal (JH), Antifeedant, *Binding to acetylcholine receptors thereby disrupting the nervous system of insects;* Repellence, Feeding deterrence Inhibition of oviposition, egg hatching and moulting; **Anti-microbial; Anti-fungal**. **Antiviral**	Chaudhary et al., 2017; Vaishali Kandpal, 2014; Saxena et al., 2014; Lengai et al. 2020 Ambad et al., 2019 Murugasridevi et al., 2017 Chandra Shekhara et al., 2014 Anil Kumar et al. 2019; Sujak et al., 2019 Adusei and Azupio, 2022
2	Nirgundi (Vitex negund)	Leaves and seeds	**Borers:** Chickpea pod borer			Red flour beetle (Tribolium castaneum)	**Insecticidal**- Repellent **Anti microbial:** Anti fungal	Saxena et al., 2014, Anbalagan et al., 2017 Tamuli et al., 2014 Haridasn et al, 2017 O Giri Babu et al. 2018
3	Karanj (Pongamia pinnata)	Leaves	**Sucking pests:** Turnip Aphid (Lipaphis pseudobrassicae), grasshoppers, caterpillars, leaf suckers, Citrus butterfly larvae (Papilio demoleus)				**Insecticidal**, **aphicidal**; Antifeedant, Juvenile Hormone Agonist (JHA)	Kumar and Singh, 2002, Saxena et al., 2014; Anindita et al. 2022
4	Stone apple, Bilva, Bael (Aegle marmelos)	Leaves	**Chewers:** Bollworm(Helicoverpa armigera), Cutworm (Spodoptera litura) Spodoptera littoralis (Cotton leaf worm),		**Fungi:** Asparigillus sp.	European corn beetle (O. nibilalsis), Cowpea weevil (Callosobruchus maculatus), Confused flour beetle (Tribolium confusum)	**Insecticidal:** Feeding deterrence, **Fungicidal**	Rejiniemon, T.S., et al., 2014, Kumari, S., et al., 2018
5	Mahua (Madhuca longifolia)	Seed	**Chewers:** Paddy leaf roller (Cnaphalocrocis medinalis), **Sucking:** paddy bug (Leptocorisa acuta)			Cowpea weevil (Callosobruchus maculatus)	**Insecticidal**	Sajith et al., 2022
6	Gajar ghas (Parthenium hysterophorus)	Whole plant	**Sucking pests:** Cowpea aphid (Aphis craccivora), **Chewers:** Diamond backmoth (Plutella xylostella), **Borers:** Cutworm (Spodoptera Litura)	Root knot nematode (Meloidogyne incognita)	**Fungi:** Fusarium pallidorosum, F. moniliformis		**Insecticidal**- Antifeedant, Feeding deterrent, growth inhibitor **Nematicidal**; **Antifungal**	Kushwaha and Maurya, 2012 Reddy, 2018 Datta and Saxena, 2001 Saxena et al., 2014,
7	Thumbai (Leucas aspera)	Leaves				Rice weevil (Sitophilus oryzae), Pulse beetle (Callosobruchus chinensis)	**Insecticidal, Antifungal, Anti microbial**- Cytotoxic	Srinivasan et al., 2011 Gharpure Pallavi1 et al, 2020 Harsha and Rosaline Mary, 2022

8	Thenpoo (Lantana Camara)	Leaves			**Bacteria:** Common gut bacteria (Klebsiella pneumoniae) E. coli (Escherichia coli); **Fungi:** Alternaria solani, Botrytis cinerea, Pythium ultimum, Rhizoctonia solani and Verticillium dahlia	Rice weewil (Sitophilus oryzae (L.)), Pulse beetle (Callosobruchus chinensis (Fab.)) and Red flour beetle (Tribolium castaneum (Herbst.))	**Insecticidal**; *Protectant;* **Anti-microbial**	Rajashekar et al., 2014 Saxena et al., 2014; Lengai et al. 2020; Debjani Choudhury et al. 2018
9	Datura (Datura metel)	Leaves			**Virus:** Cucumber Mosaic virus	Rice weevil (Sitophilus oryzae)	**Insecticidal:** Antifeedant; **Antiviral**	Nilesh Jawalkar et al., 2016 Saxena et al., 2014 Hamidson et al. 2017
10	Aak, Erukku (Calotropis procera)	Leaves	**Sucking pests:** Mustard aphid (Lipaphis erysimi (kalt)), **Chewers:** Lady bird beetle (Coccinella septempunctata)				**Insecticidal**- Antifeedant	Kumar et.al., 2012 Saxena et al., 2014
11	Ratanjot (Jatropha curcas)	Leaves and seeds			**Fungi:** Black rot (Alternaria alternata), Common mold (Aspergillus spp), Panama disease (Fusarium oxysporum), Cucumber belly rot (Rhizoctonia solani), Green mold (Trichoderma viride)	Maize weevil (Sitophilus zeamais) and Lesser grain borer (Rhyzorpertha dominica), Cowpea seed beetle (Callosobruchus maculatus)	**Insecticidal**- Anti-oviposition and ovicidal effects; Protectant, Repellent; **Anti-microbial**	Silva et al., 2012 Adebowale and Adedire, 2006 ; Saxena et al., 2014; Lengai et al 2020
12	Adusa (Adhatoda vasica)	Leaves	**Borers**: Cutworm (Spodoptera litura), **Chewers:** Leaf folder (Cnaphalocrocis medinalis)		**Bacteria:** Bacterial leaf blight, **Fungi**: Heliminthosporium Leaf spot (Helminthosporium sp.)		**Insecticidal**- Antifeedant, **Anti-fungal, Anti-bacterial**	Saxena et al., 2014
13	Kaner; arali (Nerium oleander)	Leaves	**Sucking pests:** Chaitophorus Aphid (Chaitophorus leucomelas Koch); **Chewers:** Spodoptera exigua			Rice weevil (Sitaphilus oryzae), Red flour beetle	**Insecticidal**- Inhibit oviposition	Bhuvaneshwari et al., 2007 Zaid et al., 2021 Saxena et al., 2014, Toana et al., 2022, Yuvanandhini and Dhivya, 2021 Ghannoum and Karso, 2015
14	Behaya; Neiveli Kattamanakku (Ipomea carnea)	Leaves	**Chewers:** Polyphagus cotton leaf worm (S. littoralis)				**Insecticidal**	Saxena et al., 2014, Nassar et al., 2018
15	Tulsi (Ocimum sanctum)	Leaves, seeds	**Sucking pests:** Aphids, spider mites and whiteflies			Bean weevil (Acanthoscelides obtectus)	**Insecticidal**- **R**epellent	Gonzolase et al., 2019 Saxena et al., 2014
16	Sothu kattarazhai (Aloe vera/Aloe barbadensis)		**Chewers:** Termite		**Fungi:** Effective against Pseudomonas aeruginosa, Rhizoctonia solani, Fusarium oxysporum, and C. coccodes		**Insecticidal; Anti microbial-** *Inhibits cellular activities of Bacteria; Impairs permeability of plasma membrane, Denatures proteins; Inhibits ATP production and glucose uptake*	Lengai et al. 2020
17	Guduchi (Tinospora cordifolia)	Vines (stem)	**Sucking pests:** Green leafhopper (Cicadella viridis), **Chewers:** Cutworm (Spodoptera litura).			Maize weevil (Sitophilus zeamais)	**Insecticidal**	TNAU, Shakil and Saxena, 2006 Pedro M. Gutierrez Jr, 2016

18	Tobacco (Nicotiana tabacum)	Leaves	**Sucking pests:** Aphids, thrips and bugs; **Borers:** Cotton pink bollworm				**Insecticidal**- Antifeedant; *Mimics the neurotransmitter acetylcholine*	Badhane Gudeta et al., 2021 Anindita Paul et al, 2022 Imran Ali Rajput et.al., 2017
19	Castor, Arandi (Ricinus communis)	Leaves and seeds	**Sucking pests:** Spittle bug (Mahanarva sacchari), Daimond back moth (plutella xylostella)				**Insecticidal**- Repellent; Oviposition deterrent	Tounou Agbeko Kodjo et al., 2011 Gengan, 2022; Saxena et al., 2014 Anindita et al., 2022
20	Custard apple (Annona squamosa)	Fruit & Seed Exts.	**Sucking pests:** Mealy bugs, **Chewers:**Fresh water snail (Lymnaean acuminata), bollworm (Helicoverpa armigera)			Rice weevil (Sitophilus oryzae), Red flour beetle (Tribolium castaneum)	**Insecticidal**- Antifeedant, Repellent	Vaishali S. Ghoderao, 2020 Gengan, 2022 Saxena et al., 2014
21	Papaya (Carica papaya)	Leaves	**Chewers:** Cutworm (Spodoptera litura F), **Sucking:** Mustard aphid (Lipaphis erysimi)				**Insecticidal**	Ujjan et al., 2014 Gengan, 2022 Saxena et al., 2014
22	Turmeric (Curcuma longa)	Turmeric powder, Essential oil from leaves	**Chewers:**Tobacco caterpillar(Spodoptera litura), spotted bollworm(Earias vittella),diamond black moth(Plutella xylostella); **Sucking:** aphids, mite			Rice weevil (Sitophilus oryzae)	**Insecticidal**- Repellent, protectant	Saxena et al., 2014 Alka Rani, 2017
23	Ginger (Zinziber officinale)	Rhizomes			**Fungi:** Taro leaf blight (Phytophthora colocasiae), Rhizoctonia solani	Bean weevil (Callosobruchus maculatus) and maize weevil (Sitophilus zeamais).	**Insecticidal**; **Antimicrobial, Fungicidal**- *Mycelium growth inhibition*	Edu et al., 2019 Kalhoro et al., 2022; Qian-Qian Mao et al., 2019 Debjani Choudhury et al. 2018
24	Green chillies (Capsicum frutescens)	Fruits	**Chewers:** Alfalfa weevil (Hypera postica), Green peach aphid (Myzus persicae), Sweet potato whitefly (Bemisia tabaci), and Dimond back moth (Plutella xylostella); **Sucking:** Cotton aphid (Aphis gosypii),		**Bacteria:** Early and Late blight of potato		**Insecticidal; Antibacterial**	Biao Li et al., 2019 Saxena et al., 2014
25	Garlic (Allium sativum)	Bulbs	**Chewers:** Dark-winged fungus gnat (Lycoriella ingénue Dufour (Diptera: Sciaridae), Japanese termite (Reticulitermes speratus Kolbe) (Isoptera: Rhinotermitidae) ; Leaf folder (Cnaphalocrocis medinalis)		**Bacteria**: Bacterial leaf blight, Early and Late blight of potato **Fungi**: Heliminthosporium Leaf spot (Helminthosporium sp.), Wilt of pigeon pea	Mealworm beetle (Tenebrio molitor), Mediterranean flour moth (Ephestia kuehniella) Rice weevil (Sitophilus oryzae L), Miaze weevil (Sitophilus zeamais) and Red flour beetle (Tribolium castaneum) German Cockroach (Blattella germanica L.)	**Insecticidal**- Repellent*; Induced symptoms of intoxication and necrosis in larva, pupa, and adult;* **Anitfungal**- *Delay and inhibit spore germination Fungi, Inhibits protein and DNA synthesis Inhibits production of mycotoxins Disrupts cellular components and their activities; Hyphal and mycelial modifications*	Angelica et al., 2017 Lengai et al. 2020 Bijendra Kumar and Singh, 2012
26	Pyaj/Onion (Allium cepa)	Bulbs and leaves			**Bacteria**: E. coli (Escherichia coli); **Fungi:** Helminthosporium turcicum		**Anti-microbial**	Saxena et al., 2014 Lengai et al. 2020 Debjani Choudhury et al., 2018

27	Lemon, Nimbu (Citrus spp)	Leaves, fruits, fruit peel	**Sucking pests:** Fleas (Phyllotreta vittula), aphids and mites, also kill fire ants (Solenopsis invicta), several types of flies, **Chewers:** paper wasps (Polistes dominula) and house crickets (Acheta domesticus)		**Bacteria:** E. coli (Escherichia coli), Salmonellosis (Salmonella enterica), Pseudomonas putida, Staphylococcus aureus		**Insecticidal-** Antifeedant, toxicant; **Anti-microbial**	Vaishali Kandpal, 2014 Lengai et al. 2020
28	Pudhina (Mentha spicata)	Kashayam	**Chewers:** Leaf folder (Cnaphalocrocis medinalis)		**Bacteria:** Bacterial leaf blight, **Fungi:** Heliminthosporium Leaf spot (Helminthosporium sp.)		**Insecticidal**- Antifeedant, Toxicant, **Anti-Bacterial; Fungicidal**	Vaishali Kandpal, 2014
29	Cinnamon (Cinnamomum verum)	Oil, bark powder, bark extract	**Sucking pests:** Citrus flatid plant hopper (Metcalfa pruinosa)			Rusty grain beetle (Cryptolestes pusillus), Lesser grain beetle (Rhyzopertha dominica), Wheat weevil (Sitophilus granarius)	**Insecticidal**- Poisoning, Food refusal and anaesthetize	Jun Ran Kim, et al., 2015 Mahmoud et al., 2023
30	Licorice/sweet wood (Glycyrrhiza glabra)	Leaf extract			**Bacteria:** Bacterial canker of tomato (Clavibacter michiganesnsis), black rot (Xanthomonas compestris), **Fungi:** Potato late blight (Phytopthera infestans)		**Bactericidal, Fungicidal**- ROS production, Damage cell membane, Apoptosis	Hermann, et al., 2022
31	Angelica (Angelica archangelica)	Seed oil, seed extract, pulpy roots, and Fruits	**Chewers:** Cotton leafworm (Spodoptera littoralis)				*Inhibitory effects on enzymes (AChEases and ATPases)*	Pavela and Vrchaotova, 2013
32	Mugwart (Artemisia vulgaris)	Essential oil (leaves) and extract (aerial parts)	**Sucking pests:** Asian citrus psyllid(Diaphorina citri) Cabage aphid (Brevicoryne brassicae) **Chewers:** Leptinotarsa decemlineata, Myzus persicae**,** Melonworm moth (Diaphania hyalinata) and Fall webworm moth (Hyphantria cunea), Helicoverpa armigera	Root knot nematode (Meloidogyne javanica), Cotton root knot nematode (Meloidogyne incognita)	**Fungi:** Black mold (Aspergillus niger), Ear rot (Aspergillus falvus), Early blight (Alternaria solani); **Bacteria:** Erwinia sp., Tomato canker (Clavibacter michiganense), almond canker (Psuedomonas syringae), Black rot (Xanthomonas campestris)	Rice weevil (Sitophilus oryzae), sawtoothed grain beetle (Oryzaephilus surinamensis), Cowpea weevil (Callosobruchus maculatus), Lesser grain borer (Rhyzopertha dominica) and red flour beetle (Tribolium castaneum)	**Insecticidal, Antifeedent** *Interfere with GABA reciptor,* **Antibacterial, Antifungal, Nematicidal**	D Y Luo, et al., 2022 Ivanescu, 2021
33	Chrysanthemum (Chrysanthemum indicum)	Flowers	**Sucking pests:** Ants, aphids, roaches, fleas, flies, and ticks				**Insecticidal**	Vaishali Kandpal, 2014
34	Ritha (Sapindus mukorossi)	Seeds	**Snail** (Macrochlymus indica)				**Molluscicidal**	Saxena et al., 2014
35	Cashew, Kaju (Anacardium occidentale)	Cashew nut shell oil				Rice weevil (Sitophilus oryzae)	**Insecticidal**	Saxena et al., 2014 Thomas et al., 2017

Panchpathi khada, Dasaparni, and Sarvakeetnashini, use multiple plants to capitalise on the varied biopesticidal properties of their constituent plants.

Some of the thumb rules for identifying plants with biopesticidal properties are:

- Plants with milky latex (e.g., Calotropis, Nerium, Cactus and Jatropha)
- Plants that are bitter (e.g., Neem, Andrographis, Tinospora and Leucas)
- Plants that are generally avoided by cattle, sheep and goats (e.g., Adhatoda, Ipomea fistulosa)
- Aromatic plants (e.g., Vitex, Ocimum)
- Plants that are not affected by specific insect pest and disease in the immediate environment- they are considered to have biopesticidal properties against those specific insect pest and disease

Plant parts rich in metabolites

Some plant components, by nature, have active bioingredients that are useful for promoting growth and energising crops. For example, tender coconut has plant growth regulators such as auxin, gibberellins (GAs), ethylene, cytokinins, and abscisic acid (ABA) and vitamins such as Thiamine (B1), Riboflavin (B2), Niacin (B3), Pantothenic Acid (B5), Vitamin B6, Folate (B9), Choline, Vitamin C, besides sugars, sugar alcohols, lipids, amino acids, nitrogenous compounds, organic acids, enzymes and minerals. Some plant components, like the grains of pulses, wheat and sesame, when sprouted become quite rich in bioactive compounds like enzymes, vitamins, minerals and other growth promoting compounds. For example, pulse sprouts are a rich source of enzymes (α-amylase, phytase and other digestive enzymes), protein, water soluble vitamins (Thiamine, Niacin, Vitamin A, B complex and Vitamin C), minerals and soluble sugars. Such promising properties of these ingredients are capitalised for preparing crop growth promoters.

4) Dead animal parts

Most of the dead animal parts and fish are rich in amino acids and nutrients. These are made available to the crops by breaking them down into available forms in the different bioformulations (e.g., Fish amino acid and *Kunapajala*).

5) Composts

Composts are prepared through a microbial process of breaking complex materials into simple components that can be easily used by crops. Compost has macro- and micronutrients, humus and bioactive compounds, besides the wide variety of beneficial microorganisms. These beneficial features are used in compost extracts/tea. Similar is the case with vermicompost. It benefits from the various nutrients, growth promoting hormones and other bioactive compounds secreted by earthworms and those in their excreta. It also has a beneficial microbial population. Given this combination of constituents, compost-based bioformulations can be used as a broad-spectrum product to improve soil fertility, boost immunity and promote growth.

6) Products other than those from plants and animals

These ingredients are used in the bioformulations for their specific uses. Soil is primarily used as a starter culture for a wide range of native microorganisms. It is also used for its ability to repel insect pests. Termite mound soil is used as a source of native microorganisms and also as a source of nutrients and enzymes. While alum helps in stabilising the bioformulation to which it is added by reducing the volatilization of ammonia and runoff losses of soluble P by precipitation, it also aids in altering the soil pH and controlling insect pests and diseases. Rock salt and sea salt are used for their

mineral contents. Lime is used for its antimicrobial properties and its ability to trigger the germination of seeds and induce drought resistance. It also helps in maintaining the pH of the bioformulation. Kerosene is used for its broad-spectrum insecticidal properties. Honey serves as a source of energy to meet the requirements of the fermenting microbes. It also has antimicrobial properties.

Ingredients that aid in the preparation of bioformulations

These ingredients generally fall into three categories based on their role in bioformulations: i) those that serve as energy sources or food for microorganisms, ii) surfactants/adjuvants[4] and iii) extractants. The most commonly used food sources are jaggery and pulse powders. Fruits, boiled potatoes, cooked rice and milk are also used for this purpose. Detergent powders are the most common surfactant used in biopesticides. Some studies indicate that detergents, besides serving as surfactants, also aid in controlling some of the pests (Tomislav Curkovic, 2016). In the case of cooking oil and yolk bioformulation, egg yolk is used as a surfactant. Surfactants improve the efficacy of the bioformulations. An extractant is a liquid used to extract a substance from another material.

2 Preparation methods

1) Fermentation

Fermentation is one of the common methods used for the preparation of bioformulations. While aerobic fermentation is followed in some preparations, like Fermented Plant Juice, facultative anaerobic[5] fermentation is followed in some other preparations, like bioenzymes. Aqueous alcoholic extraction by fermentation is followed in some of the bioformulations that focus on making available the specific nutrients and metabolites present in some of the plant- or animal-based ingredients. Examples are Liquid Plant Fertilizer and bioenzymes. In this method, the raw materials are soaked for a specified period of time, during which they undergo fermentation and generate alcohol in situ; this facilitates the extraction of the active constituents contained in the plant material. Fermentation without water is followed in some bioformulations. Examples are Fish amino acid and Fermented plant juice. Fermentation for a long time helps in breaking down the complex compounds into organic acids, chelated compounds and other compounds that can be easily taken by the plants. The shelf life of products developed through such fermentation is longer in general. Bioenzymes prepared through fermentation for ninety days with water do not have an expiration date, and the quality of the preparation enhances with time. The same is true of plant-based and animal-based liquid fertilisers.

Fermentation for a shorter period is followed in some bioformulations, which primarily focus on multiplying beneficial microbes for inoculating soil, rhizosphere and phyllosphere. Examples are Jadam Microbial Solution (JMS), *Sanjeevak and Jeevamruth*. The shelf life of such products is shorter in general. For example, JMS has to be used within two or three days. Cattle dung and soil are used as the starter culture for beneficial microorganisms. In the case of JMS, the leaf, stem, vegetable or any other part of the particular crop for which the solution is going to be applied is added to multiply the crop-specific microorganisms. In the case of Indigenous Microorganisms, microbes in the soil and immediate environment of a particular farm are attracted using cooked rice. Solid state fermentation is adopted for the production of gibberellic acid using cattle dung cake as a substrate in Uplamirth.

[4] An ingredient (as in a prescription or a solution) that modifies the action of the principal ingredient.
[5] Facultative anaerobes: The organisms that can survive in both oxygenated as well as the deoxygenated environments are known as facultative anaerobes. These are the most adaptable organisms that have the capability to switch between aerobic and anaerobic types of respiration.

2) Mixtures

Mixing the ingredients with or without grinding and keeping them for some time is another common preparation method followed in preparing bioformulations. Examples include Bakramruth, Pranamruth, and Gajaramrith.

3) Sprouting and grinding

This method is followed for preparing *Sapthadanyankur* tonic.

4) Decoction

The raw material is boiled in a specified volume of water for a defined time; then, the concentrated extract is cooled and strained or filtered. This procedure is suitable for extracting water-soluble, heat-stable constituents. This method is followed in the case of preparations that focus on making available the specific bioactive compounds available in animal or plant-based ingredients. Examples are *Agniastra* and *Bramastra*. The shelf life of such products is longer in general.

5) Extraction using an extractant

In most of the bioformulations, water is used as an extractant. In some cases, cow urine is used for this purpose. In the case of Oriental Herbal Nutrient, alcohol is used, and in the case of Egg Amino Acid, lemon juice is used.

3 Mode of action of bioformulations

While the mode of action of biopesticides is described in the above section, it is important to understand the mode of action of other bioformulations as well.

To understand the mode of action of microbial bioformulations like Jeevamruth, Sanjeevak, JMS, etc., one needs to understand the concepts of holobiont[6] and plant microbiome.[7] Plants live in association with diverse microbial consortia. These microbes, referred to as the plant's microbiota, live both inside (the endosphere) and outside (the episphere) of plant tissues and play important roles in the ecology and physiology of plants. While many of us are familiar with plant-associated microbes in the rhizosphere, such microbes are also present in various other parts of the plant, as shown in the picture. The core plant microbiome is thought to comprise keystone microbial taxa and has been established through evolutionary mechanisms of selection and enrichment of microbial taxa. They contain essential functional genes that are important for the fitness of the plant holobiont (Plant microbiome - Wikipedia). Plant microbiome has a direct impact on plant functional traits such as leaf longevity, specific leaf area, leaf nutrient levels, and shoot/root ratio. By providing novel nutritional and defence pathways and by modifying biochemical pathways, the plant-associated microbiome can enhance or decrease species coexistence and consequently influence not only a single plant but complete ecosystems (Frontiers | The plant microbiome and its importance for plant and human health (frontiersin.org)).

[6] A holobiont is a collection of closely associated species that have complex interactions, such as a plant species and the members of its microbiome. Each species present in a holobiont is a biont, and the genomes of all bionts taken together are the hologenome, or the "comprehensive gene system" of the holobiont. A holobiont typically includes a eukaryote host and all of the symbiotic viruses, bacteria, fungi, etc. that live on or inside it.

[7] The microbiome has been defined as "a characteristic microbial community occupying a reasonably well-defined habitat that has distinct physio-chemical properties. The term thus not only refers to the microorganisms involved but also encompasses their theatre of activity".

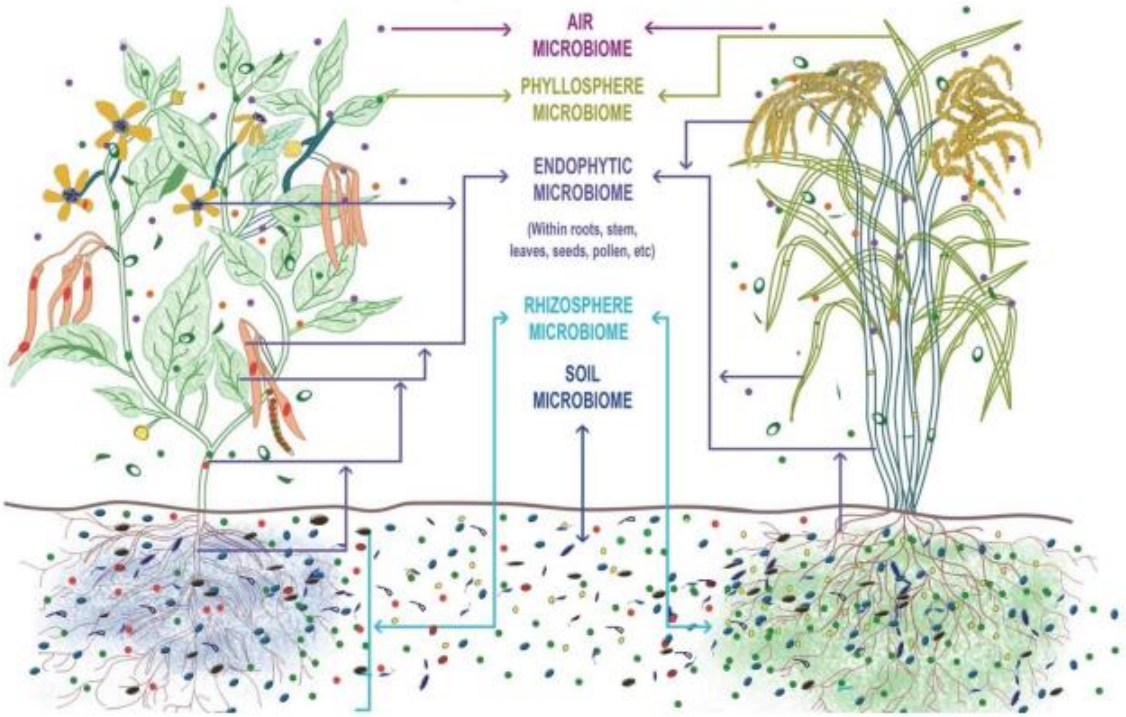

FIGURE 1 | The 'Plant Microbiome' can be described as the sum total of the genomic contribution made by the diverse microbial communities that inhabit the surface and internal tissues of the plant parts. The rhizosphere, endosphere, phyllosphere constitute the major compartments in which the microbial communities reside in the plant. The soil microbiome is the main source from which the plant selects and builds its microbiome profile. The plant genotype (e.g., dicot bean plant and a monocot rice plant), its root exudates (indicated by blue shade for bean and green for rice), the soil types and properties, and the environmental factors influence the plant microbiome makeup (indicated by different colored microbes inhabiting the plant compartments in bean and rice plant). Mycorrhizal association in both plants is indicated by thin lines extending from the roots into the surrounding soil.

The composition of the plant microbiome may differ among individual plants as well as across various stages of growth or sites and tissues of the same plant. The plant growth-promoting bacteria and the arbuscular mycorrhiza are some of the beneficial microbes that are part of the plant microbiome. It is found that these microorganisms are transmitted across generations through the seed microbiome. Microbes in the soil and the microbes that are part of the plant microbiome play many roles, including, but are not limited to, supporting plant growth at different stages, starting from seed germination, promoting plant resistance to biotic and abiotic stresses, plant defence and assisting plants in nutrient uptake.

In this context, the mode of action of biostimulants needs to be understood. The application of bioformulations like *Jeevamruth*, JMS, *Panchagavya*, etc. is taken up through seed/seedling treatment, soil application and foliar spray to enrich the huge diversity of microbes in the soil and in the plant microbiome. These microbes carry out a whole range of services, including:

1) Accessing, acquiring, accumulating, and improving the availability and cycling of nutrients
2) Improving the soil structure and humus production
3) Producing growth-promoting hormones and enzymes
4) Suppressing pathogenic microbes and inducing resistance to pests and diseases
5) Triggering physiological changes within plants to cope with environmental stresses (https://youtu.be/o_TDlxW9wdM?si=nxjJHNUDZ1K2R19F)

Given their wide range of ingredients in broad-spectrum bioformulations derived from animals and plants, they not only have microbes but also have many useful bioactive compounds, including micro- and macronutrients, amino acids, plant hormones, vitamins, Phenolics and N & S containing compounds. Furthermore, during the process of preparation of the bioformulations, the complex compounds in the ingredients are broken down into easily assimilable bioactive compounds. Therefore, their application contributes to crop performance in various ways, in addition to the ways mentioned above for the microorganisms. They enhance plant growth, quality, photosynthesis, tolerance to abiotic and biotic stresses, and resource use efficiency (nutrients, fertilisers, and water) by modulating plant biochemical, molecular, and physiological processes.

4 Utilisation of bioformulations

It can be understood that the application of DIY bioformulations is taken up primarily to enrich the soil and aid the crop to perform to its genetic potential. They should enhance the inherent abilities of the land and the crops rather than weakening them through substitution (as is the case with conventional agriculture). DIY bioformulations need to be applied from the pre-sowing stage to the fruiting stage in a timely manner to meet the requirements of crops. Brief information on ways to apply bioformulations is shared below:

1) Application of microbial bioformulations to soil before sowing for increasing the microbial population E.g.: *Jeevamruth*, *Ghanajeevamruth* and *Sanjeevak*
2) Treating seeds and seedlings: Seeds and seedlings are treated in general for the following purposes:
    a. To make available nutrients so that seed can grow vigorously immediately after germination
    b. To supplement seed and rhizosphere microbiomes
    c. To supply bioactive compounds that help in growth promotion
    d. To suppress or kill seed-borne pathogenic microbes
    e. To aid in managing post-emergence drought stress

    Bioformulations used for seed treatment meet a few (like cow urine) or most of these requirements (like *Beejamrutha, Beejaraksha*, and *Panchagavya*).
3) Application of microbial bioformulations at regular intervals during the early part of the crop growth period, either through soil application or foliar application, to enrich the soil and plant microbiomes.
4) Application of a few rounds of preventive application of biopesticides based on the potential for pest infestation. Points to be given attention include: i) choosing a set of appropriate preventive biopesticides for each crop based on the type of expected pests and their timing of infestation and ii) applying these biopesticides in rotation to avoid developing resistance. For example, if the probability of sucking pests is high, then a set of biopesticides effective against such pests that can be easily prepared on-farm or easily available close by needs to be chosen. One thing to keep in mind is that most DIY biopesticides are more effective as preventive and early-infestation control measures.
5) Application of bioformulations with specific nutrients during different stages of the crop: Initially, the focus has to be on supplying growth-promoting nutrients like nitrogen, and later, the focus needs to be on supplying nutrients needed for inducing flowering, flower/fruit retention, and grain filling/fruiting.
6) Application of growth promoting bioformulations during different stages of the crop

7) Application of biopesticides for curative purposes if the pest incidence reaches a damaging level; in this case, a set of bioformulations effective against that specific pest have to be applied in rotation at frequent intervals. Frequent applications might be needed for effective control.

It can be understood from the above points that it is mandatory to apply certain bioformulations for better crop growth and certain bioformulations can be applied based on need. It is mandatory to apply soil fertility enhancers, seed treatment bioformulations and preventive biopesticides. The curative biopesticides can be applied only if there is a need.

More importantly, one needs to keep in mind that these DIY bioformulations work well along with crucial on-farm measures like the addition of organic matter to soil, ensuring crop diversity, using resistant varieties, timely sowing, nutrient management, timely intercultural operations, and preventive measures like bird perches, removal of infested parts, etc. These bioformulations should not be considered a silver-bullet solution.

In the next chapter, details of individual DIY bioformulations, including their utility, preparation, how to use and shelf life, are presented. Furthermore, the results of research on particular bioformulations, whichever can be accessed, are presented.

Photo: SHG members preparing Agniastra

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Cow Milk

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Chapter 3:

Production, handling, application methods, and research results of DIY bioformulations

Using the right ingredients in the right quantities, adopting suitable preparation methods, and following proper application methods determines the efficacy of DIY bioformulations. Though some flexibility is allowed in terms of the local availability of ingredients, one needs to follow these aspects to get better results. For example, urine or dung could be sourced from a bull instead of a cow in some bioformulations; the herbs used can be changed based on availability. This Chapter presents details of DIY bioformulations that were encountered by N+3F in its work with its 25+ partners across India. They were standardised by different people in different contexts. It is common to see more similarities among some of these bioformulations. Some of them are also called by different names in different parts of the country. In this chapter, an attempt is made by N+3F to provide essential information on these DIY bioformulations so that the reader can use them for actual preparation. This essential information includes, i) the category, ii) the ingredients required and their quantity, iv) the preparation procedure, v) the time taken for preparation, and vi) the method of usage. Wherever possible, the source of information is provided, and readers looking for more information can refer to those sources. An attempt is also made to review the available scientific studies on each of these DIY bioformulations and present the results of the same.

The DIY bioformulations are presented in two broad categories, namely, I) biostimulants and II) biopesticides. Biostimulants are presented in the following order: i) Soil fertility enhancers, ii) Formulations for seed treatment, iii) Growth promoters, and iv) broad-spectrum formulations. Biopesticides are presented as two sub-categories, namely, a) Botanicals and b) Non-botanicals based on their ingredients. Botanicals are presented as single plant-based bioformulations and multiplant-based bioformulations.

Biostimulants

1.1 Soil fertility enhancers

Soil fertility is the ability of a soil to sustain plant growth by providing essential plant nutrients and favourable chemical, physical, and biological characteristics as a habitat for plant growth. Plant nutrients include the macronutrients nitrogen, phosphorus and potassium, sulfur, calcium and magnesium. Micronutrients are essentially boron, chlorine, copper, iron, manganese, molybdenum and zinc. Nutrient sources include chemical and mineral fertilizers, organic fertilizers, such as livestock manures and composts, and sources of recycled nutrients (FAO).

Soil fertility enhancers strengthen or improve the fertility status of the soil by providing nutrients required by plants directly or through the microbial activity they trigger which convert the unavailable form of nutrients to available form. They also act as catalyst for chain of reactions happening in the soil.

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1.1.1 Sanjeevak/Amrithpani

Sanjeevak is a bioformulation used for enriching the soil with microorganisms and quick residue decomposition. The ingredients required and procedure for preparations are taken from the TNAU (https://agritech.tnau.ac.in/org_farm/orgfarm_ofk_soil.html) and agriculture2042.com (https://agriculture2042.com/jeevamrut-preparation/)

Ingredients

- Cow urine 100 litres
- Cow dung 100 kgs
- Jaggery 500 grams
- Water 300 litres

Preparation procedure

1. Mix 100 kg cow dung, 100 litres cow urine and 500 g jaggery in 300 litres of water in 500 litres closed drum
2. Keep the drum 10 days for fermentation
3. It should be diluted with 20 times water and sprinkled in one acre of land
4. Use as soil application either by sprinkling or by applying through irrigation water

Preparation time: 10 days

Method of usage: Three applications are needed for a medium duration crop–

- Before sowing
- Twenty days after sowing and
- 45 days after sowing

Dosage: Add 1 litre Sanjeevak in 9 litres of water to prepare 10 litres solution. Or it can be diluted with 20 times water and sprinkled in one acre of land

Scientific studies on use of Sanjeevak

Nutrient content, microbial count and enzymatic activity in Sanjeevak (Sonali phate *et al,* 2014)

In this study, five different combinations of Sanjeevak are prepared by varying the quantity of cow dung, cow urine, jaggery and water used for dilution. Out of these combinations Sanjeevak 5 prepared using cow dung (10kg), cow urine (10 l), jaggery (1kg), flour of pulse (2kg), ant hill soil (1kg) and water (10 lt) performed well. Sanjeevak 5 sample, although in acidic range, had moderate levels of carbon, nitrogen and phosphorus compared to that of other Other growth promoters (OGPs); it showed highest content of potassium and available nitrogen. Sanjeevak 5 and Panchagavya samples are noted to contain the highest amount of enzyme dehydrogenase, acid phosphatase and peroxidase. Sanjeevak 5 also contains the highest amount of enzyme polyphenol oxidase.

Their study clearly indicated that Sanjeevak and Panchagavya are the best formulations of liquid manure showing highest microbial count and presence of high amounts of extracellular enzymes. Among all the liquid manures studied for their effect on root growth during seed germination for different crops, a treatment of Sanjeevak was noted to have very pronounced effect on root growth in

case of crops like cotton, pigeon pea and wheat followed by the treatments of Panchagavya and Amrithpani for crops like soy bean and Bengal gram, respectively.

	pH	**Total carbon (%)**	**Total nitrogen (%)**	**Available nitrogen (%)**	**Total phosphorus (%)**	**Total potassium (%)**
Nutrient content	6.75	0.0041	0.0111	0.0098	0.0338	0.0081
	Total bacterial CFU / ml	**Total fungal CFU / ml**	**Actinomycetes CFU / ml**	**Azotobacter CFU / ml**	**Pseudomonas fluorescens CFU / ml**	**PSM CFU /ml**
Microbial count	3.0×10^7	1.03×10^6	2.00×10^6	1.21×10^6	9.8×10^2	1.13×10^4
	Dehydrogenase (ppm)	**Acid phosphate (ppm)**	**Alkaline phosphatase (ppm)**	**Polyphenol oxidase (ppm)**	**Peroxidase (ppm)**	
Enzymatic activity	33.34	754.93	756.78	144.81	60.49	

A pot experiment conducted by Orendo Smith *et al.,* (2010) revealed that the use of Sanjeevak can be as effective as commercial fertilizer as a source of essential nutrients for crops.

Dalal *et al*., 2014 reported that plants treated with Sanjeevak (Soil application) showed better vegetative growth in comparison with plants treated with chemical fertilizers and plants treated with panchagavya.

Basavaraddi Chavadi et al., 2021, conducted the field experiment in Finger millet during Kharif 2019 in red sandy lomy soil of University of Agricultural Sciences, GKVK, Bengaluru with different liquid organic nutrient management practices. Results of the experiment reveal that application of Amritapani + Sanjivak @ 125 per cent N equivalent ha-1 produced significantly higher grain yield, straw yield and harvest index of finger millet (3,985.00, 5,366.67 kg ha^{-1} & 0.43), respectively

Inferences

- Majorly Sanjeevak is recommended for soil application and it can be used as liquid manure due to higher microbial count and presence of high amounts of extracellular enzymes.
- Sanjeevak has a pronounced effect on root growth in case of cotton, pigeonpea and wheat.

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1.1.2 Ghana Jeevamrutham

The ingredients required and procedure for preparation of Ghana Jeevamrutham is taken from Help Farming- *Natural and organic farming school* (https://www.helpfarming.com/ghana-jeevamrutha/). Ghana Jeevamrutham is dry or solid Jeevamrutham which can be dried and stored for later use. Ghana Jeevamrutham is prepared where there is a scarcity of water, scarcity of labor and abundance of cow dung. For any farmer who has an abundance of cow dung but he can't use it for Jeevamrutham, then he can convert it to Ghana Jeevamrutham and store it for a year. Ghana Jeevamrutham is as effective as Jeevamruthm to the soil. The microbial population in the soil increases. There are three types of Ghana Jeevamrutham preparation which are given below.

	Ghana Jeevamrutham 1	**Ghana Jeevamrutham 2**	**Ghana Jeevamrutham 3**
Ingredients required for 1 acre land	100 Kgs of Dried Cow Dung Cow urine as per requirement 1 kg Jaggery 1 kg Besan Powder Anthill soil fist full	200 Kgs of Dried Cow Dung/FYM/ Compost 20 Litre Jeevamrutha	50 Kgs of Dried Gobar Gas Powder 50 Kg Desi Cow Dung 1 kg Jaggery 1 kg Besan Powder
Time of preparation	Morning/ Evening		
Procedure	Spread Cow Dung in a shaded place for 48 hours Mix with 1 Kg Jaggery and 1 Kg Besan Now make a heap of the treated cow dung and cover it again using jute bag for 48 hours. After 48 hours, spread it on the floor and dry it in sunlight.	Spread Cow Dung/ FYM/ Compost in a shaded place for 48 hours Mix with 20 Litre Jeevamrutha Now make a heap of the treated cow dung/ FYM/ compost and cover it again using jute bag for 48 hours. After 48 hours, spread it on the floor and dry it in sunlight.	Spread Dried Gobar Gas Powder and Cow Dung in a shaded place for 48 hours Mix with 1 Kg Jaggery and 1 Kg Besan Now make a heap of the treated cow dung and cover it again using jute bag for 48 hours. After 48 hours, spread it on the floor and dry it in sunlight.
Preparation time	4 days		
Storage	Dried Ghana Jeevamrutham should be made into powder form. It can be stored in a Gunny Bag. Keep bags on Wooden Plank.		
Shelf life	Maximum 1 year		
Method of Usage	➢ After 48 hours ready for usage. ➢ At the time of sowing, use the 200kg Ghana Jeevamrutham per acre. For example, two hands of Ghana Jeevamrutham to be added along with each seed sown. ➢ Again during the flowering period of the crop, add 50kg of Ghana Jeevamrutham in between two crop lines on the soil per acre. ➢ Always apply Ghana Jeevamrutham on the wet soil. ➢ Ghana Jeevamrutham is quite suitable for rainfed agriculture.		

Type 1: Using Cowdung

Type2: Using FYM/ Compost

Type3: Using Dry biogas slurry

Scientific studies on use of Ghana jeevamrutham

A field experiment was conducted by Kavitha *et al.,* 2022 to study the effect of Ghana Jeevamrutham (Type 1) and liquid jeevamrutham at different levels on Banana at Hanagal Taluk of Haveri district Karnataka. The experiment contains ten treatments with three replications laid in a randomized complete block design and the cv. *Ney poovan* is the commercial variety used for the study. Among the different levels of Ghana jeevamrutham and liquid jeevamrutham application the maximum bunch length (58.33 cm), bunch width (30.47 cm), finger length (11.10 cm), finger girth (3.33 cm), finger weight (76.67 g), finger volume (71.08 cc), yield per plant (9.35 kg) and yield per acre (5.19 t) were recorded in T9 – Ghana jeevamrutham @ 600 kg/acre + liquid jeevamrutham @ 300 l/acre. These fermented organic nutrients can be a better alternative for the use of inorganic inputs to maintain soil health for sustainable development.

Bhagyashree *et al.,* 2023, carried out an experiment to know the "Influence of Ghana jeevamrutham (Type-1) and foliar application of panchagavya on growth, yield and quality of China aster (*Callistephus chinensis [L.] Nees.*)" at Department of Floriculture and Landscape Architecture, K. R. C. College of Horticulture, Arabhavi. They concluded that, application of Ghana jeevamrutham @ 2000 kg per hectare and foliar application of panchagavya @ 1 per cent resulted in significantly higher vegetative growth, flower weight, flower diameter, more shelf life and flower yield per hectare.

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1.1.3 Bakramruth

Bakramruth is used for improving soil fertility. This can be considered as an alternative to chemical fertilizer like DAP. Ingredients required and method of preparation is obtained from Gram Sudhar Samithi, an NGO located in Madhya Pradesh

Ingredients

- The Goat manure 5kg
- Ash 1kg
- Mustard/Mahua cake 1kg
- Water 10 litres

Goat manure

Wood Ash

Mustard/Mahua cake

Preparation procedure

1. Make fine powder of mustard cake and goat manure
2. Mix powdered mustard cake, goat manure and ash on concrete surface and add water till mixture becomes wet
3. Keep the mixture for 10-12 days under shade
4. Maintain optimum moisture during the storage
5. After shade drying, it can be stored using plastic sacks

Preparation time: 10-12 Days

Shelf life: Can be stored for 6 months

Method of usage: Bakramruth can be applied at the time of sowing at the rate of 4 quintals per acre

1.1.4 Pranamruth

Pranamruth is used for improving soil fertility. This can be considered as an alternative to chemical fertilizer like DAP.

The procedure of preparation of Pranamruth is similar to Bakramruth. As a major ingredient poultry manure is used against goat manure in Bakramruth.

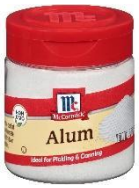
Poultry manure

1.1.5 Gajaramruth/Bio Urea

Gajaramruth can be used as an alternative source of nitrogen as foliar spray. Ingredients required and method of preparation is obtained from Gram Sudhar Samithi, an NGO located in Madhya Pradesh

Ingredients

- Carrot grass (*Parthenium hysterophorus) 4kg*
- Cow urine 8 litres
- Alum 20 mg
- Rock salt 20 mg



Parthenium plant

Preparation procedure

1. Make powder of alum and rock salt
2. Mix the powder with carrot grass and cow urine
3. Keep the mixture for 15 days
4. Add 5 times water to the mixture, filter and spray the solution on crops

Cow urine

Preparation time: 15 days

Shelf life: Have to be prepared whenever needed

Method of usage: For one acre 8 litres of solution need to be mixed with 40 litres of water

Precautions

- Spraying should be done in morning or evening hours of the day.
- It can be used for all crops
- There is a possibility of respiratory disease due to usage of carrot grass, advised to use protective clothing viz., hand gloves, face mask, cap, full trouser etc to cover whole body.

1.1.6 Fermented Liquid Plant Fertilizer (FLPF)

Ingredients used and preparation methods are obtained form the video link given below. Fermented liquid plant fertilizer is prepared using the readily available plants such as weeds, grasses, crop resides, rotten fruits, food scrapes and more. It's a simple and inexpensive method that anybody can practice. For meeting the basal needs of the crop use cover crops for preparing the liquid fertilizer and for additional fertilizer need use crop reside and wild grass.

Ingredients

- Organic materials available in the farm such as crop resides, weeds, wild grass and more

Preparation procedure

1. Take a 200 litres capacity plastic drum.
2. Fill the drum with the ingredients
3. Add water to the container and add a handful of leaf mould
4. Close the lid and keep it aside.
5. In summer decomposition will be completed in 7 days and in winter it may take 14 days
6. Dark colour of the liquid indicates the readiness to use.

Weeds and other plants soaked and fermented in water to extract nutrients

Preparation time: 7-14 days.

Shelf life: Its is advised to prepare the fertilizer for next year in the current year itself. The older the liquid – the better.

Method of usage

- If the liquid fertilizer is young then dilute it with 30 times water
- If the liquid fertilizer is very old the dilute it with 100-times water
- Filter the content and applied to the root zone of the plant

Video on preparation: https://www.youtube.com/watch?v=6izQfXMO9nY

Scientific studies on use of FLPF

Jamilah *et al.*, 2015 studied the effect of fermented liquid organic fertilizer and potassium for nutrient uptake and yield of rice at tropical upland in screen house at Padang, West Sumatera from June to November 2013. The goal of research was to get the right formula of natural fermented organic fertilizer in various compositions to substitute the use of potassium fertilizer at tropical upland rice. Experiments conducted in factorials form of treatment with 2 factors, at first factor consisted of 5 types of organic fertilizer compositions, namely; P1. (20% *Chromolaena odorata* + 70% coconut fiber + 10% activators), P2 (40% *Chromolaena odorata* + 50% coconut fiber + 10% activators) ; P3. (60% *Chromolaena odorata* + 30% coconut fiber + 10 % activators); P4. (80% *Chromolaena odorata* + 10% coconut fiber + 10% activators), P5. (activators), and second factor consists of three levels, namely K_2O ; K0 . 0 kg ha^{-1} ; K1 . 25 kg ha^{-1} K2. 50 kg ha^{-1} at a dose of liquid organic fertilizer given 1 : 5 (liquid organic fertilizer and water), given every 2 weeks, which began at planting. Analysis of nutrient content and composition of the liquid organic fertilizer includes macro nutrients (N, P, K, C-organic, pH) and micro (Fe, Mn, Zn, Cu, B and Co). The results showed that P2 (40% C. odorata + 50% coconut fiber +

10% activator) without applying the potassium fertilizer application improved nutrient uptake of N, P and potassium and grain yield up to 29% at tropical upland.

Moh *et al.*, 2018 conducted plant growth experiments in microbe-free vermiculite to study the effects of four types of fermented seaweed liquid fertilizer (SLF) made from nori (*Pyropia yezoensis*) seaweed on the germination, plant growth characteristics, SPAD value, and nutrient content and uptake of komatsuna (*Brassica rapa L. var. wakana komatsuna*). The nitrogen (N), calcium, magnesium, sodium (Na), and iodine (I) contents of plants treated with SLF1 were significantly increased relative to plants treated with the other SLFs. Plants treated with SLF1 and SLF2 exhibited the highest Na uptake. Foliar spray treatments with SLF1 resulted in the highest I contents in plants.

Taisa *et al.,* 2022 prepared liquid organic fertilizer using 2 kg bamboo shoots, 2 kg banana cobs, 2 kg baby corn, legumes, cow/goat urine, rice washing water, coconut water, molasses, and bioactivator fermented for 7 days. They reported that the application of liquid organic fertilizer (banana weevil, legumes, bamboo shoots, baby corn, bioactivator EM4, molasses, cow/goat urine) on three cauliflower cultivars significantly increased the height of the plant. This was presumably because the liquid organic fertilizer that was applied is containing the nutrients which plants need to grow.

Inferences

- Soil application of FLPF improves the plant growth and development due to availability of major and minor nutrients in the solution.
- Plants absorb the nutrient directly when FLPF is applied on Foliage of plants.

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1.1.7 Jadam Microbial Solution (JMS)

Jadam Microbial Solution is a low-cost microbial solution that was created by Youngsang Cho, the founder of the Jadam farming system. JMS is an anaerobic solution made using leaf mold, as the inoculate, in the absence of air. Leaf mold is rich in microorganisms. Leaf mold can be found in piles of leaves or sticks that have been sitting for a few weeks or months. White powdery substance on the leaves is noticed in the leaf mold. JMS is created by allowing these microbes to multiply in nutrient-rich water through the process of fermentation. Most of the nutrients required by crops are produced by microbial activities. Microbial conditions and farming are directly linked. By applying JMS, soil microorganisms will suppress specific pathogens, moderate soil temperature, and increase the diversity of nutrients for plants (Khairani *et al.,* 2023).

Ingredients

- Leaf mold 0.5 kg
- Boiled potato 1kg
- Sea Salt: 0.5kg
- Plastic container with lid
- 2 socks or cotton bags
- 2 rocks
- Stick & String

Leaf mold

Boiled potatoes

Preparation procedure

1. Pour 500 litres of water in a container. Dissolve 0.5kg of sea salt into the water.
2. Put 1 kg of boiled potatoes, 0.5kg of leaf mold and some rocks in a fine net bag.
3. Hang the bag over the container so that the bag is underwater. Knead well so that the contents melt into the water
4. To culture crop customized microbes, blend 1kg of crop residues (fruits, leaves and branches), put it in a fine bag and hang it over the container
5. Close the lid and leave under the sun for culturing. Place it in the same environmental condition as the crops. Leave it at ambient temperature.
6. It takes 1-3 days till completion. It is faster, and there are more foam in summer. If water temperature drops below 18^{0}C, use an electric heater to keep at 20^{0}C and wrap the container with insulation. It takes 24 hours when the daytime temperature is 28^{0}C; 72 hours at 25^{0}C and 96 hours at 19^{0}C.

Boiled potato, leaf mold and some rocks submerged in water

Frothing indicates the beginning of microbial multiplication

Preparation time: 4- 5days

Shelf life: Cannot be stored need to be prepared afresh every time.

Method of usage

- Dilute the solution with 10 times water and use up completely
- 500 litres of JMS can be applied to 0.1 to 3.3 hectare.

Final product ready to use

- For foliar application, dilute over 20 times, filter with a fine net.

Precautions

- Run clean water through hose after running JMS
- One must filter the liquid through a fine net before applying on soil or plants

Videos: https://www.youtube.com/watch?v=Lv-TOGhwlW4
https://www.youtube.com/watch?v=-1ST1TzBYr4

Scientific studies on use of JMS

Khairani *et al.,* 2023 conducted an experiment with the aim of examining the effect of compost tea organic fertilizer and JADAM Microorganism Solution (JMS) on the growth of chili pepper in PT. Cinquer Agro Nusantara, Bangka Belitung. This research used a completely randomized design with 15unit treatments which were divided into control group, compost tea group, and JMS group. The result showed that the plant group with JMS performed the highest height expansion, increasing the number of leaves significantly compared to control and compost tea group. This study concludes that application of compost tea and JADAM Microorganism Solution (JMS) as organic fertilizer on *C. frustescens* can increase the plant's growth.

Reference

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1.2 Formulations for seed treatment

Seed treatment refers to the application of physical and biological techniques to seeds to disinfect them from seed-borne pathogens or to protect seeds from soil-borne pathogenic organisms, to inoculate the seed and rhizosphere with microorganisms, and to supply some critical nutrients. Seed treatment can also encourage healthy crops by improving their immunity and promoting uniform germination.

In conventional agriculture primary focus of seed treatment is crop protection. While traditional crop protection methods that are applied on a broader level to the crops have their place, with seed treatment, the needs of every individual seed can be met. Seed treatment enhances the resistance of the seeds, making them stronger against pest attacks and stresses in their environment. Seed treatments can provide critical protection since the germination stage, protecting the emergence out of the soil and during the first stage of the crop cycle by preventing seeds against soil-borne pathogens, seed-borne insects, diseases, and pests. However, there are some seed treatments, such as priming, pelletizing, and the use of hot water, that can also be used by farmers to improve seed performance.

But in alternative agriculture, besides crop protection, inoculation of seed and rhizosphere with microorganisms that help in mobilising nutrients and protect from pathogens is given focus along with supply of nutrients. Seed treatment is an important concept in alternative agriculture practices like natural farming, organic agriculture and Non-Pesticide Management.

1.2.1 Beejamrutha

The ingredients required, procedure of preparation, method of storage and usage are obtained from components of Natural farming by NITI Ayog (https://naturalfarming.niti.gov.in/components/). Beejamrutha means Beej (seed) dip in Amrut (Magical Liquid). It is a treatment used for beej, seedlings or any planting material. It is an effective method to protect young roots from fungus and any soil and seed borne diseases and it improves germination also. These diseases affect crops after monsoon. It is made up of locally available ingredients and materials such as cow - dung, cow- urine, water, ant hill soil and lime powder.

Ingredients

- For 100kg seed use water 20 litres
- Use cow urine 250 ml for one litre of water
- Use Cow dung 250 grams for one litre of water
- Use Lime 2.5 g per litre of water
- Use soil-like dikes or clay bundles, which do not have any stone

Reference: Dev kumar (2007)

Preparation procedure

1) Take 5 Kg cow dung in cloth & tie it with rope.
2) Arrange something to dip this cow dung in the barrel / bucket which containing 20 Litre of water up to 12 hours.
3) In other pot, add 50 gm of lime in one Litre of water. Let it stable for night.

4) Next morning, squeeze the bundle of cow dung in same water thrice continuously, so that all essence of cow dung will get accumulated in the water.
5) Add handful of soil from bund of field in that water and stir well
6) Add 5 liter desi cow urine in the solution and lime water and stir well.

Preparation time:12-24 hours

Shelf life: It can be kept for 7 days

Method of usage

- Add Beejamrutha to seeds of any crop, coat them, mix by hand, dry them and use for sowing.
- For leguminous seeds, which may have thin seed coats, , just dip them quickly and let them dry
- For seedlings, dip them in Beejamrutha for 5mins and transplant.

Scientific studies on use of Beejamrutha

Nutrient and Microbial content of Beejamrutha (Devakumar *et al.*, 2014)

The nutrient composition of Beejamrutha and their constituents in the below table reveals that Beejamrutha is alkaline in nature and it is a good source of macro and micro nutrients. Maximum Colony Forming Units (CFU) of bacteria (623), fungi (22) actinomycetes (2), N-fixers (71) and P-solublisers (52) were recorded on the day of preparation of Beejamrutha and thereafter, it decreased progressively and it was minimum on 7th day after preparation.

	Content in Percent				**Content in PPM (Fresh)**			
	N	**P**	**K**	**pH**	**Zn**	**Cu**	**Mn**	**Fe**
Beejamrutha	2.38	0.127	0.485	8.02	18	36	16	168

Microbial load	**Bacteria (10^5)**	**Fungi (10^4)**	**Actinomycetes (10^3)**	**N fixers (10^3)**	**P solubilizers (10^3)**
1 DAP	623	22	2	71	52
2 DAP	435	11	2	40	42
3 DAP	371	11	1	39	34
4 DAP	259	9	2	39	34
5 DAP	208	2	1	28	25
6 DAP	190	2	1	19	20
7 DAP	171	1	1	15	10
*Days after preparation					

The study on Beejamrutha (prepared using the ingredients viz cow dung, cow urine, water and lime) contains not only general microflora, but also certain beneficial biochemical groups such as free living N2-fixers, P- solubilizers and bacteria producing plant growth promoting substances as well as bacteria having biological deterrent activities. Presence of such beneficial microbial biomass and nutrient status might have resulted in improved seed germination, seedling length and seed vigour in soybean indicating Beejamrutha as an efficient plant growth stimulant (Sreenivasa, *et al.,* 2009).

Sreenivasa *et al.,* (2010) conducted an experiment on Beejamrutha, a source of beneficial bacteria at the Institute of Organic Farming, UAS, Dharwad. The beneficial microorganisms present in Beejamrutha were tested for their beneficial traits. The isolates were capable of nitrogen fixation and phosphate solubilization. The isolate Az82 showed the highest amount of nitrogen fixation (13.71 mg/g carbon source utilized) whereas BPS3 showed highest amount of phosphate solubilization (8.15%). Inoculation of these beneficial isolates resulted in the improvement of seed germination, seedling length and seed vigour index in soybean.

The experiment was carried out by Naikwade Pratap Vyankatrao (2019) to evaluate effectiveness of organic liquid treatments including Beejamrutha on seed germination and seedling growth of legume crops. Seeds of four major legume crops i.e. Groundnut, Soybean, Moth bean and Green gram commonly grown in Maharashtra were collected from local markets. Treatments were seven with four replicates each *viz*. T1:Beejamrutha 25%, T2:Beejamrutha 50%, T3: Beejamrutha 75%, T4: Beejamrutha 100%, T5: Local desi cow dung extract, T6: Local desi cow urine, T7: Control. When comparing different concentrations of Beejamrutha; 100% Beejamrutha showed high germination percentage, seedling growth and Seed Vigour Index. Beejamrutha is recommended for the farmers to use in agriculture. Its regular use for seed treatment will reduce dependence on use of chemicals and subsequently reduce pollution caused by chemical treatments.

Sai Kiran *et al.,* 2021, conducted an experiment to study the influence of Seed Invigoration with Seaweed, Panchagavya and Beejamrutha on Seed Quality Parameters of Quinoa under saline condition. The treatments used in this experiment are T0 distilled water as Control, T1 and T2 Seaweed 5% and 10%, T3, T4, T5 Panchagavya 4%,6% and 10%, T6, T7, T8 and T9 Beejamrutha 25%, 50%, 75% and 100%. The results indicated the superiority with the interaction of treatment and salinity of T9S0 Beejamrutha 100% in 0mM NaCl shows 92% in germination percentage, 3.60cm in shoot length, 6.85cm in root length, 10.45cm in seedling length, 0.25g in dry weight, 961.32 in Seedling vigour index compared with control. The better performance of Beejamrutha increases the seed quality parameters due to the presence of beneficial microorganisms, nutrients, and growth-inducing hormones

Jha *et al.,* 2020, studied the comparative performance of seed treatment by Beejamrutha and Bavistin on germination percentage and seedling growth of maize and finger millet. The treated seeds of maize resulted in an increased seed germination percentage of 93% in Beejamrutha whereas germination varied from 77 to 93%. The seed germination percentage in finger millet ranged from 61-77 % with highest in Beejamrutha treated seeds (71%). Significantly highest shoot length (47.72 cm) and seedling length (70.82 cm) was found in Beejamrutha in comparison to the chemical treatments in maize. The use of Beejamrutha for seed treatment resulted in better seed germination percentage, seedling growth attributes and promotes eco-friendly agriculture of good practices devoid of chemicals.

Inferences

- Beejamrutha contains maximum CFUs of microbial count on the day of preparation and thereafter it decreases progressively. hence it is recommended to use on the day of preparation to obtain maximum benefits
- It not only contains general microflora, but also contains beneficial biochemical groups such as free living N2-fixers, P- solubilizers and bacteria producing plant growth promoting substances as well as bacteria having biological deterrent activities.
- To realise good seed germination and seedling vigor, one can rely on Beejamrutha for seed treatment

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https://www.upl-ltd.com/agricultural-solutions/crop-protection/seed-treatments

1.2.2 Beejaraksha

This helps in improving the germination rate and also protects the seedlings from soil borne pathogens and insects. The ingredients and procedure of preparation are obtained from the Advanced course on non pesticidal management, Grameen academy.

Ingredients

- Well sieved red soil or Soil from ant mounds 100 g
- Wood or dung cake ash 100 g
- Asafoetida (dry) 20 g
- Turmeric powder 20 g
- Cow urine 10 ml

Mound soil

Wood ash

Turmeric

Asafoetida

Preparation procedure

1. Mix soil and ash and sieve them well.
2. Add asafoetida and turmeric powders to this and mix well.
3. Add cow urine slowly and mix it well with a stick. Then allow it to dry in shade.
4. After drying the powder can be stored in a glass bottle, close it with a lid and keep it in shade.

Preparation time: One day

Shelf life: This Beejaraksha can be stored for six months.

Method of usage

- Spread the seeds on a plastic sheet and sprinkle rice gruel on the seeds.
- Apply 10 g of Beeja raksha per kilo seeds evenly.
- Mix the seeds well with the Beeja raksha and see that it sticks to the seeds.
- Shade dry the seeds and then sow in the field.
- In case of seeds with a thin seed coat like groundnut, the seeds can be sown immediately after application of Beeja raksha.

Video: Making of Beej Raksha: https://www.youtube.com/watch?v=BzG01Mock_k

Scientific studies on use of Beejaraksha

Chari *et al.,* 2015 stated that seed treated with concoctions depending on the problem; for example, cow urine, ash and asafoetida concoction provides protection against several seed borne diseases like rice blast, or Beejaraksha, Beejamrut to induce microbial activity in the soil and kill any seed borne pathogens.

Reference

M.S. Chari, Ramanjaneyulu, G. V., Zakir Hussain, Chandra Sekhar G, and Rajashekar G., 2015, Managing Pests without using Pesticides, *Knowledge for Change, WASSAN FOUNDATION and Permanent Green*.

1.2.3 Seed coating method for bold seeded crops

Seed coating is a mainly done for bold seeded crops like redgram, cowpea, soybean, maize, chickpea, etc. to protect the seed from damages caused by ants and termite. It helps to filter out the poor-quality seeds, increases the germination percentage and results in growth of healthy seedling (*Reference: People Science Institute, Panna, MP*).

Materials required for coating 1kg seed

- Jaggery 100g
- Termite soil: 250g
- Dry cow dung manure: 250g
- Cow urine: 250ml
- Ash: 100-250g
- Water: 1ltr

Ingredients needed for preparation

Preparation procedure

1. Select the healthy seeds by soaking in water. Healthy and bold seeds will sink to bottom and chaffy seeds float on the surface. Remove the floating seeds.
2. Soak the seeds in cow urine for 15 to 20 mins. Soaking for longer period in cow urine may result in losing seed viability.
3. Prepare jaggery syrup by heating. After cooling, mix it with seeds after soaking in cow urine.
4. Firstly, Add termite soil to seed and mix, due to stickiness of jaggery a layer of termite soil will be coated.
5. Similarly repeat the process by adding dry cow dung manure followed by ash to form a thick coat on the seed.
6. Shade dry for 30 mins before sowing to avoid aggregation of seed due to stickiness and to get individual seeds for smooth sowing.

How it works

- Plant will get all essential nutrients in the form of tonic near the root zone resulting in good and healthy seedling which offer resistance for pest and disease incidence.
- Cow manure will serve as inoculum for micro-organism
- Jaggery will serve as sticky agent and source of food for microorganism which make nutrients available for plant uptake at the root zone
- Termite soil protects seeds from termite and ant attack by repelling them

1.Sieving termite soil and manure to get fine particles

2. Jaggery syrup by heating

3. Adding jaggery syrup to seed

4.Mixing termite soil with seed

5.Mixing dry cow manure

6.Mixing Ash with seed

7. Coated Seeds ready for sowing

1.2.4 Cattle urine

Cattle urine contains about 1.0% Nitrogen, traces of P_2O_5 and 1.0% of K_2O. It is also considered as a natural disinfectant and pest repellent. Apart from cattle, urine of other farm animals are rich in major nutrients and is available in plenty which can be used for pre-sowing seed treatment to enhance germination. Bovine urines contain growth regulators, nutrients, and trace element. Treating seeds with cattle urine is affordable and so even small scale farmers can practice the same.

Ingredients

- Cattle urine 200 ml
- Water 1 litre

Seeds soaking in cow urine

Procedure

1. Take 1 litre of water in a bowl
2. Add 200 ml cattle urine to make it 20% strength

Preparation time: 10 mins

Shelf life: Can be prepared as and when required

Method of usage

- Take required quantity of seeds in a container
- Add the above solution see that seeds are completely soaked
- Keep it aside for 3 hours
- Drain the solution and shade dry the seeds before sowing

Scientific studies on use of cow urine for seed treatment

Ambika *et al.,* 2014, conducted an experiment at Department of Seed Science and Technology, Agricultural College and Research Institute, Madurai during 2014-2015, to find out the effect of pre sowing treatments with bovine urines of cow, buffalo, sheep, goat and pig. The paddy, maize, sorghum, cumbu and irungu cholam seeds (local type) were soaked for 3h with different concentrations of 5 and 10% along with control (dry treatment). The seed quality parameters viz., speed of germination, germination percentage, seedling length (cm)and vigour index were evaluated. Among the bovine urines treatment best performance was observed in cow urine (5%) in all the cereals.

Shridhar et al., 2013 recommended dosage of cow urine for treating various crop seeds:

a) *Paddy*: Collect cow's urine in a mud pot and keep it for 48 hours. Soak paddy seeds in 10% of this cow's urine (100 ml cow's urine in 1 litre of water) before sowing for healthy crop.

For bacterial leaf blight control in paddy: Soak seeds in water for 12 hours and then mix it with 10% cow's urine (10 ml cow's urine + 90 ml water) and dry it for 30 minutes. Use the seeds for sowing within 24 hours.

For seed borne fungal and bacterial diseases: Soak paddy seeds tied into small bundles using kada cloth in cow's urine solution (500 ml of cow's urine with 2.5 litres of water) for 30 minutes and shade dry before sowing.

b) *Sorghum*: Treat the seeds with dried cow dung powder and cow's urine (100 gms cow dung powder and 250 ml cow's urine per kilogram of seeds). This will break the dormancy and improve germination.

c) *Bhendi*: Soak seeds in cow's urine at 5% or 10% concentration (50 ml of cow's urine in 950 ml of water or 100 ml of cow's urine in 900 ml of water) for 12 hours before sowing.
For resistance against bacterial and fungal disease: Soak the seeds in cow's urine solution (dilution 1:5 ratio – 1 part of cow's urine in 5 parts of water) for 30 minutes before sowing.

d) *Brinjal and chilli*: Seeds should be soaked in a solution of cow's urine (1 part cow's urine + 5 parts of water) for 30 minutes prior to the sowing. This will inhibit the seed borne diseases like fruit rot and die back.

e) *Bitter gourd:* Soak the seeds in diluted cow's urine for 12 hours and in diluted cow's milk for 6 hours before sowing for good germination percentage. The dilution should be at the ratio of 1:1 (1 part of cow's urine or cow's milk with 1 part of water).

f) *Bottle Gourd:* Soak seeds in cow's urine solution (1 part cow's urine + 5 parts of water) for 30 minutes prior to the sowing. This will inhibit the seed borne diseases.

References

S Sridhar, S. Ashok Kumar, R. Abarna Thooyavathy and K. Vijayalakshmi, 2013, Seed Treatment Techniques, *Centre for Indian Knowledge Systems (CIKS) Seed Node of the Revitalising Rainfed Agriculture Network*, http://ciks.org/old-site/6.%20Seed%20Treatment%20Techniques.pdf

S. Ambika, K. Balakrishnan and K. Sujatha., 2014, Enhancing the Seed Germination and Vigour in Coarse Cereals by Bovine Urines, *Journal of Agroecology and Natural Resource Management*, 1 (2): 40-43

Yawalkar, K. S., J. P. Agarwal and S. Bokde. 1996, Manures and Fertilizers, *Agri-Horticultural Publishing House*, Nagpur: pp. 29-82.

1.2.5 Cow milk

Fresh cow milk contains hormones that relieve seeds from photo, thermo, physiological and mechanical dormancy (Rahman *et al.,* 2021 and Olusegun & Bello, 2016). Seed treatment with cow's milk increases the germination percentage and seedling vigour. It will also reduce the intensity of the vein clearing disease and increase the yield.

Ingredients

- Raw cow milk
- Water

Cow's milk

Procedure

1. Take raw cow milk (150 ml or 250ml) in a container
2. Add 850ml or 750 ml of water to it.
3. Solution is ready for usage

Preparation time: 10 mins

Shelf life: Recommended to use fresh milk every time

Method of usage

- Soak the seeds in the above solution keep it aside for 6 hour
- Drain the solution and shade dry the seeds before sowing

Scientific studies on use of cow's milk for seed treatment

Adelani and Bello, 2016 conducted a study to assess the effect of fresh cow milk and coconut milk on the germination percentage and mean germination time of *Tamarindus indica* seeds. Results revealed that the percentage germination value of seeds soaked in all concentrations of fresh cow milk ranged from 70 to 100%. Soaking of T indica seeds for 14 hrs in 50% and 100% fresh cow milk are recommended for mass production of its seedlings for mass production of its seedlings.

Rahman *et al.,* 2021, conducted a study to assess the effect of hydro priming and fresh cow milk on different seed quality attributes like germination percentage, mean germination time, the uncertainty of germination process, and synchrony of germination process of bitter gourd seeds. Results revealed that the percentage germination value of seeds soaked in all concentrations of fresh cow milk was better than hydropriming. A significant germination percentage value of 96% and 93% were recorded for seeds treated for 18 hours in 80% and 100% concentrations of fresh cow milk respectively.

Shridhar *et al.,* 2013, Recommended strength of cows milk for treating seeds of different crops; a) *Bhendi:* Treat seeds with 15% or 25% raw cow's milk (150 ml of milk in 850 ml of water or 250 ml of milk in 750 ml of water) for 6 hours and then sow. b) *Brinjal*: Soak the seeds in 12% raw cow's milk (120 ml of raw cow's milk in 880 ml of water) for good germination percentage and seedling vigour. c)*Bitter gourd:* Soak the seeds in diluted cow's urine for 12 hours and in diluted cow's milk for 6 hours before sowing for good germination percentage. The dilution should be at the ratio of 1:1. Soak the seeds in raw cow's milk for 24 hours before sowing for good germination and yield. d)*Tomato*: Soak the seeds tied in a khada cloth in diluted milk solution (75 ml milk and 425 ml water) for 6 hours and then sow. e) *Beans*: Soak the seeds in raw cow's milk for 24 hours before sowing for good germination and yield. *f) Flower crops and trees:* Soak the seeds of Sunflower and Tamarind in a mixture of wheat flour,

rice flour, black gram, ground sesame and milk (50 gms of each diluted in 1 litre of fresh buffalo milk) overnight. Shade dry and fumigate with turmeric for one minute before sowing.

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Adelani D. O. and Bello M. I., 2016, Effect of fresh cow Milk and coconut milk on the germination of Tamarindus indica seeds, *Applied tropical Agriculture,* 21(3):37-45

Md. S Rahman, I Ahmed, S Biswas, M Morshed, P C Sarker, Md Arafat Hossain, M Islam, T Jahan and A K Choudary, 2021, Effect of milk and hydro-priming on seed germination characteristics of Bitter gourd, *Turkish Journal of Agriculture-Food Science and Technology*, 9(2):296-300.

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1.3 Growth promoters

Growth promoters are bioformulations that help in enhancing the growth of the crops in terms of robust vegetative growth, strong roots and fruit setting. These bioformulations mainly contain plant hormones line Auxins, Gibberellins and Cytokinins or growth promoting substances like amino acids, proteins, humic acid and fulvic acid.

1.3.1 Shri Amruth/ Sapthadanyankur tonic

Shri Amrith is used as a natural growth enhancer (Fasal tonic). It can be sprayed during flowering of the crop to reduce the flower drop and increase the fruit set. Ingredients required and method of preparation is obtained from http://njkheti.blogspot.com/2017/07/saptdhanyankur-ark-tonic-for-plants.html

Ingredients

1. 5 types of any pulses 100 grams each
   - Green gram (Moong) 100 grams
   - Cowpea 100 grams
   - Lentil 100 grams
   - Horsegram 100 grams
   - Chickpea (Channa) 100 grams
2. Wheat 100 grams
3. Black sesame 100 grams
4. Cow urine 10 litres
5. Water 40 litres

Sprouts of pulses

Preparation procedure

1. Soak black sesame seeds in water in a bowl. Keep it aside for 1 day. After 24 hours proceed to next step.
2. Soak the seeds of greengram, cowpea, lentil, horsegram, chickpea and wheat in water in a separate bowl. Soak it for 24 hours. After 24 hours proceed to next step.
3. Next day take all the 7 types of seeds by draining the water. Tie the seeds in a cloth and hang it in shade for sprouting.
4. Keep the drained-out water separately. The seeds are hanged till the seeds are sprouted with at least 1 cm root.
5. After the seeds are sprouted crush them using grinding stone. Do not use mixer grinder.
6. Mix the cattle urine and the water that was used to soak the seed.
7. Put the seed pulp in the solution and mix it properly. Use wooden stick for stirring the solution clockwise. Cover the tank with gunny bag. Keep the solution for 2 hours.
8. After 2 hours filter the solution and use it within next 24 hours.

Preparation time: 4-5 days

Shelf life: Final product should be used within 24 hours

Method of usage: No further dilution is required.

- Spray on the vegetable crops (kharif or rabi) when the vegetables are in milking stage.
- Spray on fruit trees when the fruits are small, medium or before they mature.
- Spray on flower crops when the flowers are in budding stage.

Note: Above solution is sufficient for one acre. Use cow urine of desi cow only.

Videos on preparation: https://www.youtube.com/watch?v=JtUNXm-fBHg
https://www.youtube.com/watch?v=EscVZI9sxWQ

1.3.2 Fish Amino Acid (FAA)

Fermented fish waste is found to enrich the soil nutrients required for plant growth and favourably influences the conducting functions of xylem and phloem vessels. Thus fish waste could also be used as a valuable organic liquid fertilizer for better yield of crops at a lesser cost and without any harmful effects on soil environment (Balraj *et al.* 2014). Method of preparation is obtained from Eric Weinert Jr *et al.,* 2014.

Ingredients

- Waste of native fish 5kg
- Jaggery/Brown sugar 5kg

Preparation procedure

1. Collect fish waste (head, bones, skin, fins, viscera)
2. Weigh the fish waste and mix with an equal amount of brown sugar (1:1 ratio by weight)
3. Select a fermentation container (clay jar, plastic cooler) and place a layer of large rocks at the bottom to provide aeration, minor minerals, and an area where the liquids will collect during the fermentation process.
4. Place a layer of the fish waste and brown sugar mixture on the rock layer and cover with more brown sugar. Continue with alternating layers of the fish waste and brown sugar until the container is nearly full, ending with a layer of brown sugar. Do not leave any fish exposed.
5. Cover the container with a breathable cloth to keep out insects but allow aeration, and store out of direct sunlight in a cool, well-ventilated location secured from animals.
6. After approximately 3 to 5 days, the fish waste will begin to break down and liquefy through fermentation and the osmotic pressure generated by the addition of brown sugar. However, the process takes 2 to 6 months to complete, producing a mature FAA that is ready to use. FAA, when completely fermented, will have a sweet, slightly fishy odour.
7. Decant or pour off only the liquid portion from the fermentation container to use as FAA.

Preparation time: 60 to 180 days

Shelf life: 6months

Method of usage

- Add 5 ml of this with one litre water for spraying. It could also be mixed with irrigation water (but it should be used in larger quantities: minimum 5kg of fish and 5kg jaggery).

Precautions

- Avoid spray during full sunlight hours to prevent foliar burning and evaporation of the solution before the plant has had a chance to absorb it.

Scientific studies on use of Fish Amino Acid (FAA)

Su Su Shwe and Myat Myat Moe (2018) conducted a study at the organic fields of Vegetable and Fruit Research Development Centre (VFRDC) Hlegu Township Yangon. There are two different types (Small fish and Fish waste) and three rates (4, 8 and 12ml) of Fish Amino Acid (FAA) foliar application. Results showed that small fish (12ml/L) of Fish Amino Acid foliar applications on pumpkin

plants produced the tallest in plant length, the best quality of fruits, the highest number of young shoots, flowers, and marketable fruits yield (6.44ton/ acre).

Fish Amino Acid Fertilizer Effect & Function in Agriculture (Darren chan, 2020)

The Specific Application of Fish Protein in Crops

a. Tomato:

In the early stage: Spraying fish protein promote leaf hypertrophy, develop roots, and improve seedling adaptability.

Bud stage: Fish protein application reduce malformed flowers, and increase the fruiting rate.

Expansion period: Application of fish protein 2 times improve fruit size uniformity, increase the weight of single fruit, enhance the intensity of photosynthesis, and can extend the picking period.

b. Watermelon

(1) Spraying fish protein **at the seedling stage** helps to develop roots, strong stems, reduce the occurrence of viral diseases, and improve crop stress resistance.

After melon fruit setting, spraying fish protein 2-3 times at the interval of 7-14 days will enhance photosynthesis, increase yield and increase the sugar content.

c. Chili

After transplanting: Spraying 2-3 times at an interval of 7-15 days improve disease resistance, reduce fall of flowers and fruits, extend the harvest period, strengthen the flower and fruit bearing stems, increase the yield of pepper, and improve the quality of pepper.

Johari *et al.,* 2020 conducted an experiment to determine the effects of Fish Amino Acid (FAA) application on growth and development of okra. Results showed that FAA application and different sampling times significantly affected the shoot length of okra. Besides, the volume of FAA and the number of weeks significantly affected the soil pH and the soil moisture content, respectively.

Priyanka *et al.,* 2019 studied the effect of Fish Amino Acid and egg amino acid on various physiological parameters of rice. The result revealed that foliar spray of egg amino acid 1.0 % increased the LAI, total chlorophyll, soluble protein and yield significantly more than recommended dose of fertilizers. Foliar spray of Fish Amino Acid 1.0 % + recommended dose of fertilizers increased the Crop growth rate.

A study was carried out by Balaraj *et al.,* 2014 to evaluate the effect of Gunapaselam – fermented fish waste, on the growth of *Solanum melongena* (Brinjal) plants. Gunapaselam was prepared by fermenting the fish wastes like head, gut, fins, bones etc., with Jaggery. After 15 days, the fermented liquid fish waste was filtered and used as liquid manure. Brinjal seeds were sown in different pots with only water (control), Urea (reference) and Gunapaselam (test). Application of Gunapaselam decreased the soil pH and enhanced the exchangeable cation levels, organic matter and the essential plant nutrients nitrogen, phosphorus and potassium. Improvement in the growth traits of brinjal plants like leaf area, plant height, stem diameter, root length, fresh plant weight were observed when compared with water control and urea fertilized treatment groups.

Inferences

- FAA could be used as a valuable organic liquid fertilizer for better yield from crops at lesser cost and also without the harmful effects of chemical fertilizers.

- FAA is applied as a source of nitrogen during the early or vegetative stage of development to boost growth and size.

References

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1.3.3 Fermented Plant Juice (FPJ)

The ingredients required and method of preparation is obtained from Chos Global Natural Farming (CGNF) book. Fermented Plant Juice (FPJ) is a fermented extract of a plant's sap and chlorophylls. It is a rich enzyme solution full of microorganisms such as lactic acid bacteria and yeast that invigorates plants and animals. FPJ is used for crop treatments.

Ingredients

- Mugwart / Water amaranth / Bamboo shoot, etc.
- Jaggery / Brown sugar
- Clay jar / glass jar
- Porous paper (paper towel)
- Rubber band / thread

Extracting microorganisms from plants

Preparation procedure

1. Shake off dirt from the Plants but do not wash in water. Washing will remove useful microorganisms. If the ingredients are too big, cut them to adequate sizes, about 3 to 5 cm. This increases contact surface area and promotes osmotic pressure. (Do not mix different kinds of ingredients in one container. Use separate container for each ingredient.)
2. Measure the weight of the ingredient and the weight of brown sugar. Brown sugar should be about half of the weight of the ingredient. You should add or subtract sugar according to plant's moisture level.
3. Put the ingredients and brown sugar in a large wide container and mix them with your hands. Cover with porous paper and leave for 1 to 2 hours.
4. Put the mixture into the clay jar/pot. It should fill up ¾ of the jar. It is important that the jar is not too full or under full. The empty space is not empty. It is filled with air, for optimum fermentation to occur.
5. Put weight (Stone) on the mixture to control the amount of air in it.
6. Put on the cover and tie the jar. A cover is needed to prevent insects from getting into the mixture. Paper is ideal because it lets the air in and out.
7. Remove the weight after 1 or 2 days. After the air has escaped, put back the cover again.
8. Put the jar in a cool and shaded place. Do not open, move or stir the ingredients during the process of fermentation.

Preparation time: 5-7 days

Shelf life: 30 days at room temperature. At 15°C can be stored up to a year

Method of usage

- FPJs are normally used at a dilution rate of 1: 800 to 1000 in water.
- Apply FPJ once per week in the late afternoon, ideally an hour before sunset
- The solution can be foliar sprayed or applied to soil. The nutrient solution is applied once per week and is adjusted as the plant passes through its life-cycle stages and vegetative and reproductive phases.

Precaution

- Avoid collecting plants when there is excessive sunshine or rainfall. Collect the ingredients just before sunrise. Plants have perfect moisture level during this time.
- Avoid picking plants near the road side to prevent the polluted plants.

Scientific studies on use of FPJ

Sakimin *et al*., 2017 conducted an experiment with five treatments of Fermented Plant Juice and Fermented Fruit Juice (FFJ). The treated plant plants produced early flowers and fruits compared to untreated plants due to the enhanced production of auxin and essential nutrients. Total soluble solids were also observed to increase after 10 weeks of FPJ and FFJ application. Photosynthesis rate increased in all treatments except FPJ prepared using spinach while transpiration rate increased only in the case of FPJ prepared bamboo compared to control (without FPJ).

Gonzaga (2019) conducted research to determine the effectiveness of fermented plant juice and Fermented Fruit Juice on growth and fruition of eggplant. Results showed a positive impact on the growth of the plant with respect to time. The treated plants produced early flowers as early as 4 weeks than the other experiments. It was also observed that the treated plants exhibited pest resistance.

The results of study conducted by Sulok *et al.,* 2020 revealed that combined fermented juices, biochar, and compost positively improved soil bulk density, soil porosity, TOC, C/N ratio, available P, exchangeable K, and exchangeable Ca. The fermented juices incorporated with biochar and compost had favourable effects on the leaf chlorophyll concentration, Normalized Difference Vegetation Index (NDVI), and gas exchange rates such as photosynthesis, stomatal conductance, and transpiration.

Montojo *et al.,* reported that the FPJ can be applied to fields to accelerate soil microorganism activities, and it can be applied to plant leaves to fortify phyllosphere microbes. Furthermore, FPJ is applied to animal bedding to encourage manure decomposition. Farmers sometimes feed FPJ to weakened animals to strengthen microbial activities in gastrointestinal tracts.

References

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1.3.4. Oriental Herbal Nutrient (OHN)

The Oriental Herbal Nutrient (OHN) is a very important input in Natural Farming. It is made from herbs which are full of energy and function to increase plant robustness, to sterilize and keep plants warm. OHN revitalizes crops and activates their growth. It is made from popular oriental herbs such as *Angelica, Acutiloba,* Licorice and Cinnamon that are fermented, not boiled, to maintain the vigorous growth of crops. Method of preparation obtained from https://www.ctahr.hawaii.edu/oc/freepubs/pdf/sa-11.pdf

Ingredients

- Garlic (1kg)/ Ginger (1kg)/Cinnamon (250g)
- Toddy (1ltr)/ Ricewine (1ltr)/ Beer (750 ml)
- Jannery 1kg
- Jars/ bottles
- Porous paper
- Rubber band

Fig 1: Ginger slices

Fig 2: Garlic slices

Fig 3. Mason Jar

Preparation procedure

A. **Preparation of fresh herb extract** (*when using fresh ginger or turmeric root and garlic cloves*)

1. Slice or crush fresh ginger (Fig. 1) or turmeric root, weigh, and place in a clean glass jar to fill 2/3 full. Slice or crush garlic cloves (Fig. 2), weigh, and place in another clean glass jar.
2. Add an equal amount of brown sugar by weight to each jar. Cover the jars with muslin or a paper towel and secure with a rubber band or threaded ring portion of a Mason jar (Fig. 3), and let sit for 5 to 7 days at room temperature out of direct sunlight.
3. Fill each jar with Toddy/Ricewine/Beer/vodka (or other liquor that is 40% proof).
4. Replace the jar's cover. Let sit at room temperature, stirring clockwise with a wooden spoon every morning for 14 days.
5. Strain 1 /3 of the liquid from each jar into separate, labelled glass jars ("Ginger OR Turmeric Extract" and "Garlic Extract," respectively).
6. Repeat Steps 3 through 5, adding to the respective extract jars.
7. This extraction process (Steps 3 through 6) can be repeated up to 5 times before discarding the herb, brown sugar, and liquor mixtures (which can be composted or made into tea).

B. **Preparation of Dehydrated Herb Extracts** (*when using dehydrated or dried angelica bark, licorice root, and cinnamon bark; also if using dehydrated or dried ginger or turmeric and garlic*)

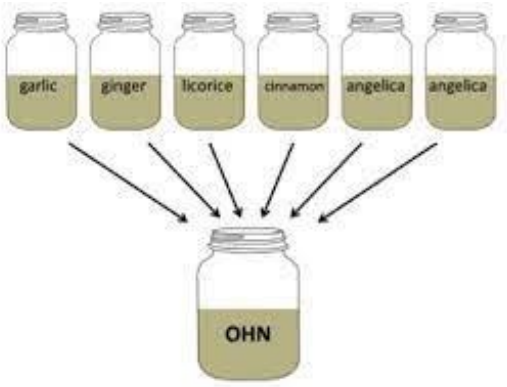
1. Chop each dehydrated herb into ½" cubes. Using a SEPARATE jar for each herb, fill a clean glass jar 1 /3 full. Prepare TWO jars of angelica.
2. Add rice wine or beer to bring the contents of each jar to ½ full. Let sit at room temperature for 2 days to allow the herbs to rehydrate.
3. Add brown sugar to bring the contents of each jar to 2 /3 full. Cover the jars with muslin or a paper towel and secure with a rubber band or threaded ring portion of a Mason jar, and let sit for 5 to 7 days at room temperature out of direct sunlight.
4. Add vodka (or other liquor that is 40% proof) to fill the jar completely (Fig. 5). Replace the cover and let sit at room temperature, stirring clockwise with a wooden spoon every morning for 14 days.
5. Strain 1 /3 of the liquid from each jar and store each extract into separate labeled jars (for example, "Licorice Extract," "Cinnamon Extract," and two "Angelica Extract" jars).
6. Repeat Steps 4 through 5, adding to the respective extract jars.

7. This extraction process (Steps 4 through 6) can be repeated up to 5 times before discarding the herb, brown sugar, and liquor mixtures (which then can be composted or made into tea).

Process of extracting fresh and dry herbs individually

C. **Preparation of OHN**

1. In a clean glass jar, combine equal portions of each herb extract in the following proportions: 2 parts angelica, 1part licorice, 1part cinnamon, 1part ginger or turmeric, 1part garlic.
2. Stir slightly with a wooden spoon, then cover LOOSELY and store for 6 to 12 months in a cool, dark cabinet. It is important to keep the jar loosely covered to allow air circulation and to prevent the build-up of gases produced by the fermentation process.
3. Always SHAKE OHN before use.



Preparing OHN from individually fermented juice

Preparation time: 15 days

Shelf life: 45 days if liquor not used and 6-12months if liquor is used

Method of usage

When ready to use, shake the jar of OHN well and dilute with water to a ratio of 1:1,000. Make the solution weaker (1:1,500) if it is to be applied to stressed plants or during drought conditions, or if the OHN has been concentrated by storage for more than 6 months

- Apply as a foliar spray on plants to repel insects. Apply during late afternoon or early morning hours. OHN can be mixed in a cocktail with Fermented Plant Juice (FPJ) and Brown Rice Vinegar (BRV) and applied as a foliar spray every 10–12 days to make plants less susceptible to powdery mildew and downy mildew.
- Apply diluted OHN as a soil drench prior to planting to activate dormant soil microorganisms.
- OHN is also an ingredient in other Natural Farming inputs, IMO#2 and IMO #4 (Park and DuPonte 2008), as part of a seed-soak solution or soil-treatment solution.

Scientific studies on use of OHN

Clint and Abdani, 2020, studied the effect of oriental herbal nutrient on the growth and yield performance of lettuce. Treatments are: T1 (Garlic), T2 (Ginger), T3 (Black Pepper), T4 (Onion), and T5

(Control) with a dilution rate of concoction of 1 tbsp. OHN: 1 liter of water. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Plant height, number of leaves developed, pest incidence, insect damage rate, weight per plant, and yield per plot were measured. The findings showed that T4 (Onion) and T2 (Ginger) significantly affect the plant height and number of leaves. The pest incidence of lettuce is higher at early and vegetative stage of the plant since the plant is much succulent and also due to the environmental factors. In controlling pest infestation, it was observed that among the treatments, the most effective are T3 (Black pepper) and T1 (Garlic). However, with apt application of OHN, generally, the insect damage rate of the study fell under the scale 2 which means that the damage is less than 24% of the plants. This showed that the application of Oriental Herbal Nutrients has significant effect on the lettuce that lessens both pest incidence and insect damage rating on the plant.

Gasana *et al.,* 2020, studied the Effect of foliar spraying Mixed with Fish Amino Acids (FAA) and Oriental Herbal Nutrient (OHN) extract on Growth, Yield and Quality of watermelon (*Citrullus lanatus*). The mixture of F_3O_3 ($3ml.l^{-1}$ of FAA + $3ml.l^{-1}$ of OHN) shows the highest vine length, internode length and number of leaves compared to control (F_0O_0). The high concentration of FAA in a mixture had negative effect on total soluble solids content but their effects were positive in lycopene content while the high concentration of OHN had a positive effect on the total soluble solids content in brix percentage and less effect on Lycopene content.

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1.3.5 Upla amrith/ Gibberlic acid

Upla amrith mainly contains growth promoter gibberlic acid along with 14 other compounds which are beneficial for the growth and development of the crop.

Ingredients

- Cow cake 8 to 10
- Water 20-40 litres

Cowdung cake

Preparation procedure

1. Take 30 to 40 litres of water in a plastic container
2. Keep the cow dung cake completely immersed in water
3. Keep the entire setup under shade for 4 days
4. After 4 days solution appears reddish in colour

Preparation time: 4 days

Shelf life: Can be prepared afresh whenever required

Method of usage

- For foliar application, add 13 litres of water and 2 litres of upla amrith in a spray pump. This can be sprayed to all crops
- 12 litres of upla amrith in 80 litres of water is required to cover an area of 1 acre.
- Spraying can be started from 15 days after germination at the recommended rate and can be repeated at 15 -20 days interval regularly till harvest of the crop

Note: One year old cow dung cake to be used to get good result

Video on method of preparation: https://www.youtube.com/watch?v=whnD7e-RXSs

Scientific studies on production and use of Upla amrith

El-Sheikh et al., 2020 reported the use of cow dung for the production of gibberellic acid. This substrate was recognized as a cheap material and it was used as substrate for gibberellic acid production by *Paecilomyces sp*. ZB. In Solid State Fermentation (SSF), production of gibberellic acid ranges from a few mg to 8 mg / g of dry substrate. In the present study, 200 ppm gibberellic acid spray concentration was maximum and enhanced plant growth (74.5 ± 6.7 cm). At higher GA concentration, plant growth suppressed. GA increased number of branches, plant height, number of leaves, leaf area, dry and fresh weights (Khan et al., 2010). In dwarf pea seeds, application of GA enhanced shoots growth stimulation (Baumgartner *et al.,* 2008). In Faba Bean, the combination of 20 mM Ca^{+2} with 10^{-6} M GA3increased shoot fresh weight, plant height, shoot dry weight, root fresh weight, root length, root number, root dry weight, water content, anthocyanin, chlorophyll and carbonic anhydrase activity (Al-Whaibi *et al.,* 2010).

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1.3.6 Egg Amino Acid

The amino acid requirement is highly essential to **increase yield and overall quality of crops.** The application of amino acids for foliar use is based on its requirement by plants in general and at critical stages of growth in particular. Plants absorb amino acids through stomata and absorption is proportionate to environment temperature. The egg amino acid is an excellent compound for pest control and growth acceleration in vegetables. Egg amino acid spraying is recommended for good flowering and large berries. It can also be used against fungal and viral diseases occurring in chilly. Ingredients required, procedure of preparation and method of usage in obtained from TNAU. (https://agritech.tnau.ac.in/org_farm/orgfarm_cropproduction_plantprotection_eggextract.html)

Ingredients

- 30-40 lemons (Juice should be sufficient enough to soak eggs)
- 12 eggs
- 250 gram Jaggery
- Detergent powder 50 gm

Eggs

Lemon

Preparation procedure

1. Place the eggs in a jar and pour lemon juice in it until the eggs are completely immersed.
2. Keep it for ten days with the lid closed.
3. After ten days smash the eggs and prepare the solution.
4. Add equal quantity of thick jaggery syrup to it and set aside for ten days.
5. The solution will then be ready for spraying.
6. This is a great nutrient for the plants just like Fish Extract and will boost plant growth.

Detergent powder

Preparation time: 20 days

Shelf life: 30 days after filtering

Method of usage

- To the above mixture add 50 gms of detergent powder and use for spray
- Dilute egg amino acid in 2 ml of one litre of water and spray on the plants. It is best to spray once in 10 days.

Video on preparation and usage: https://www.youtube.com/watch?v=c6OqiLZJuQs
https://www.youtube.com/watch?v=WmuDdwBoYqU

Precautions

- Eggs has to be cleaned thoroughly to remove dirt from the shell before soaking in the lemon juice
- Open and close the lid of container twice a day to release the gases produced during the process of fermentation.

Scientific studies on use of egg amino acid:

Priyanka, *et al.,* 2019, revealed that recommended dose of fertilizers + egg amino acid 1.0 % applied during basal, tillering, panicle initiation and flowering stages recorded higher growth and yield parameters in rice.

Karthika *et al.,* 2017 undertook a study to evaluate the antifungal potential of selected organic preparations, botanicals and non-hazardous chemicals under in vitro against *Rhizoctonia solani* Kuhn causing sheath blight in rice. A total of twenty treatments were tested for their efficacy in inhibiting the mycelial growth of *R. solani.* Among the treatments, six treatments viz., garlic extract (10%), fermented weed (*Setaria barbata*) extract (100%), fermented egg-lemon juice extract (10%), potassium silicate (1%), lime solution (12.5%) and panchagavya (5%) showed cent percent inhibition of *R. solani* in potato dextrose agar medium. Further, dipping the sclerotia for different time intervals in the most effective six treatments revealed that fermented egg-lemon juice extract (10%), fermented weed extract (100%), lime solution (12.5%) and panchagavya (5%) completely inhibited the mycelial regeneration from sclerotia at 24 hours after dipping.

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1.3.7 Soyabean Tonic

Soyabean tonic offers help in promoting protein generation with its constituent amino acid acting as building blocks for achieving proper growth. It's constituents comprising humic acid, amino acid, and folic acid and also supports the demands of regulating growth of plants. It helps in enhancing flowering and fruiting. It has good chelating effect on micronutrients which helps in storage of nutrients in plant tissues

Ingredients

- Soybean seeds 1kg
- Jaggery 250 g
- Water 4 litres

Soybean seeds

Preparation procedure

1. Soak 1 kg of soyabean seeds in water for 24 hours
2. Grind and make paste from the soaked seeds
3. Add 250 grams of jaggery to the paste and mix well
4. Add 4 litres of water and ferment it for 4-5 days

Jaggery

Preparation time: 5-6 days

Shelf life: Prepared tonic should be used within 24 hours

Method of usage

- Foliar spray: 250 to 500ml of tonic should be mixed with 16 liters of water and sprayed
- With irrigation water: For an acre 5-7 liters of tonic is mixed with irrigation water which helps in improving soil fertility.

1.4 Broad spectrum biostimulants

1.4.1 Jeevamrutha

Jeevamrutha is made of two words – Jeeva and Amrutham. Both are derived from Sanskrit and widely used words in Hinduism. The word "**Jeeva**" means is a **living being** or any entity imbued with a life force. The word "**Amrutha**" means the **elixir of life** capable of prolonging life. In our context, Jeevamrutha is elixir for crop life. Jeevamrutha can be used for the increase in microbial activities in the soil. In the initial 2-3 years of shifting to alternative agriculture, give Jeevamrutha as much as possible to the soil.

Ingredients

Preparation of Jeevamrutha for one acre of land:

- Water 200 litres
- Desi cow dung 10 kgs
- Desi cow urine 10 litres
- Jaggery 1 kg or any fruit pulp 1kg (Papaya, Guava, Banana or Mango)
- Flour of any pulses (Greengram, Bengal gram, blackgram, Beans, Redgram, etc.) 2kg
- A handful of fertile soil from your farm

Source: Dev kumar, 2007

Role of ingredients used in preparation of Jeevamrutha

(Allu Vishnu and Sandeep Menon, 2021)

- **Cow dung:** Cow dung based organic manures contain different species of beneficial microbes, predominantly bacteria, fungi, yeast, and actinomycetes. These microbes bring in the mineralization process and make nutrients available to the plants when applied to soil.
- **Cow urine:** Cow urine is rich in amino acids, result in increased nitrogen percentage in organic preparations and also provide resistance to plants against plant pathogens
- **Jaggery:** Jaggery contain potassium a quality nutrient for plants and increase drought resistance; further it acts as the energy source for the microorganisms.
- **Pulse flour:** Pulse flour is rich in amino acids which in turn improve the beneficial microorganisms and it is a good source of dietary protein with less fat. It acts as food for the microbes in the bioformulation.
- **Fertile soil:** A handful of soil is collected from the field for which this formulation is to be used and is also added at the time of preparation. This would serve as an initial inoculum of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers native to the field.

Preparation procedure

Follow the steps given below to prepare Jeevamrutha for **one acre of the crop**:

1. Take a **water barrel** or a tank that is big enough to have 200 litres of water; now pour 200 litres of water into the tank or barrel.
2. Do keep the water barrel in the **shade**.
3. Add 10kgs of desi cow dung into the water.
4. Stir the mixture well with the help of stick in **clockwise direction**. If you can use your hand to stir, it's even better. Most of the beneficial microbes are present in the mixture.
5. Now add the handful of **fertile soil** from your farm along with 10 litres of desi cow urine to the mixture. Stir the solution well in the clockwise direction.

6. Finally, add the semi powdered **jaggery** and the pulse flour to the mixture, and stir again. Give a proper stir for some time, till you know all the ingredients are mixed well.
7. Cover the water barrel or tank with a **jute bag**. The cover should be breathable, the air should pass through.
8. Keep the mixture stable for two to three days to ferment.
9. During the process of fermentation, all the poisonous gases like Ammonia, Methane, Carbon monoxide, and Carbon dioxide are emitted.This is the reason to use the cover which is breathable so that the poisonous gases can escape. Aerobic fermentation should be followed.
10. Stir the solution thrice a day and keep the solution in shade. **Do not expose Jeevamrutha to the direct sunlight or to rain.**
11. After two- or three-days fermentation will be at peak. The microbial count would have increased multiple folds by now making it as a perfect **organic fertilizer**. These microorganisms are the ones required by the crops to convert most of the unavailable nutrients to available form.

Shelf life: It has to be applied between 7-9 days from the days after preparation.

Do's and Don'ts in Jeevamrutha preparation

a) Don't use copper or iron drums for preparation
b) Fresh cow dung should be used
c) Application should be done in morning or evening hours
d) There should be enough moisture in soil at the time of application
e) Drum should not be covered with lid; instead cover with gunny bags for movement of gases

Scientific studies on use of Jeevamrutha

1. Nutrient and Microbial content of Jeevamrutha (Devkumar, et al., 2014):

From the table it was noticed that jeevamrutha is acidic in nature and a good source of macro and micro nutrients. The higher colony forming units (CFU) in Jeevamrutha were recorded between 9th to 12th days after preparation. In the preparations, higher number of bacterial CFUs viz., *Azotobacter sp., Bacillus sp., Beijerinckia sp., Chromatium sp., Chromobacterium sp., Pseudomonas sp., Rhodomicrobium sp., Serratia sp., Xanthomonas sp*., were recorded. The different fungi observed were: *Aspergillus sp., Fusarium sp., Penicillium sp., Trichoderma sp*., and N-fixers like Bacteria - *Azotobacter sp., A.chroococcum, Bacillus sp., Beijerinckia sp.,* Actinomycetes - *Streptomyces sp*. It clearly indicates that the Jeevamrutha is an enriched consortia of native soil microorganisms. The preparation would give best results if it is used between 9th to 12th days after preparation.

	Content in Percent				**Content in PPM (7DAP*)**			
	N	**P**	**K**	**pH**	**Zn**	**Cu**	**Mn**	**Fe**
Jeevamrutha	1.96	0.173	0.280	4.92	12	51	46	318

Microbial load	**Bacteria (10^5)**	**Fungi (10^4)**	**Actinomycetes (10^3)**	**N fixers (10^3)**	**P solubilizers (10^3)**
1st DAP	213	11	1	34	61
5th DAP	361	1	1	23	37
10th DAP	855	28	8	69	80
15th DAP	562	18	06	40	34
20th DAP	292	04	02	30	35
*Days after preparation					

Santosha Gowda *et al* (2021) conducted an experiment to study shelf life of Jeevamrutha prepared from cow dung and cow urine of different desi breeds. In this study cow dung and cow urine of three different desi cow breeds viz., malnad gidda, gir and sahiwal were collected aseptically and separately to prepare Jeevamrutha. After preparation of Jeevamrutha samples were collected daily from 1st day to 15th days and enumerated the general and beneficial microorganisms viz., bacteria, fungi, actinomycetes, phosphate solubilizing microorganisms (PSM), nitrogen fixers, Pseudomonas, potassium solubilizing microorganisms (KSM), Zinc solubilizing microorganisms (ZnSM) and *Trichoderma* with their respective media. Among the three desi cow breeds the Jeevamrutha prepared from, malnad gidda breed of cow contained the maximum microbial population. In general, the highest microbial population was noticed between 7 to 9 days after preparation (DAP) of Jeevamrutha in all the desi breeds.

Boraiah *et al* (2017) reported that among two levels of organic liquid formulation (Jeevamrutha and without Jeevamrutha), application of Jeevamrutha recorded significantly higher fruit yield of capsicum. Whereas, N-fixers and P-solubilizers were found to be higher in plot treated with Jeevamrutha at harvest during kharif and summer, respectively.

Shaikh and Gachande, 2015, study the effect of various liquid organic inputs and inorganic inputs on soil physico-chemical properties. Overall results show the in the case of field applied with organic inputs there was significant increase in soil properties like organic carbon (0.11 % to 0.34 %), phosphorus (6.62 kg/h to 15.16 kg/h), and water holding capacity (3.3 % to 8.5 %) over inorganic inputs applied field. There is a significant decrease in pH (0.79 to 1.23) and Electrical conductivity (0.07 ms/cm to 0.36 ms/cm) of soil in organic fields compared to inorganic fields. From above findings it is clear that application of organic inputs like farm yard manure, Beejamrutha and Jeevamrutha significantly improves soil nutrient properties which results in increase in fertility and productivity of soil for sustainable development.

Inferences

- The higher colony forming units (CFU) in Jeevamrutha were recorded between 9th to 12th days after preparation.
- N-fixers and P-solubilizers were found to be higher in plots treated with Jeevamrutha.
- Fields applied with organic inputs showed significantly minimum and maximum increase in soil properties like organic carbon, phosphorus, water holding capacity over inorganic inputs applied field.

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1.4.2 Panchagavya

The Panchagavya is an efficient plant growth stimulant that enhances the biological efficiency of crops. It is used to activate soil and to protect the plants from diseases and also increase the nutritional quality of fruits and vegetables. It is used as a foliar spray, soil application along with irrigation water, seed or seedling treatment, etc. Ingredients required, method of preparation, method of application are obtained from TNAU (https://agritech.tnau.ac.in/org_farm/orgfarm_panchakavya.html)

Ingredients

- Fresh cow dung- 7kg
- Ghee- 1 kg
- Curd – 2 litre
- Cow urine- 10 litre
- Milk- 3 litre
- Water 10 litre
- Tender coconut water 3litre
- Jaggery 3kg
- Well ripened banana 12no

Ingredients needed for Panchagavya

Preparation procedure

1. Cow dung - 7 kg
2. Cow ghee - 1 kg

Mix the above two ingredients thoroughly both in morning and evening hours and keep it for 3 days

3. Cow Urine - 10 litres
4. Water - 10 litres

After 3 days mix cow urine and water and keep it for 15 days with regular mixing both in morning and evening hours. After 15 days, mix the following and panchagavya will be ready after 30 days.

5. Cow milk - 3 litres
6. Cow curd - 2 litres
7. Tender coconut water - 3 litres
8. Jaggery - 3 kg
9. Well ripened poovan banana – 12 nos.

All the above items can be added to a wide mouthed mud pot, concrete tank or plastic can as per the above order. The container should be kept open under shade. The content is to be stirred twice a day both in morning and evening. The Panchagavya stock solution will be ready after 30 days. (Care should be taken not to mix buffalo products. The products of local breeds of cow are said to have more potency than exotic breeds). It should be kept in the shade and covered with a wire mesh or plastic mosquito net to prevent houseflies from laying eggs and the formation of maggots in the solution. If sugarcane juice is not available add 500 g of jaggery dissolved in 3 litres of water.

Preparation time: 45 days

Shelf life: 6 months

Method of usage

- **Spray system:** 3% solution was found to be most effective compared to the higher and lower concentrations investigated. Three litres of Panchagavya to every 100 litres of water is ideal for all crops. The power sprayers of 10 litres capacity may need 300 ml/tank. When sprayed with power sprayer, sediments are to be filtered and when sprayed with hand operated sprayers, the nozzle with higher pore size has to be used.
- **Flow system :** The solution of Panchagavya can be mixed with irrigation water at 50 litres per hectare either through drip irrigation or flow irrigation
- **Seed/seedling treatment:** 3% solution of Panchagavya can be used to soak the seeds or dip the seedlings before planting. Soaking for 20 minutes is sufficient. Rhizomes of Turmeric, Ginger and sets of Sugarcane can be soaked for 30 minutes before planting.
- **Seed storage:** 3% of Panchagavya solution can be used to dip the seeds before drying and storing them.

Periodicity

- *Pre flowering:* Once in 15 days, two sprays depending upon duration of crops
- *Flowering and pod setting stage:* Once in 10 days, two sprays
- *Fruit/ Pod maturation stage:* Once during pod maturation

Scientific studies on use of Panchagavya

Vinay Kumar and Prabhat Kumar Singh (2021) studied the influence of organic formulations as foliar sprays on yield attributing traits of Onion (L.) *Allium cepa*. Three organic formulations were applied as pre- harvest spray viz., neem based formulation (Besara), Panchgavya, *Trichoderma viride* (bio shield) and Control (water). Organic formulations sprayed as foliar application at the interval of fifteen days on pre-harvest gave better results in yield and yield attributing characters of onion as compared to control condition. Panchgavya applications resulted in maximum plant height, number of leaves, bulb diameter and bulb weight irrespective of onion varieties.

Shiva kumar *et al.,* (2020) studied the effect of organic manures and liquid organic formulations on wheat (*Triticum aestivum* L.) economics. The result concluded that the maximum grain yield (2.39 t/ha) and straw yield (3.67 t/ha) was recorded with application of FYM 75% + VC 25% + Panchagavya at 2% + Vermiwash at 5% spray. The economic analysis clearly indicates a higher benefit: cost ratio (2.11) recorded with application of FYM 50% + VC 50% + Panchagavya at 2% spray.

Ashokh Aravind *et al.,* 2020 conducted a field experiment at Agricultural College and Research Institute, Killikulam, during rabi season (2019-2020) to study the impact of various solid and liquid organic supplements on growth and yield of transplanted finger millet. Treatments consisted of two solid organic supplements (100% FYM and 100% poultry manure) each in combination with three different liquid organic supplements (3% Panchagavya, 3% Jeevamrutha and 3% Beejamrutha, respectively). The higher growth and yield was significantly recorded with the application of 100% poultry manure + 3% Panchagavya at 30 and 45 DAT.

Boraiah *et al* (2017) studied the effect of spraying 2 different doses (3% and 6%) of Panchagavya along with control on yield of capsicum. Results of study indicated that spraying of Panchagavya 6 per cent recorded significantly higher fruit yield compared to control and Panchagavya sprayed at 3 %.

Sailaja *et al*., 2014 conducted a field experiment to evaluate the potential of utilizing Panchagavya as biofertilizer, on the leafy vegetable *Spinacia oleracea*. The total microbial count and the physicochemical properties of the soil such as pH, EC, N, P, K and OC (organic carbon) were analyzed. Quantity of phytohormones like Indole Acetic Acid (IAA), Gibberlic acid (GA3), Kinetin and

Abscisic acid in the soils are enhanced due to application of panchagavya. There is an increase in biomass (301%), shoot length (88.53 %) and root length (71.03 %) in panchagavya treated plants over control. The chromatographic analysis of the leaf reveals that there is an increase in the carbohydrate, vitamin and mineral content of the leaf. The total viable count and the total bacterial count of *Rhizobium*, *Azospirillum* and Actinomycetes were enhanced in Panchagavya treated soil.

An experiment conducted by Choudhary *et al*, 2014 to study the effect of foliar application of panchagavya and leaf extracts of endemic plants on groundnut. The results revealed that foliar application of panchagavya + leaf extract of neem recorded significantly higher number of nodules, number of pods per plant, pod weight per plant, pod yield, haulm yield and harvest index as compared to other treatments. Panchagavya + leaf extracts of neem recorded significantly higher 100 kernels weight, shelling per cent, nutrient uptake of N and P, and oil content over other sources. Foliar application of panchagavya with leaf extract of plants both at branching and flowering stages was found most effective with respect to nutrient uptake of N and P kernels and haulms as compared to single application either at branching or flowering stage.

Nutrient content and microbial count in panchagavya (Sonali phate *et al,* 2014): Panchagavya treatment was seen to be more favourable for the proper growth of Actinomycetes and PSM in the soil. Panchagavya samples are noted to contain the highest amount of enzyme dehydrogenase, acid phosphatase and peroxidase.

	pH	**Total carbon (%)**	**Total nitrogen (%)**	**Available nitrogen (%)**	**Total phosphorus (%)**	**Total potassium (%)**
Nutrient content	7.78	0.0046	0.0085	0.0069	0.0426	0.0046
	Total bacterial CFU / ml	**Total fungal CFU / ml**	**Actinomycetes CFU / ml**	**Azotobacter CFU / ml**	**Pseudomonas fluorescens CFU / ml**	**PSM CFU /ml**
Microbial count	15.1×10^7	25.0×10^6	2.13×10^6	1.31×10^6	9.6×10^2	20.8×10^4
	Dehydrogenase (ppm)	**Acid phosphate (ppm)**	**Alkaline phosphatase (ppm)**	**Polyphenol oxidase (ppm)**	**Peroxidase (ppm)**	
Enzymatic activity	33.70	753.51	756.66	84.49	60.95	

The experiment was undertaken by Naik *et al*., (2013) during 2009 to 2012 to study the different concentration of Panchagavya on the growth and flowering of Cymbidium 'Sleeping Nymph'. The media application of 1:30 panchgavya registered highest pseudobulb length and girth and resulted in 31.66 and 41.3% increase over control, respectively. Furthermore, the number of spikes per plant, floret per spike, spike length and rachis length were recorded highest in the media application of Panchagavya at 1:30 and resulted in 130, 55.3, 22.4 and 26.3% increase over control, respectively. Among the foliar application of Panchagavya, the treatment receiving Panchagavya at 1:30 (T3) performed better for growth and flowering of Cymbidium hybrid. The results confirmed that the application of Panchagavya at 1:30 either in media or in foliar application was best for the growth and flowering of Cymbidium hybrids.

Joseph and Sankarganesh (2011) has also reported the antifungal property of Panchagavya. The current study evaluated its use in microbiological mediums. 10µl, 100µl, 500µl and 1000µl of Panchagavya mixed with 1.5% water agar medium and after sterilization, incubated at room temperature. After 5 days of incubating the samples from Panchagavya, the 1000 µl dilution alone showed 100% antifungal activity. Additionally, the remaining dilutions (500, 100 µl) showed moderate

antifungal activity. But at no antifungal activity at lower dilution(10 µl). According to these data, the higher dilutions of Panchagavya are a promising source for simple and naturally derived less expensive bacteriological media with antifungal effect with growth promotion.

Pathak and Ram (2007) reported that Panchagavya krishi- a system of agriculture by using Panchagavya from five products obtained from cow i.e., cow dung (7 kg), cow ghee (1 kg), cow urine (10 litres), water (10 litres), cow milk (3 litres), cow curd (2 hires), tender coconut (3 litres), jaggery (3 kg) and well ripened banana (12 Nos.). The preparation was rich in IAA, GA and microflora i.e., bacteria (19x10 /ml), anaerobes (1x10/ml), acid formers (360/ml) and methanogens (250/ml).

In 2007, Swaminathan *et.al.* reported that ultimate product of Panchagavya had total N (302 g/kg), total P (219 mg/kg), total K (355 mg/kg), total organic carbon (0.80%), Zn (0.26 mg/kg), Fe (0.83 mg/kg), Mn (0.23 mg/kg), Cu (0.20 mg/kg), pH (6.02) and electrical conductivity (3.02 dS/m).

Boomiraj and Christopher (2007) used the Panchagavya and botanical spray on the soil microbial population. Higher bacterial and fungal population were recorded in treatment given poultry manure and Panchagavya (145 x 10^6 cfu and 103 x 10^4 cfu), followed by the application of neem cake and Panchagavya (140.0 x 10^6 cfu and 102 x 10^4 cfu) and poultry manure and herbal leaf extract (138.5 x 10^6 cfu and 101.5 x 10^4).

Panchagavya acts as growth promoter (75%) and immunity booster (25%) and exactly fills the missing link to sustain the organic farming without any yield loss (Vedivel, 2007). Biochemical properties of panchagavya revealed that it contains almost all the major nutrients like N, P, K and micronutrients necessary for plant and growth hormones like Indole acetic acid (IAA) and Gibberellic acid (GA) required for crop growth as well as the predominance of fermentative microorganisms like *yeast, azotobacter, phosphobacteria and lactobacillus* (Selvaraj, 2003)

Inferences

- The importance of Panchagavya and its usage in soil fertility enhancement, microbial count, antifungal property and enzymatic activity can be seen.
- It can be used as growth promoter due to presence of hormones like Indole acetic acid and gibberellic acid
- Panchagavya can be used as foliar spray due to presence of major and micronutrients.
- It can be used to treat many fungal diseases due to its antifungal properties.
- It can be applied to soil directly which helps in mineralization due to presence of microorganisms and enzymes required for the mineralization process.

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1.4.3 Indigenous Micro Organisms (IMO)

Ingredients required and procedure for preparation is obtained from Chos Global Natural Farming (CGNF) book written by Rohini reddy. The microorganisms that have been living in the farm or local area for a long time are more suitable and better than microorganisms sourced from outside in aiding agriculture in various ways, including improving soil fertility and pest resistance. They have survived and can survive the extreme climatic conditions of the local environment. Since they are already available in the field, they are considered the best inputs for conditioning the land. The IMO bioformulation builds on this principle (CGNF Book).

Ingredients

- Wooden box
- Hard cooked rice (Less moisture to collect aerobic microbes)
- Porous paper (Paper towel)
- Rubber band/ Thread
- Wooden box
- Container box/ Basket made out of bamboo
- Jaggery / Brown sugar (Unrefined sugar)
- Glass jar / Clay pot

Preparation procedure

1. A wooden box of Length 12 inches x Width 8 inches x Height 4 inches is made with ½ an inch thickness wood.
2. Fill the wooden box with steamed rice. Its moisture content will attract the indigenous microorganisms living in the local soil. (Allow adequate air supply by not stuffing the rice higher than 3 inches (do not press/hard the rice in the box))
3. Cover the wooden box with white plain paper (avoid newspaper) and use a rubber band or thread to hold the paper to the box. Paper allows air to pass through.
4. Mark an area 12 inches x 8 inches in the soil in a place where microorganisms abound, such as in a forest / field or at the site where many decomposed leaf molds are found. Excavate 2 inches of soil to make a rectangular pit. Place the rice-filled wooden box in this pit, Cover the box with leaves.

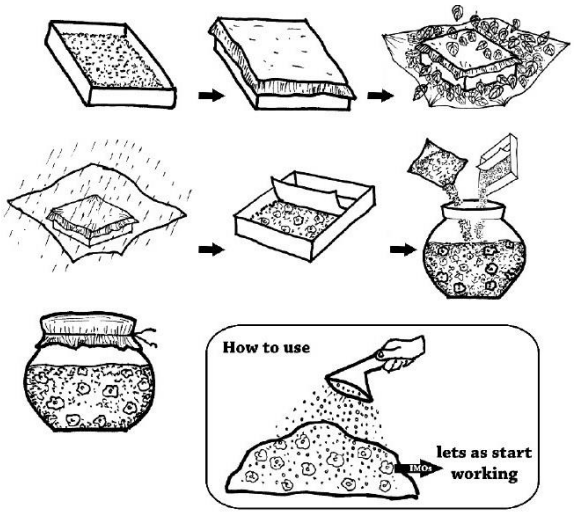

Photo credit Cho's Global Natural farming book

5. A container box or basket is placed on this set-up to protect the wooden box from stray animals.
6. Prevent rain from getting through by covering with leaves (use plastic sheet only if necessary during excess rains).
7. *At 20°C, it will take about 5 to 6 days to grow the microbes in the box filled with IMOs. Collection will be faster (2 to 3 days) if the temperature is higher than 30°C to 35°C*
8. After 3 days the rice will be covered with microorganisms. Move the IMO formed rice to a clay pot / glass jar. The IMOs thus collected is called as IMO-1.
9. Mix jaggery with the IMO-1 in 1:1 ratio. For Eg 1 Kg of jaggery should be mixed with 1 Kg of IMO-1. This mixture of brown sugar and IMO-1 is called as IMO-2.

10. *The less process the sugar has undergone, the more effective it is. Therefore, white refined sugar is not recommended. Brown sugar is advisable, but crude and unrefined sugar (jaggery) is better.*
11. Cover the container using paper and hold in position using a rubber band or thread and keep the pot in a cool place.
12. IMO 2 have to be diluted in the ration of 2: 1000 and to be applied on rice bran along with Fermented Plant Juice and Fermented fruit juice to make IMO-3

Preparation time: 20 days

Shelf life: IMO-1 has to be added with dry brown sugar. The brown sugar pulls all of the water out of the microbe bodies by absorbing the water molecules. The microbes sporulate and become dormant through the loss of water. This process is called IMO-2 and causes the spores to be shelf stable for atleast two years.

Method of usage

- Combine 1 part of IMO-3 with 1 part of soil. 50% of the soil used for the mixture should be from field for crops and other half is from fresh new soil (mountain soil, red fine soil etc). This will harmonize wild IMOs with field IMOs.
- Mixing should be done on the soil floor not on the concrete
- Create a heap of this mixture not more than 20cm height.
- Keep the mixture covered for two days.
- When needed, control moisture with natural farming inputs such as Fermented Plant Juice, Fermented Fruit Juice, Fish Amino Acid etc.
- Final mixture can be incorporated in soil or IMOs can be added to the compost for microbial boost or used as organic fertilizer.

Mode of action

- When we have established a range of IMO into the soil by feeding them Natural Farming solutions, the bodies of the microbes will become our fertilizer. The solutions give the plants the ability to control and select the particular microbes they need for their root system. This selection is done through the plant's release of exudates from the roots that feed and attract specific microbes.
- Once the plant has attracted the specific fungi or bacteria they desire, larger microorganisms like protozoa and nematodes, naturally come to graze on the bacteria/fungi. These larger organisms consequently excrete the bacterial/ fungi in a water soluble form at the plants roots, where the plant will absorb the nutrient rich waste.
- Beneficial fungi found in IMO will regulate pathogenic organisms in soil through their hyphae and release anti-bacterial/fungal substances to keep pathogenic organisms in check.

Useful videos

Making IMO-1: https://www.youtube.com/watch?v=vOAMqvuoKYM

Making IMO-2: https://www.youtube.com/watch?v=g5q_vKUfP7Y

Extracting Fermented Plant Juices (FJP): https://www.youtube.com/watch?v=P9ELg7PmJEU

NOTE: It will take 3 days in summer and 5 days in winter. You can experiment based on the climate of the place where you live. Black molds on the steamed rice indicate that you have exceeded the number of days

Scientific studies on use of IMOs

James Rushing determined that IMO 4 was rich in indigenous microorganisms and possesses an appreciable concentration of plant available nutrients. The physical, chemical, and biological analyses of IMO 4 indicated a potential as a soil bio-stimulant if the indigenous microorganisms survive inoculation. A greenhouse experiment comparing IMO 4 to organic matter applications showed IMO 4 had a similar effect on soil dynamics and growth of corn as the application of organic matter. A further experiment examining the effect of IMO 4 in conjunction with organic fertilizers showed that IMO 4 had similar impact on soil dynamics as organic matter amendments, due to the substrate effect of IMO 4 applications.

Sumathi *et al*., 2012, studied the effect of Indigenous microorganisms (IMO's) on the native soil. Supplementation of IMO's suspension to the soil alters the physico-chemical, biological and enzyme properties of the soil. These alternations include decreases in pH from 7.2 to 6.8, increase in electrical conductivity 0.36 to 1.21(µmohs/cm), water holding capacity 0.36 to 2.2ml/g. Enzyme activities such as protease and urease were assessed in both the soil samples with and without amendment of respective substrates (casein and urea). Accumulation of hydrolytic products tyrosine and ammonia from the substrates in the soil was estimated at periodic intervals. Protease and urease enzyme activities were relatively higher in soil amended with IMO's and respective substrate than control.

Nurul and Nazlina, 2014, did the production of indigenous microorganisms (IMO) and studied the effect of addition of IMO in composting process. Production of IMO was done in a series of steps to allow propagation of beneficial microorganisms. Effect of IMO addition in composting process was investigated by having 4 treatments; 1) rice straw without IMO nor manure and rice bran, 2) rice straw with IMO only, 3) rice straw with manure and rice bran, 4) rice straw with IMO, manure and rice bran. In conclusion, this study showed that IMO addition in composting increased microorganisms which are responsible in organic decomposition.

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1.4.4 Kunapajala

Kunapajala (a Sanskrit word meaning filthy fluid) is an ancient innovation of animal waste recycling into agricultural inputs. This liquid animal manure, narrated originally in "Vrikshayurveda" by Surapala around 1,000 AD, is a formulation of decomposed animal waste such as bones, viscera, fins, and scales from fish waste or waste of crushed bones, skins, and flesh derived from livestock including cattle, goats, pigs, and sheep. Kunapajala is also an abundant source of plant growth promoting bacteria (PGPB) that could offer various benefits to its host plants, including nutrient availability, plant growth promotion, and control of pests and diseases.

Method given by Thakur, 2018: *Non-Herbal Kunapajala*

Ingredients

- Animal flesh/ fish 1kg
- Cow urine 1 liters
- Cow milk 1 liter
- Ghee 1 kg
- Honey 500g
- Water 5 litres

Preparation procedure

1. Animal flesh/fish is boiled in water and transferred thereafter in an earthen container.
2. All the other ingredients are then added in to it
3. 5 litres of hot water is added in to the mixture
4. Mouth of the container is closed with a clean cloth
5. Regularly, the mixture is stirred up to 14 days
6. After that, the materials are sieved well and used on any crop at any time by diluting it (Kunapajala) with water in 1:10 ratio.

Preparation time: 15 days

Method given by Naik et al. (2022):

A) *Herbal Kunapajala (Nettle based)* commonly known as Thurike gida (kannada), Bicchu buti (hindi)

Ingredients

- Nettle plant 20 kg
- Cow dung 20 kg
- Cow urine: 20 litres
- Sprouted Urd: 2kg
- Mustard cake: 2kg
- Nettle plans: 20 kg
- Cow dung: 20kg
- Crushed jaggery: 2kg
- Water 20 liter
- Milk and butter milk: 1 litre each
- Paddy husk

Nettle plant used in Herbal Kunapajala

Preparation procedure

1. In a plastic drum of 200 litres capacity, cow dung, cow urine, sprouted urd, mustard cake, crushed jaggery and water are added.

2. Thereafter, fresh finely chopped nettle plants are added into it
3. Paddy husk is boiled in water 2 days prior to Kunapajala preparation for 15-20 minutes and filtered contents are added into that plastic drum along with milk and butter milk
4. All the ingredients are mixed thoroughly with wooden stick and water is mixed up to the mouth of the drum
5. The lid is closed after preparation
6. Stirring continues during morning and evening up to 20-25 days. During start of fermentation, bubble appears, which is not visible if preparation is completed.
7. Finally, solution is filtered and stored.

Preparation time: 25 days

B) Herbal Kunapajala (Weed based)

Ingredients

- Neem, Wild jasmine, Beal, Datura, Lantana, Mango, Guava, Calotropis, Castor and Billy goat weed 2kg (each)
- Cow dug 20 kg
- Cow urine 20 litres
- Sprouted Urd 2kg
- Mustard cake 2kg
- Crushed jaggery 2kg
- Water 20 liters
- Milk and butter milk 1 litre each
- Paddy husk

Preparation procedure:

1. Preparation process is same as nettle based herbal *Kunapjala* except the use of weeds instead of nettle plants.

Shelf life: 3 months

Method of usage

- Soil application: It can be directly applied to soil up to 40days of preparation from the beginning
- Foliar application: 10-20% foliar sprays can be advocated for all the crops at an interval of 10-15 days regularly
- Seed treatment: 5-10% solution can be used for treating seeds

Scientific studies on uses of Kunapajala

Ali *et al.,* 2012 conducted an exploratory study using two Vedic bio-inoculums Shashyagavya (3 different stages) and Kunapajala (4 different grades) to spray on black gram and mustard for evaluating the beneficial effects of bio-inoclulums on crop yield and improving their shelf life. In black gram, Shasyagavya @ 20 and 10% spray and Kunapajala @5 and 10% spray produced better yields whereas highest yield was recorded with Shasyagavya 20%. In mustard, the only yield indicator which significantly varied among treatments was 1000 seed weight. The average 1000 seed weight was maximum with Shasyagavya 10% spray and minimum in control. Notably, Kunapajala 3% spray exhibited better result for most of the characters as compared to other treatments in mustard.

Mishra 2007 in his study, tested the specially prepared Kunapajalam upon paddy. Various parameters like plant height, leaf length, leaf number and inflorescence length were evaluated in test culture receiving Kunapajalam at different time intervals. Administration of Kunapajalam every tenth and fifteenth day exhibited remarkable enhancement in paddy growth.

Bhat and Vasanthi (2008) obtained more number of branches, greater fruit yield of brinjal with lesser seeds and less vulnerability to diseases with the use of Kunapajala over chemical fertilizer application.

Seed priming with herbal Kunapajala was done by Halder *et al.* (2022) on chickpea and results indicated that seed priming with 10% Kunapajala ensured highest germination percentage, speed of germination, shoot and root lengths, seedling length, seedling dry weight, vigour index-I and II, water imbibition rate, α-amylase activity and seed metabolic efficiency as well as quickest germination time in chickpea over control, hydropriming and others .

Deshmukh *et al.,* 2008, conducted experiments in PG Research Centre, Tuljaram Chaturchand College, Baramati, Dist-Pune (M.S.) India, using pot culture for N.P.K (N = 11g/plant, P= 21.5 g/plant and K= 4.5 g/plant respectively) and Kunapajala treatment (5 times at interval of 10 days). Kunapajala treatment was found to be more effective for inducing early flowering and enhancing fruiting period, size, fresh weight and shelf life of fruit and weight of seeds as compared to N.P.K. farming. Analysis of nutritional value showed that Kunapajala had upper hand, followed by N. P. K. farming in terms of total solids, fiber content, lycopene, ascorbic acid, carotenoids, soluble proteins, total carbohydrates and proline. It is interesting to know that the antioxidant property of tomato fruit was highest in the plants treated with Kunapajala.

Adhikari *et al.,* (2022) used Kunapajala not only to stimulate plant growth but also protect from pests and diseases. The potato cultivar Kufri Bahar was used against early blight and black scurf disease under field conditions during the rabi season of 2020-21 at VRC, Pantnagar. The results revealed that 10 per cent solution of KJ2 (50% nettle grass + 50% seasonal local weed based KJ) at 2000 L/ha dose and KJ3 (seasonal weed based KJ) at 1000 L/ha were found effective against black scurf and early blight disease of potato, respectively showing 12.37 and 35.79% reduction disease severity over control, respectively.

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1.4.5 Dasagavya

Dasagavya, is an organic preparation made from ten products in the form of panchagavya and certain plant extracts. “Gavya '' is the term given to cow’s products consisting of cow dung, cow urine, cow’s milk, curd and ghee, which have miraculous effects on plant growth when suitably mixed. Ingredients, method of preparation and mode of usage is obtained from TNAU

(https://agritech.tnau.ac.in/org_farm/orgfarm_dasakavya.html#:~:text=The%20plant%20extracts%20are%20prepared,litre%20of%20the%20panchagavya%20solution.)

The Horticultural research station, Ooty, has identified certain plant species for the temperate regions, *viz., Artemisia nilagirica, Leucas aspera*, *Lantana camara*, *Datura metel* and *Phytolacca dulcamara*. These are commonly available weed plants in the district, found abundantly along roadsides and in wastelands. The plants recommended for the tropical areas are neem (*Azadirachta indica*), erukam (*Calotropis)*, Kolingi (*Tephrosia purpurea*), notchi (*Vitex negundo*), umathai (*Datura metel*), Katamanaku (*Jatropha curcas*), adathoda(*Adhatoda vasica)* and pungam (*Pongamia pinnata*).


Leucas aspera


Lantana camara


Datura metel


Calotropis


Vitex negundo


Pongamia pinnata


jatropha curcas


Adhatoda vasica


Azadirachta indica

Preparation procedure

1. The plant extracts are prepared by separately soaking the foliage in cow urine in 1:1 ratio (1 kg chopped leaves in 1 litre cow urine) for ten days.
2. The filtered extracts of all the plants are then added @ 1 litre each to 5 litre of the panchagavya solution.
3. The mixture is kept for 25 days and stirred well, meanwhile, to ensure thorough mixing of panchagavya and the plant extracts.

Preparation time: 25 days

Method of usage

- The Dasagavya solution is filtered to avoid clogging of sprayer nozzles and is recommended as foliar spray at 3% concentration.

- Soaking of seeds or dipping the roots of seedlings in 3% solution of Dasagavya for 20 minutes before planting enhances seed germination and root development.

Periodicity: Weekly sprays during crop growth for all vegetables and plantation crops.

Advantages

- Increases growth, yield and quality of the crops
- Controls pests like aphids, thrips, mites and other sucking pests
- Controls diseases like leaf spot, leaf blight, powdery mildew, etc.

Scientific studies on use of on Dasagavya

Kumarimanimuthuveeral and Sathiya, 2014, conducted an experiment to study the growth and yield of Rice in response to organic sources FYM, Pressmud, Panchakavya and Dasagavya. The experiment was laid out in a split plot design. For this organic source of nutrients assigned to the main plot and foliar sprays to subplot. Organic sources of nutrients viz., M_1 (Farm yard manure + RDF + BF), M_2 (Pressmud @12.5 t ha^{-1} + RDF + BF) and M_3 (control, inorganic alone) in main plot and foliar application viz., S_1 (No spray), S_2 (3% Panchagavya, two times at tillering panicle initiation), S_3 (3% Panchagavya, three times at tillering panicle initiation, flowering), S_4 (3% Dasagavya, two times at tillering panicle initiation),) and S_5 (3% Dasagavya 3 times at tillering, panicle initiation and flowering) under sub plot were evaluated. Among foliar spraying 3 % Dasagavya for 3 times recorded the highest growth and yield attributing characters compared to spraying 3% Panchagavya for 3 times and 3% Dasagavya for 2 times. Crop raised with pressmud @ 12.5 t ha^{-1} +RDF + BF registered the highest grain and straw yields among the organic sources. Application of organic sources and foliar spray had significant influence on the N, P and K uptake by the crop at harvest stages. Hence it can be concluded that this combination can be recommended to the rice growing farmers in the coastal areas of Tamil Nadu

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1.4.6 Compost Tea

Compost teas are aqueous extracts prepared by mixing compost in water in a specific ratio. Compost tea is composed of water extractable components such as mineral supplements, organic acids, active microorganisms primarily bacteria, fungi, protozoa and other microbial metabolites. Various reports have suggested the application of compost tea has significantly enhanced the plant productivity by improving plant nutrient status and by diminishing disease incidence

Ingredients

- Compost 5kg
- Water 50 litres

Mature Compost soaked in water

Preparation procedure

1. In a plastic container add 50 liter of water
2. Add 5 kg well matured compost in to the container and mix it well
3. Keep the mixture for 7 days with stirring twice a day
4. On 7th day filter the suspension to remove unwanted solid particles

Shelf life: Prepare afresh and use whenever needed

Preparation time: 7days

Method of usage

- Solution can be directly applied to soils near the root zone
- Foliar sprays can be taken up without dilution

Precaution

- If you are using tap or chlorinated water, make it stand in the container for 24 hours so that chlorine gets evaporated. Using chlorinated water will kill the beneficial microorganism present in the compost.

Scientific studies on use of compost tea

Ramírez-Gottfried *et al.,* 2023 reported that the application of aerated compost tea to the soil and the combination of compost tea with beneficial microorganisms (mycorrhizae and a mixture of microorganisms) are an alternative for modifying the characteristics of the soil microbial community and significantly reducing soil-borne diseases

The results of study of Gonzalez-Hernandez *et al.* (2022) to use compost tea (CT) as an alternative to promote plant growth and resistance against *Rhizoctonia solani* in potato plants showed that CT-treated plants displayed a higher resistance to *Rhizoctonia solani*, being Hermes the most susceptible cultivar. Moreover, CT-treated plants showed an enhancement in yield, shoot number, tuber weight and tuber size, as well as an advance in potato sprouting, especially in those plants treated with the highest CT dose.

Compost teas contain a significant quantity of total nutrients with the majority being primary macronutrients. Secondary and micronutrient concentrations are more variable, but contents are generally insufficient to satisfy crop requirements. Noting this, compost tea use in agriculture and horticulture supports crop nutrition directly and indirectly. Improvements in soil quality have been widely reported for a range of soils and compost teas. A key feature of compost tea-amended soils is

the increase in soil organic matter and microbial diversity and its associated benefits (Gaius Eudoxie and Micah Martin, 2019).

References

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Gonzalez-Hernandez, A I., Perez-Sanchez, R., Javier Plaza, and Morales-Corts, M. R., 2022, Compost tea as a sustainable alternative to promote plant growth and resistance against Rhizoctonia solani in potato plants, *Scientia Horticulturae*, 300:111090, https://doi.org/10.1016/j.scienta.2022.111090

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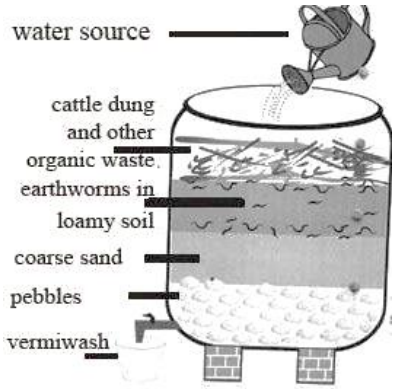
1.4.7 Vermiwash

Vermiwash is a brown coloured liquid extract obtained from vermicomposting beds and is used as an organic fertilizer for crop plants. Vermiwash is a collection of excretory products and mucus secretions of earthworms along with micronutrients from the soil organic molecules. It is rich in dissolved nutrients and amino acids which can be easily taken by the plants. Vermiwash is a non-toxic and eco-friendly compound, which arrests the bacterial growth. Vermiwash at 5 to 10 percent dilution inhibits the mycelial growth of pathogenic fungi.

Ingredients

- Gravel or broken bricks
- Coconut husk
- Partially decomposed waste
- Water

Method of extraction



Vermiwash extracting process

1. Take 10 lit of mud pot or plastic container for preparation of vermiwash. Arrange a tap for it at the bottom.
2. Then place 10 cm gravel or broken bricks at the bottom.
3. Spread coconut husk up to 4 cm on this.
4. Place partially decomposed agricultural waste material and dung and moisten the material with water.
5. After wetting the material for 2 days, release two dozen earthworms.
6. In 2 weeks the wastes get transformed into black compost.
7. At this stage pour 3 litres of water.
8. After 24 hrs, 2 litres Vermiwash can be collected through the tap.
9. Continue this method for one week, remove the compost from the container and it can be used as manure.
10. Again refill the container as explained above and prepare vermiwash.

Shelf life: 2 months

Preparation time: 25-30days

Method of usage

- 10 litre Vermiwash is mixed in 100 liters of water and sprayed on an acre of crop.
- Vermiwash can be used on all crops, nurseries and fruit crops.
- Can be sprayed 1-2 times during crop duration to get good results
- Spraying Vermiwash controls micronutrient deficiencies to some extent.

Precaution

- Liquid extract obtained till 15 days should not be used, concentrated vermi wash will be obtained only after 15 days.

Videos

https://www.youtube.com/watch?v=XtboRVMtDXE

https://www.youtube.com/watch?v=g4LnpHGGF6c

Scientific studies in use of vermiwash

The role of vermiwash, an organic liquid fertilizer as foliar spray on plant growth, germination and the exo-morphological characters of *Abelmoschus esculentus* (Okra) and *Trigonella foenumgraecum* (Methi) were investigated by Jandaik *et al.* (2015). On 21st day parameters such as plant height, shoot and root length, numbers of branches and leaves, leaf length and leaf breadth were measured. Four different concentrations of vermiwash i.e. 25, 50, 75 and 100% were prepared by using distilled water. Among the various foliar treatments used in the study, 100% vermiwash showed growth enhancing effects followed by 75% vermiwash concentration. Increased Vigor index in both the plants exposed to different concentration of vermiwash was observed as compared to control.

Sundararasu 2016, conducted a study to evaluate the growth and yielding pattern of chilli plant by the application of vermiwash and also physico- chemical properties of vermiwash applied soil were analysed. Significant improvements were observed in in total organic carbon, total potassium, total calcium and magnesium. Number of leaves and plant height were significantly improved at 50:50 ratio. Growth and yielding pattern of chilli was significantly improved in 50:50 ratio.

Fathima and Sekar (2014) from their study revealed that Vermiwash at lower concentrations was effective in improving seed germination and seedling growth. The germination percentage and seedling growth in terms of length of hypocotyl and radical was maximum in 10% vermiwash treatment in both the experimental plants but response to Gibberellic acid and 20% Vermiwash slightly varied between the two plants.

References

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Mujeera Fathima and Malathy Sekar, 2014, Studies on Growth Promoting effects of Vermiwash on the Germination of Vegetable Crops, *Int. J. Curr. Microbiol. App. Sci.,* (6):564-570

2. Biopesticides

Biopesticides are naturally occurring compounds or agents that are obtained from animals, plants, and microorganisms such as bacteria, cyanobacteria, and microalgae and are used to control agricultural pests and pathogens. The use of biopesticides is, by far, more advantageous than the use of their counterparts, traditional chemical pesticides, as they are eco-friendly.

Botanicals: Over the last several years, plant-based extracts and essential oils have emerged as attractive alternatives to synthetic insecticides for insect pest management. These insecticides are naturally occurring insecticides as they are derived from plants and contain a range of bioactive chemicals. Depending on physiological characteristics of insect species as well as the type of plant, plant extracts and essential oils (EOs) exhibit a wide range of action against insects: they can act as repellents or antifeedants; they also may inhibit respiration, hamper the identification of host plants by insects, inhibit oviposition and decrease adult emergence by ovicidal and larvicidal effects.

Botanicals which primarily serve as insecticides

2.1 Single plant-based products

Single plan- based products are the formulation prepared using one type of plant. Formulations can be obtained by simple fermentation, water-based extraction and decoction by boiling.

2.1.1 Neemastra

Neemastra is a very good mixture to fight the dangers of nymph-sucking insects and mealybugs. This mixture can be prepared by farmers easily at home. Ingredients required, procedure of preparation is obtained from TNAU (https://agritech.tnau.ac.in/org_farm/orgfarm_ofk_pltprotection.html)

Ingredients

- Water 100 litres for one acre of land
- Cow urine 5 litres
- Cow dung 2 kgs
- Neem leaves (with thin stems) 5kg or neem seed powder 50 gm per litre of water.

Neem leaves

Preparation procedure

1. Crush 5 kg neem leaves in water, and add 5 lit cow urine and 2 kg cow dung
2. Cover the tank with a jute sack or poly net. The tank should be in shadow and the tank should not be directly exposed to sunlight or rain water.
3. Leave the mixture for 24-48 hours for fermentation with intermittent stirring.
4. Filter squeeze the extract and dilute to 100 lit
5. Use as foliar spray over one acre

Preparation time: 24 -48 hours

Shelf life: 6 months

Method of usage

- The mixture should be sprayed on plants.
- Sprinkle or spray the same mixture without adding water.

Precautions

- Crush neem leaves and stems using a stone crusher or stone grinder.
- Only use urine and dung of indigenous cattle

Scientific studies on use of Neemastra

Pati *et al*., 2023 conducted a field experiment to study the effect of organic manure and Neemastra on growth and yield of Indian mustard varieties in split split-plot design replicated thrice during rabi season of 2017-2018. Results revealed that the susceptibility of mustard to aphid (*Lipaphis erysimi*) was increased progressively with the advancement of crop growth or age, and severe infestation was found at maturity. The three spray schedules of Neemastra at 3, 6 and 9 weeks after sowing (WAS) had significant protective effects against aphid infestation in mustard plants of the treated plots (P2) compared to the unprotected check (P1). A careful study on aphid infestation data for a period from 3 to 11 WAS revealed that the effectiveness of Neemastra was evident upto 1 week after their respective foliar applications.

Reference

S. Pati, S. Banerjee, M. Ghosh, Debnath and Dolui, 2023, Effect of organic manure and Neemastra on growth and yield of Indian mustard varieties in lower gangetic plains of West Bengal, *Journal of Crop and Weed,* 19(1): 95-99, DOI: https://doi.org/10.22271/09746315.2023.v19.i1.1666

2.1.2 Neem Bio-enzyme

Bio enzymes in agriculture have emerged as a powerful tool for enhancing plant growth, increasing yields, and improving overall plant health. These enzymes break down organic matter in the soil, making essential nutrients more accessible to plants. Bio enzyme formulations can be used to control pests, such as rice stem borers and brown planthoppers. The enzymes disrupt the pests' feeding and reproductive processes, reducing the need for chemical insecticides. It can also be used effectively against fungal diseases.

Ingredients: The ratio of ingredients would be 1:3:10

- Jaggery 100 grams
- Neem leaves 300 grams
- Water 1 litre

Neem leaves

Jaggery

Preparation procedure

1. Take an empty plastic container
2. Add 100 grams of jaggery or brown sugar to it
3. Chop the neem leaves into small pieces and add to the container
4. Finally add water to it, ensure that water is not completely filled till the neck of the container
5. Cover the lid of container and mix the ingredients by shaking it
6. Keep the container at room temperature in shade/ dark place for 3 months
7. After 3 days, gas formation starts and everyday ensure to release gases by loosing a lid but make sure that lid is not completely removed from the container
8. After 3 months, filter the content to clean container and keep it for usage

Preparation time: 3 months

Shelf life: One year when stored in room temperature.

Method of usage

- It can be applied on all the crops as foliar sprays at the rate of 1ml in 1 litre of water.
- Dosage can be increased to 2-3 ml/ litre of water if pest and fungal incidence is severe
- It can be directly applied as a natural fertilizer to root zone of the crops at the rate of 1 ml per litre of water

Precautions

- Use Plastic container for preparing the formulation, glass containers may burst if you forget to release of gases regularly.
- Should not expose the content to oxygen during the process of fermentation, as it leads to development of fungus.

Video on preparation: https://www.youtube.com/watch?v=19EPR71caJY

https://www.youtube.com/watch?v=N0fyL7oBbjs

Scientific studies on use of Neem bioenzyme

Rungta et al., 2022 prepared bioenzymes using organic waste like peels of citrus, pineapple, banana, neem leaves, marigold and rose petals along with jaggery, water and yeast. The mixture was

allowed to ferment for about one month in an air-tight plastic bottle. Banana and neem bioenzymes were found effective for use as natural fertilizers. Neem bioenzymes also showed positive results when used as a natural pesticides. To study the antifungal properties of bioenzymes simple bread mould experiment was conducted in which neem bioenzymes were found to be most potent in retarding the fungal growth.

Reference

Rungta S, Ojha A, Mishra, S K., 2022, Study of physico-chemical property of bioenzymes produced from organic household waste and their application in daily life. *Discovery*, 58(315):228-234

2.1.3 Neem Seed Kernel Extract (NSKE)

Neem seed kernel extract is effective in controlling a variety of leaf eating insects.

Ingredients

- Neem seed kernel 5kg
- Water 20 litres
- Soapnut powder 100gm

Neem seed kernel

Preparation procedure

1. Take required quantity of Neem seed kernel (5 kg)
2. Grind the kernels gently to powder it
3. Soak it overnight in 10 litres of water.
4. Stir with wooden plank in the morning till solution becomes milky white
5. Filter through double layer of muslin cloth and make the volume to 100 liter
6. Add 1% detergent (Make a paste of the detergent and then mix it in the spray solution)
7. Mix the spray solution well and use

Preparation time: 24 hours

Shelf life: Prepare afresh whenever needed

Method of usage

- 500 to 1000ml Neem Kernel seed extracts is required per tank.
- Before spraying khadi soap solution @ 10 ml/litre should be added to help the extract stick well to the leaf surface.
- This concentration of the extract can be increased or decreased depending on the intensity of pest attack

Precautions

- Do not use the seeds over eight months of age. The seeds stored over and above this age lose their activity and hence not fit for NSKE preparation.
- Spray the extract after 3.30 pm to get effective results.

Videos on preparation: https://www.youtube.com/watch?v=uJTiy23JMnE

https://www.youtube.com/watch?v=ZY7B8fZmeXM

https://www.youtube.com/watch?v=Tlo0eFKrJo8

Scientific studies on use of NSKE

Field experiments were conducted to determine the comparative efficiency of NSKE and Synthetic insecticide (Carbofuradan) against rice stem borers by Ogah *et al.,* 2011. Results indicated that the two pesticides significantly ($p < 0.01$) reduced stem borers damage (number of dead hearts, white heads) compared to untreated check, and also significantly ($p < 0.05$) increased number of productive tillers with resultant increase in grain yield than the control plots. He also reported maximum numbers of different natural enemies in neem extract treated plots against the carbofuran treated plots. It is suggested that on the basis of less infestation of borer, high yield and conservation

of natural enemies, neem seed extract can be regarded as suitable alternative to synthetic insecticides for the management of rice stem borers in the field.

Jeykumar and Gupta, 2011 studied the effect of Neem seed kernel extract on *Helicoverpa armigera*. Results indicated that neem seed kernel extract reduced the oviposition of *Helicoverpa armigera* Hubnen in a dose dependent manner during the exposure periods of 0-24h and 24-48 hrs and showed oviposition deterrence effect. The percentage reduction in oviposition due to NSKE treatment over control was maximum in higher doses of NSKE. The hatchability of the laid eggs was also affected on NSKE treated surface. Ovicidal effect of NSKE was also noticed in different age groups of eggs and mortality decreased with increase in age group of eggs.

References

Ogah, E.O., Omoloye, A.A., Nwilene, F.E. and Nwogbaga, A.C., 2011, Effect of Neem Seed Kernel Extracts in the Management of Rice Stem Borers in the Field in Nigeria, *Nig J. Biotech*., 23: 13-21

Jeykumar, P. and Gupta G P., 2011, Effect of Neem seed kernel extract on *Helicoverpa armigera, Pesticide Research Journal,* 11 (1):32-36. https://www.indianjournals.com/ijor.aspx?target=ijor:prj&volume=11&issue=1&article=006

Preparation procedure: https://www.agrifarming.in/neem-seed-kernel-extract-procedure-and-preparation#google_vignette

2.1.4 Vitex Decoction

The presence of many alkaloids makes Vitex an effective pesticide and fungicide. Dry Vitex negundo leaves are traditionally used to protect woollen garments since the leaves repel wool-destroying insects and worms. Dry leaves are used for storing cotton and warm clothes in Hazaribagh. Leaves are burnt in a fire during the rainy season to keep mosquitoes away from animals and human beings; the smoke repels mosquitoes and insects. Method of prepration is obtained from Kerela agriculture department (https://keralaagriculture.gov.in/wp-content/uploads/2021/04/botanical-extracts-1.pdf)

Vitex negundo plant

Ingredients

- Vitex leaves 5kg
- Detergent powder 100g
- Water 110 litres

Preparation procedure

1. Grind the vitex leaves (5kg) to paste using wooden pestle and mortar
2. To an earthen pot transfer the paste and add 10 litres of water
3. Boil the content for 30mins
4. Stir the boiling solution regularly
5. Make the solution cool and filter through a thin cloth

Preparation time: 2 hours

Shelf life: Should be prepared afresh every time

Method of usage

- Take the decoction in 150 litre drum
- Add 100 gm Detergent to the decoction
- Add 100 litres of water to the decoction to spray in 1 acre
- Spray the decoction in the evening time

Videos on preparation: https://www.youtube.com/watch?v=q_jRbDLahxI

Precautions

- Tie a cloth to nose while making the decoction
- Depending on the crop stage and pest intensity, this can be applied for two to three times
- Never store the decoction
- We can also make a decoction with leaves of custard apple. This decoction can be effectively used as anti-bacterial and anti-fungal agent

2.1.5 Tobacco decoction

Tobacco decoction can control the soft-bodied insect pests viz., sucking pests like aphid, jassids, whitefly, thrips, mites, and mealybugs and the initial stages of leaf-eating caterpillars *viz*., tobacco leaf eating caterpillar, *Helicoverpa*, leaf folder, hairy caterpillars, etc. (*Source - AgroStar Agronomy Center of Excellence*)

Ingredients

- Tobacco: 1kg
- Detergent powder: 200g
- Water 10 litres

Tobacco leaves

Preparation procedure

Tobacco decoction can be made in two ways:

1. Hot water treatment:
   - Collect 1 kg of tobacco leaf powder/ dust and soak in 10 litres of water overnight.
   - Next day morning, boil it at 60 to 70 degree C temperature for about one hour.
   - While boiling, maintain 10 litres quantity by adding water. The stock solution becomes dark coffee colour.
2. Cold water treatment:
   - Tobacco decoction can be prepared by steeping 1kg of tobacco waste in 9 litres of water for 24 hours.
   - Filter the decoction using muslin cloth and store it in air tight container

Preparation time: One day

Shelf life: 6 months

Method of usage

- Filter the decoction with a muslin cloth and add 200 g soap powder or any washing detergent powder.
- Obtained liquid should be mixed in 100 litres of water
- This solution should be sprayed on to the crop in early morning or evening hours.

Precautions

- If you do not want to spray on the day of preparation, do not add additional water or soap or washing detergent powder in stock solution.
- Keep this stock solution in an air-tight container.
- Further, keep your mouth closed with wet-cloth while preparing and applying the solution.
- The person should not be engaged if he/she had a problem with tobacco toxicity. If any sedating effect is felt, immediately stop the spraying work.

Videos on preparation: https://www.youtube.com/watch?v=AAvphcG0blg

Studies on use of Tobacco decoction

Patel *et al.,* 2021 evaluated nine biopesticides against aphid in coriander. Application of tobacco decoction 2 per cent was found the most effective followed by GRE 5 per cent, GBE 5 per cent and neem oil 1 per cent with coriander seed yield 449, 437, 420 and 408 kg/ha, respectively.

Nascimento *et al.,* 2022, in their study evaluated the insecticidal effects of aqueous extracts of garlic, rue, cinnamon, lemongrass, clove, star anise, eucalyptus, tobacco, and thyme on M. spectabilis nymphs. The results indicated that the tobacco extract was the most effective among all extracts, as it reached a mortality of 76%. Concentration of 25%, and with extraction by infusion and decoction showed the better result.

Trogoderma granarium and *Rhyzopertha dominica* are the primary insect pests of the stored wheat throughout the world. In present study acetone extracts of medicinal plants *Moringa olifera* and *Nicotiana tabacum* at three concentrations viz., 5, 10 and 15% were checked for their repellent and mortal action against test insects. The reported results revealed that maximum repellence 44.07% and 61.11% in *T. granarium* and *R. dominica* was achieved respectively by the extract of *N. tabacum*, after an interval of 48h (Ali *et al.,* 2017).

A study was conducted by Kanmani *et al.* (2021) to determine the toxicity of tobacco (Nicotiana tabacum) leaf extracts as an alternative to synthetic insecticides in the management of rice weevils. The crude solvent leaf extracts of N. tabacum were analyzed for its phytochemical compounds via GC-MS and tested for its toxicity to the adults of S. oryzae at concentrations of 0.625, 1.25, 2.50, 5.00, 10.00, and 20.00 mg/L by Petri dish bioassay method. Results indicated that with the use of tobacco leaf extracts with its excellent insecticidal activity owing to the action of nicotine it would be economically feasible to alleviate the rice weevil problem.

References

K. N. Patel, R. K. Thumar, Atul Mohapatra, A. H. Barad and K. D. Parmar, 2021, Bio-Efficacy of different Biopesticides Evaluated against Aphids Infesting Coriander, Int. J. Curr. Microbiol. App. Sci., 10(03): 2169-2178, https://doi.org/10.20546/ijcmas.2021.1003.272

Nascimento, V.F., Auad, A.M., de Resende, T.T., Visconde, A.J.M., Dias, M.L. 2022, Insecticidal Activity of Aqueous Extracts of Plant Origin on Mahanarva spectabilis (Distant, 1909) (Hemiptera: Cercopidae). Agronomy, 12:947. https://doi.org/10.3390/ agronomy12040947

Ali, K., Sagheer, M., Hasan, M., Hanif, C.M.S., Malik, S., Rizwan, M., and Rashid, A., 2017, Medicinal response of *Moringa oleifera* and *Nicotiana tabacum* as repellent and toxicant against *Trogoderma granarrium* and *Rhyzopertha dominica*. *Z. Arznei-Gewuzpfla*, 22, 132–135.

Kanmani, S.; Kumar, L.; Raveen, R.; Tennyson, S.; Arivoli, S.; Jayakumar, M. Toxicity of tobacco Nicotiana tabacum Linnaeus (Solanaceae) leaf extracts to the rice weevil Sitophilus oryzae Linnaeus 1763 (Coleoptera:Curculionidae). J. Basic Appl. Zool. 2021, 82, 10.

2.1.6 Mahuhastra

It's a biofungicide that can also be used against viral disease. Ingredients required and method of preparation is obtained from Gram Sudhar Samithi, an NGO located in Madhya Pradesh

Ingredients

- Mahua dry fruit 1kg
- Cow urine 2 litres
- Jaggery 200 grams

Mahua fruit

Mahua Seeds

Preparation procedure

1. Mix all the ingredients in earthen pot
2. Boil the content 4 times
3. Keep the solution under shade for 24 hours
4. After 24 hours, squeeze the content to plastic bottle and store

Preparation time: 24 hours

Method of Usage

- Add 30 to 60 ml of the solution in a litre of water and spray on the plant

Scientific studies on use of Mahua

Balamurugan and Arivudainambi, 2022, conducted the bioassay studies to investigate the anti – insect properties of various oil formulations against aphids and mites of chilli under in-vitro conditions. The botanicals Soap flake formulation of Neem oil, Soap flake formulation of Pungam oil, Mahua oil were tested against aphids and mites with three different concentrations (1%, 3% and 5%). The observations were made on the mortality of aphids and mites at 6h, 24h and 48h respectively. Two different types of bioassay viz., on plant and poison food bioassay were conducted. Results revealed that the Mahua oil 5% showed high mortality in both type of bioassays.

Reference

Balamurugan and S Arivudainambi, 2022, Anti–insect properties of various oil formulations against major sap feeders in chilli, International Journal of Entomology Research, 7 (1):97-100

2.1.7 Onion Kashayam

Onion kashayam can be used against white and yellow flies and red mites effectively. Ingredients used and method of preparation is obtained from Natural Farming Technical process manual produced by NCNF.

Ingredients

- Onion-5 kgs
- Cow urine: 10 liters
- Jaggery -2 Kgs
- Coconut water-2 liters
- Turmeric powder-100g

Onion

Preparation procedure

1. Take 5 kgs of onion and grind it into paste.
2. Take 10 litres of cow urine in a container and add onion paste to it and mix well.
3. Allow it ferment for 48 hours and then filter the liquid
4. Add the remaining ingredients i.e., jaggery, coconut water and turmeric powder
5. Mix the content and add 200 liters water

Shelf life: It has to be prepared as and when required

Preparation time: 3days

Method of usage

- Foliar application: No further dilution is needed

Studies on use of onion extract

Baba Salifu *et al.,* 2019 reported that application of 20% and 15% spring onion extract concentrations increased yield components and grain yield similar to the synthetic insecticide. Yield losses due to insect pest infestation was greatly reduced by 20% and 15% spring onion extract concentrations. It was evident that yield loss could be as high as 76% in uncontrolled fields. It can therefore be concluded that spring onion extract concentration of 20% and 15% could be effective substitutes for synthetic cowpea insecticides

Sumartini (2014) from his field experiment concluded that application of the onion extract (50 gr/l) by soaking sweet potato stems for an hour and spraying the plant at 4, 5, and 6 week after planting inhibited the scab disease on sweet potato of Ayamurasaki from 70% to 80%, and increasing the weight of large tubers by 46%, and prevent the yield losses due to scab disease by 33%.

Cornago *et al.,* 2011, studied the antifungal activities of methanol (FA), ethyl acetate (FC) and aqueous (FD) extracts of onion bulb against *Fusarium oxysporum* and *Colletotrichum sp*. FC showed significant activity against both fungi even at 2000 microgram per ml. The results showed that onion bulb can be a source of compounds that can serve as templates for future fungicides against *Fusarium oxysporum* and *Colletotrichum sp*.

References

Baba Salifu, Ayaaba A Atongi and Samuel Yeboah, 2019, Efficacy of spring onion (Allium fistulosum) leaf extract for controlling major field insect pests of cowpea (Vigna unguiculata L.) in the guinea

savannah Agroecological zone of Ghana, *Journal of Entomology and Zoology Studies,* 7(1): 730-733 https://www.entomoljournal.com/archives/2019/vol7issue1/PartL/6-5-370-680.pdf

Sumartini, 2014, Efficacy of Onion (*Allium cepa L*.) extract as a biofungicide to control scab disease (*Sphaceloma batatas*) of sweet potato (*Ipomoea batatas*), *Journal of Experimental Biology and Agricultural Sciences*, 2(4):397-402 https://www.cabidigitallibrary.org/doi/pdf/10.5555/20143319119

Cornago D F., Amor E C and Rivera W L, 2011, Antifungal activity of Onion (Allium cepa L.) bulb extracts against *Fusarium oxysporum and Colletotrichum* sp., *Philippine Agricultural Scientist*, 94(1):78-82

2.1.8 Datura Leaf Extract

Datura species are herbaceous sprawling annuals or short-lived perennials, characterized by large trumpet-shaped flowers. The fragrant flowers can be white, yellow, pink, or purple and produce a spiny capsule fruit with numerous seeds. The leaves are simple and alternately arranged, with lobed, wavy, or entire margins. The plants contain potent alkaloids, including atropine, scopolamine, and hyoscyamine, and can be fatal if ingested. It Can be used against aphids, jassids, and thrips.

Ingredients

- Datura leaves 8 kgs
- Detergent powder 50 grams
- Water 10 litres

Datura plant with flower

Datura fruit

Preparation procedure

1. Take 8 kg of Datura leaves
2. Grind them and boil it in 10 litres of water for ½ hour
3. Cool it and filter it with fine muslin cloth and
4. Add it to 100 litres of water

Shelf life: Need to be prepared afresh whenever needed

Preparation time: 1 day

Method of usage

- Foliar spray: Add 100 grams of soap nut powder or 50gms of surf dissolved in water. No further dilution is needed. This quantity is sufficient for spraying 1 acre of area

Videos: https://www.youtube.com/watch?v=Fol1N2FxS5c
https://www.youtube.com/watch?v=3GG1sDBvESg

Scientific studies on use of Datura extracts

The insecticidal property of *Datura stramonium* seed extracts against the rice weevil, *Sitophilus oryzae* was tested in the laboratory by Nilesh Jawalkar et al. (2016). The results suggest that the mortality increased with increase in concentration as well as exposure time and the extracts of *D. stramonium* seed may be of high value in grain storage against *S. oryzae,* especially in subsistence agriculture where the plants are locally available to farmers with little resources.

Habib Abbasipour *et al.* (2011) tested the mortality of adults at different concentrations and two exposure times (24 and 48h). The effect of different concentrations on egg hatching was also tested after 6 days. Also, sublethal effect of different concentrations was tested on oviposition rate. The results showed that the mortality increased with increases in concentration and exposure time. After 12h, high increases in mortality were seen. Data probit analysis demonstrated that lethal concentration to kill 50% of the population (LC50) was estimated at 1680 and 16058ppm, for 24 and 48h, respectively.

References

Nilesh Jawalkar, Sureshchandra Zambare and Sunita Zanke, 2019, Insecticidal property of *Datura stramonium L*. seed extracts against *Sitophilus oryzae L*. (Coleoptera: Curculionidae) in stored

wheat grains, *Journal of Entomology and Zoology Studies*; 4(6): 92-96, https://www.entomoljournal.com/archives/2016/vol4issue6/PartB/4-5-142-567.pdf

Habib Abbasipour, Fahimeh R, M Mahmoudvand and M H Hosseinpour, 2011, Insecticidal activity of extract from *Datura stramonium (F.)* (Solanaceae) against *Callosobruchus maculatus*, *Integrated Protection of Stored Products IOBC/wprs Bulletin*, 69; pp. 251-256

2.1.9 Thutikada Kashayam (Ipomea solution)

Ipomoea carnea, the **pink morning glory**, is a species of morning glory that grows as a bush. This flowering plant has heart-shaped leaves that are a rich green and 6–9 inches (15–23 cm) long. It can be easily grown from seeds. These seeds are toxic and it can be hazardous to cattle. These plants can be seen prominently on the banks of the water bodies such as ponds and canals. Ipomoea solution can be used for controlling brown plant hopper. (Source: *https://agritech.tnau.ac.in/itk/itk_crop_traditional_pesticides.html*)

Ingredients

- Ipomoea leaves 5 kgs
- Cow urine 10 litres
- Detergent 250 grams

Ipomoea plant with flower

Preparation procedure

1. Clip and pool 5 Kg of fresh leaves of Ipomoea, leaving the waste materials like bark and dried stem.
2. Clip the fresh leaves and make them into fine paste.
3. Mix the paste with equal volume of water and boil.
4. Now add 500ml of cow urine to this boiling mixture.
5. When mixture is at one fourth of its actual volume, remove from the burner and allow it to cool for overnight.
6. Filter the solution in the morning and repeat the washing with cow urine and make the volume to 4.5 litre.

Shelf life: Need to be prepared afresh whenever needed

Preparation time: 2 days

Method of usage

- Foliar spray: Add 250g of soap powder in 500 ml of water
  Mix the extract with the soap solution to make it 5 litre
  Use 500 ml in 10 litre of water for spraying in an acre.

Scientific studies on use of Ipomoea

Naveen *et al.,* 2013 conducted a study with the aim to identify pest management potentials of certain locally available non-economical weed plants namely *Ipomea carnea* and *Jatropha curcas* commonly found in waste lands. The above weed plants were studied for their antifeedant efficiency against rice pest namely the Leaf folder (*Cnaphalocrosis medinalis*). 50% Ethanolic extract of aerial parts of *I. carnea* was used for pesticidal (anti-feedant) activity. 500 and 1000 ppm of the extract was found to have significant anti-feedant activity on leaf folder.

Vetal and Pardeshi (2019) studied the larvicidal activity of aqueous and ethanol leaf extracts of *Ipomea carnea* against third instar larvae of *Spodoptera litura* at different concentrations (5, 10, 15, 20 and 25 mg/ml). Results revealed that the mortality was increased with increasing in concentration of the plant extracts. The ethanol solvent extract of *I. carnea* showed higher larvicidal property against third instars larvae of *S. litura*.

References

Naveen, X. A. J, Deepa, C., Kavitha, K. K. and Jegadeesan, M, 2013, Study On Biopesticidal Activity Of Ipomea Carnea, Jatropha Curcas And Calotropis Gigantea Against Leaf Folder (Cnaphalocrosis Medinalis), *International Journal of Pharmacy and Biological Sciences*, 3(3):135-146

Vetal D. S and A. B. Pardeshi, 2019, Larvicidal activity of Impomea carnea jace plant extract against Spodoptera litura Fab, *International Journal of Current Research in Life Sciences*, 8(5):3108-3111

2.1.10 Ocimum Kashayam

Ocicum are the aromatic annual and perennial herbs and shrubs. Presence of Alkaloids in Basil makes it effective in disease management. This decoction is effective against *Alterneria* leaf spots and other fungal diseases.

Ingredients

- Picchi Tulasi/Ocimum: 5 kg
- Soap powder: 100gms
- Water: 10 litres

Ocimum plant

Preparation procedure

1. Take 5 kg of Basil leaves in a earthen container
2. Add 10 liters of water and boil it for 30 minutes
3. Stir the solution regularly
4. Cool the decoction and filter it through a thin cloth

Shelf life: Prepared afresh whenever needed

Preparation time: 1 day

Method of usage

- Foliar spray: Add 100 g of Soap nut powder detergent
  Add100 L of water and spray it in the evening.

Scientific studies on use of *Ocimum* kashayam

The present study was conducted by Naveen *et al.,* 2021 to evaluate the insecticidal property of *Ocimum basilicum* (L.) against cigarette beetle, *Lasioderma serricorne* (Fab.). The bioactive compounds from the leaves were extracted using Soxhlet apparatus with methanol. In contact toxicity, highest mean mortality was effected by 5% methanol extract (66.67%), followed by 4% methanol extract (58.33%), 3% methanol extract (52.22%), 2% methanol extract (47.22%) and 1% methanol extract (43.33%). In repellency test, 5% methanol extract produced highest mean repellency (86.88%) (Class V) followed by 4% methanol extract (80.00%) (Class V), 3% methanol extract (73.75%) (Class IV), 2% methanol extract (68.13%) (Class IV) and 1% methanol extract (64.38%) (Class IV).

Prasad *et al.* 2003 reported that extracts from *Ocimum gratissimum* and E. globules inhibit wilting in cowpea seedlings induced by *Sclerotium rolfsil* from 39.6% for untreated to 4–12% for treated plants

The aqueous extracts from bark, leaf, and seed of *Cassia siamea*, *Cassia sieberiana*, *Dolnix regia, Isoberlinia doka, Tamarindus indica, Ocimum gratisimmum, and H. suaveolens*, drastically reduced egg hatching of *M. incognita* (Bello et al., 2006)

References

Bello, L.Y.; Chindo, P.S., Marley, P.S., Alegbejo, M.D., 2006 Effects of some plant extracts on larval hatch of the root-knot nematode, *Meloidogyne incognita*. *Arch. Phytopathol. Plant Prot.*, *39*, 253–257.

Prasad, C.S., Gupta, V., Tyagi, A., Pathak, S., 2003, Biological control of *Sclerotium rolfsii* Sacc., the incitant of cauliflower collar rot. *Ann. Plant Prot. Sci.*, *11*, 61–63.

Naveen M., Jayaraj J., Chinniah C., Mini M. L., Vellaikumar S. and Shanthi M., 2021, Insecticidal property of methanolic leaf extract of Sweet Basil, Ocimum basilicum (L.) against cigarette beetle, Lasioderma serricorne (Fab.) (Coleoptera: Anobiidae), *Journal of Entomology and Zoology Studies*; 9(1): 259-262 DOI: https://doi.org/10.22271/j.ento.2021.v9.i1d.8155

2.1.11 Lantana preparation

Lantana has wide variety of chemical substances, including triterpenes, mono and sesquiterpenes, iridoid and phenyl ethanoid glycosides, nafthoquinones and flavonoids, among other compounds. It can be effectively used against sucking pest such as aphid and storage pest such as weevils.

Ingredients

- Lantana leaves 10 kgs
- Jaggery 1kg
- Water 15 litres

Lantana plant

Preparation procedure

1. Take 10 Kg of Lantana leaves and chop it into small pieces.
2. Place the leaves in a container and add 15 litres of water and boil.
3. Keep the boiled solution over-night
4. Filter the content and store the solution in clean container.

Shelf life: Decoction can be stored up to 15 days by adding 1kg jaggery

Preparation time:2 days

Method of usage

- Foliar sprays: Add 150 litres of water to spray it in one acre of land.

Scientific studies on the use of Lantana extract

The insecticidal property of methanol, ethanol, and ethyl acetate extracts of *Lantana camara* leaf oil and powder for controlling maize weevils, *Sitophilus zeamais*, was studied by Ayalew, 2020. The extracted oil by the three-solvent fraction had direct repellent and toxic effect to the weevil. From all treatment applied, extracted by methanol fraction had showed highest percentage mortality (74%). The lowest mortality rate was observed in ethyl acetate extract (26%) at 2% (w/w) concentration. The effect of leaf powder and extracted oil on repellency and mortality for insects was due to the presence of bioactive and phytochemical molecules such as Phytol, Pyrroline, Paromomycin, Pyrrolizin, and 1-Eicosano.

Culver Mvumi and Maunga (2018) from their study revealed that Lantana leaf extract has the potential to control aphids in rape. The highest concentration (3 kg l-1) showed the most efficacious effect on *B. brassicae* in *B. napus*. The study has shown that the degree of efficacy of lantana leaf extract is greatly influenced by the dosage or concentration of the extract applied and the exposure time. The mortality recorded for the treated plants was an indication that they can be used as alternatives to chemical insecticides.

Baidoo et al., 2017 conducted an experiment to know the impact of ethanolic extract of leaves and roots of lantana in management of okra pest. Parameters studied included the major pests of the plant and the damage caused, leaf area, plant height as well as yield of okra. Cotton aphids: *Aphis gossypii*, the tobacco whitefly: *Bemisia tabaci* and the cotton flea beetle: *Podagrica puncticollis* were the major pests encountered on okra plants. *Aphis gossypii* and *B. tabaci* populations were significantly lower on the L. camara-sprayed plots compared with the control plots. Similarly, *P. puncticollis* numbers were significantly smaller on the L. camara-sprayed plots than the control plots. There were no significant differences between the treatments and the control for plant height, leaf

area and yield. The significant reduction in pests numbers on the L. camara-sprayed plots indicates its potential as an alternative to chemical insecticides, thereby reducing the reliance on chemical insecticides in the management of insect pests.

References

Adane Adugna Ayalew, 2020, Insecticidal activity of Lantana camara extract oil on controlling maize grain weevils, *Toxicology Research and Application* 4: 1–10, DOI: 10.1177/2397847320906491

Culver Mvumi and Maunga P. R., 2018, Efficacy of lantana (*Lantana camara*) extract application against aphids *(Brevicoryne brassicae*) in rape (*Brassica napus*) over varied periods of time, 17(8), pp. 249-254 https://doi.org/10.5897/AJB2017.16160

Baidoo, P. K., Adu, E. and Peprah, S., 2017, The Role of ethanolic extracts of leaves and Roots of *Lantana camara (L.)* in the management of pests of Okra *Abelmoschus esculentus (L.)* Moench. *Advances in Entomology*, 5, 99-108. https://doi.org/10.4236/ae.2017.53010

2.1.12 Turmeric Extract

This can be effectively used to control pest such as aphids, tobacco caterpillar, diamond back moth, paddy stem borer and pests of legumes and storage pests and also can be used against grey rot disease in various crops.

Turmeric Powder

Ingredients

- Turmeric Powder 1kg
- Cow urine 4 litres
- Detergent powder 100g

Preparation procedure

1. Take 1 kg of turmeric powder in a container
2. Add 4 litres of cow urine and mix thoroughly
3. Filter the solution using thin cloth

Shelf life: Need to be prepared afresh whenever needed

Preparation time: 2 hours

Method of usage

- Foliar application: Add 100 gm of detergent to the filtered solution mix well

  Dilute the solution with 100 liters of water

  Spray mixture is sufficient to cover one acre area

Scientific studies on use of turmeric extract

Nurmaisah *et al.,* 2023 conducted a research with the aim to evaluate the effectiveness of turmeric extract as a botanical insecticide on the feeding activity and mortality of *Spodoptera litura* larvae. The method used in this study was a toxicity test using the leaf dip method. The results showed that the application of turmeric extract on cabbage leaves reduced the feeding activity of instar 2 and 3 larvae. Meanwhile, the turmeric extract had an effect on the mortality of instar 2 and 3 larvae only at a concentration of 16%. The io-= symptoms observed in the dead larvae were changes in colour and body texture.

Amin *et al.,* 2013 evaluated the effect of different plants extracts and namely rhizome of turmeric, rhizome ginger, neem leaf, tobacco leaf, tobacco leaf extract in water, tobacco leaf extract in cow's urine, and cow's urine at different concentrations (70%, 60%, 50%, 40% and 30%) on the growth and sclerotia formation of *Sclerotium rolfsii,* causal agent of foot and root rot disease of betel vine. Considerable growth inhibitions were observed in all concentrations of turmeric rhizome which were 47.16%, 50.04%, 55.97%, 56.43% and 57.13% at 30%, 40%, 50%, 60% and 70% concentrations respectively.

References

Nurmaisah, Mellia Wasti Mau and Abdul Rahim, 2023, Application of Turmeric Extract Botanical Insecticide On Feeding Activity And Mortality Of *Spodoptera Litura* Larvae, *Jurnal Pertanian Tropik*, 10(1):20-29, DOI: 10.32734/jpt.v10i1, April.13564

R. Amin, B. C. Sarker, S. K. Adhikary, S. Sultana and T. Zubair, 2013, Effect Of Some Botanical Extracts And Cow's Urine On Sclerotium Rolfsii Causal Agent Of Foot And Root Rot Of Betel Vine, *The International Journal Of Engineering And Science*, 2(9):77-82

2.1.13 Chunastra

Hydrated lime is also called calcium hydroxide. This simple substance has been mixed with water and sprayed over plants as a basic pesticide for many years. It is known to repel aphids, flea beetles, Colorado potato beetles, squash bugs, cucumber bugs and other undesirable insects.

Ingredients

- Earthen pot (15 litre capacity)
- Lime 1kg
- Kerosene 1 litre
- Neem oil or Pongamia oil 1 litre
- Water 4 litres

Lime powder

Kerosene

Neem oil

Procedures

1. Thoroughly mix all the above ingredients in earthen pot
2. Cover the mouth of the pot with cloth
3. Keep the pot under shade for 24 hours

Shelf life: Need to be prepared afresh whenever needed

Preparation time: 24 hours

Method of usage

- This repellent should be used after draining out water from field.
- It can be used for controlling stem borer in paddy, which will lead to drying of ears if not controlled.

Recommended dose

- For cereals: 200 ml in 15 litres of water
- For vegetables: 100 ml in 15 litres of water

Note: This should not be used in tomato and bottle gourd

2.1.14 Asafoetida Concoction

Asafoetida can be used against sucking pest and also to control viral diseases. Presence of sulphur (Di-sulphide) in Asafoetida makes this solution as a fungicide as well as bactericide.

Ingredients

- Asafoetida 250 grams
- Cow urine 5 litres
- Cow dung 5 kg
- Calcium 100 grams

Asafoetida

Preparation procedure

Fermentation process:

- Mix 5 kg of cow dung, 5 litres of cow urine and 5 litres of water in a vessel and keep it for 4 days duly stirring the contents two times a day with a wooden stick.
- Mixing of 200 g of Asafoetida in cow dung and urine make it a strong fungicide.
- This solution is effective against blast in Paddy.

Preparing concoction:

- After fermentation process mentioned above on 5th day mix 250 gms of Asafoetida in 2 lts of boiling water.
- After cooling add the same to the dung- Urine solution and thoroughly stir it and filter it.
- This is Cow dung – Urine – Asafoetida concoction.
- It is also effective against fungal and bacterial diseases in Paddy

With cow urine:

- To control sucking pests spray solution of 4 litres of cow urine and 100 grams of Asafoetida.
- After adding 100 grams of calcium to cow urine and Asafoetida solution can be used to prevent spread of viral diseases.

Shelf life: Have to be prepared afresh whenever needed

Preparation time: 5 days

Method of usage

- Soil application:
  For dry root rot diseases: 5 litres of asafoetida concoction in 200 litres of water
  For damping off/ wilt diseases: 6 litres of Asafoetida concoction in 100 litres of water to be mixed and applied
- Foliar application:
  For spider mite, aphids, powdery mildew, downey mildew: 5 litres in 100liters of water and sprayed
  Leaf spot, leaf blight, blast, rust, fruit rot and dieback: 6 litres in 100 litres of water mixed and sprayed

2.2 Multiplant-based products

Multiplant products are prepared using more than one plant. These products have broad range of activity due to presence of more number of bioactive compounds which have multiple actions. When more plants are used it will not also act as bio repellent or bio insecticide it will also act as source of nutrients and hormones to some extent.

2.2.1 Agniastra

It can be used for vegetables, fruits, flowers and other agriculture crops. It is effective against Leaf roller, stem, fruit and pod borer


Tocabbo


Green chilli


Garlic

Ingredients for 2 litres of Agniastra

- Tobacco 500gm
- Green chillies 500gm
- Garlic 500gm
- Neem leaf 2kg
- Cow urine 20liter


Neem leaves


Cattle urine

Preparation procedure

1. Take a pot.
2. Add 20 litre local cow urine in it.
3. Crush 500 gram of green chili, garlic and tobacco and add them in urine.
4. Add 2 Kg of neem leaves
5. Then boil this solution well for 5 times
6. Let this solution to ferment for 48 hours with 1 minute stirring twice a day.
7. Filter this by cloth.
8. Spray this medicine Agniastra on the pest like Leaf Roller, Stem Borer, Fruit borer, Pod borer.

The bio repellent must be kept in shade and then covered with a wire mesh to prevent houseflies from laying eggs and the formation of maggots or worms in the solution.

Shelf life: Agniastra is effective for 3 months

Preparation time: 3 days

Method of usage

- Mix 200 Litre water with 6 litre Agniastra and spray it for shoot borer and drench the same to control root borer infestation.

2.2.2 Brahmastra

Brahmastra is a very powerful missile against large insects such as borer, fruit borer and pod borer.

Ingredients

- Cattle urine
- Neem leaves are crushed (with a thin stem) or neem seeds powder 100 grams per acre
- Karanj leaves crushed 100 grams
- Custard apple leaves crushed 100 grams
- Castor leaves crushed 100 grams
- Dhatura leaves crushed 100 grams

Preparation procedure

1. Mix all the ingredients in a pot. Use a wooden stick to mix the ingredients clockwise.
2. Keep the mixture on the fire and boil it.
3. Cover the tank with a jute sack or poly net. The tank should be kept in shadow and it should be noted that the tank is not directly exposed to sunlight or rain water. Leave the mixture for 48 hours for fermentation.
4. Twice in a day for 1 minute, keep the mixture rotating clock wise using a wooden stick.
5. Filter the Brahmastra after 48 hours, and keep the mixture in the bottle and keep it safe.

Shelf life: 6 months.

Preparation time: 48 hours

Method of usage

- Foliar spray: Spray the mixture on infected plants or mix 3% Brahmastra with water. If the nuisance is high, then you can use a mixture of 4%. For 1 acre farm, mix 6 to 8 litres of Brahmastra with 200 litres of water and spray on the plants.

Pay attention:

- Using pestle and mortar crush the neem leaves and other plants leaves.
- Use only urine of indigenous cattle.

2.2.3 Dasparni Ark

The ingredients required and method of preparation is obtained from Natural farming by Niti Ayog. Dashaparni ark acts as substitute for Neemastra, Bramhastra, and Agniastra. It is used to control all types of pests and used depending on the level of infestation.

Ingredients

- Water 200 litres
- Cow urine 20 litres
- Cow dung 2kg
- Turmeric powder 500 grams
- Asafoetida 10 grams
- Tobacco powder 1kg
- Chilly pulp 1kg
- Garlic paste 500 grams,
- Ginger paste 200 grams
- Any 10 leaves*

Preparation procedure

1. Take 200 litres of water in a drum, add 20 litres of cow urine and 2 kg of cow dung. Mix it well and cover with the gunny bag and keep aside for 2 hours.
2. Add 500 gram of turmeric powder, 200 gram of ginger paste, 10 grams of Asafoetida into the mixture. Stir it well in the clockwise direction; cover with gunny bag and keep overnight.
3. Next morning, add 1 kg of tobacco powder, 2 kg of hot green chilli paste and 500 gram of garlic paste and stir it well with wooden stick in the clockwise direction, cover with gunny bag and leave for 24 hours under shade.
4. Next morning, add paste of any 10 types of leaves* (from the list given at the bottom) to the mixture.
5. Stir thoroughly and cover with the gunny bag. Keep it for 30-40 days for fermentation so that the alkaloids present in the leaves will get dissolve in the mixture. Stir twice a day
6. Filter this after 40 days with a muslin cloth and use it.

*Neem leaves – 3 kg, Leaves of *Pongamia pinnata* – 2 kg, Leaves of *Annona sqamosa*- 2 kg, Castor leaves (*Ricinus communis*) – 2 kg, Datura leaves (*Datura metel*)- 2 kg, Leaves of *Calatropis procera* – 2 kg, Leaves of *Vitex negundo* – 2 kg, Leaves of *Datura stramonium* – 2 kg, Leaves of *Nerium indica* – 2 kg, Leaves of *Hibiscus rosa* – 2 kg, Mango leaves (*Mangifera indica*) – 2 kg, Leaves of *Lantana camara* – 2 kg, Leaves of *Casia tora* – 2 kg, Leaves of Guava (*Psidium guava*) – 2 kg, Leaves of Pomegranate (*Punica granatum*) – 2 kg, Leaves of Drumstick (*Moringa oleifera*) – 2 kg, Leaves of Coffee (*Coffea arabica*) – 2 kg, Leaves of Mahua (*Maduca indica*) – 2 kg, Coco leaves (*Theobroma cacao*) – 2 kg, Leaves of *Acacia nilotica* – 2 kg, Leaves of *Psoralea corylifolia* – 2 kg, Leaves of Bitter Gourd (*Momordica charantia*) – 2 kg.

Shelf life: 4 months

Preparation time: 45 days

Method of usage

- The prepared kashayam of 6-8 litres should be diluted in 200 litres of water for spraying

Reference

Preparation of Dashparni ark: https://naturalfarming.niti.gov.in/components/#:~:text=Preparation%20of%20Dashparni%3A,of%20Asafoetida%20into%20the%20mixture.

2.2.4 Handikhata

The ingredients and method of preparation is obtained from Organic- Technical protocol by Madhyam foundation. Handikhata is a broad spectrum bioformulation capable enough to prevent the insects entering the farm from adjacent farms and damaging the crop due to its repellent and antifeeding nature. It is 100% eco-friendly. It can also cure many of the diseases in the vegetable crops including viral diseases such as yellow mosaic virus in okra. It can also be used as a solution for seed treatment.

Ingredients

- One Earthen Pot [Approx. 5-7 litre capacity]
- Fresh cow dung -1 Kg [Country cow]
- Cow urine [Approx. 5 litre]
- Gur/Jaggery [Molasses]- 50 gm
- Neem leaves-1 Kg.
- Karanja leaves -1Kg [*Pongamia Pinnata*]
- Arakha leaves -1Kg [*Calotropis*]

Preparation procedure

1. Keep the cow dung, cow urine, gur (jaggery) in the earthen pot and mix thoroughly.
2. Make all the leaves (Neem, Arakha & Karanja) in to small pieces.
3. Then add all the chopped leaves to the pot.
4. Thoroughly mix it and cover the mouth of the pot. Keep the pot in shade for a week (7 days).
5. After a week take out only the liquid portion from the pot keeping the solid part in side. The solution is called Handikhata.
6. Then add about 5 litres of cow urine only to the pot and repeat the process. Then keep the pot as instructed previously for another week and extract the solution in same process.
7. One can do like this for 4 months without adding any other ingredients except cow urine. In similar process one can collect the medicine every week for 4 months and get 60-70 litres of the medicine.
8. After four months, it is required to prepare fresh solution with all the ingredients once again .This 60 -70 litres of medicine are sufficient for one hector of crop for one season.

Shelf life: 6 months

Preparation time: 7 days

Method of usage

- The standard recommended dose for foliar spray to main field is 20 ml per 1 litre of water.
- For nurseries and younger plants- 10-12 ml per litre of water.
- Use 20 ml handikatha in l litre of water and soak the seeds before sowing. This helps in quicker germination and vigorous plant growth.

Scientific studies on use of Handikhatha

After fermentation, the surface liquid is utilized for spraying the crop @ 15-20 ml/ litre of water. The formulation suppresses insect pests like yellow stem borer, leaf folder and case worm in rice (Patnaik and Subhashree Dash, 2017).

2.2.5 Sarva Keetanashi

It can be used effectively against sucking and leaf eating pest

Ingredients

- Cow urine 20 litres
- Neem leaves 3 kg
- Custard apple leaves 3 kg
- *Ipomea carnea* (Bhesram leaves) 3 kg
- Calotropis leaves (Madar leaves) 3kg
- Parthenium leaves (Ghajar grass) 3kg
- Green chilli: 250 gram
- Garlic: 250 gram

Preparation procedure

1. Grind all the leaves, chilli and garlic.
2. Mix everything and boil it in earthen pot
3. Take off the pot after boiling for 2-3 mins
4. Repeat the boiling process for 4 times
5. Keep the mouth of the pot tied with jute bag
6. Keep it in shade for 48 hours
7. Keep stirring with wood for 10 minutes in the morning and evening
8. After 48 hours, filter and store it in a plastic container

Shelf life: This solution can be kept for 3 months without adding water.

Preparation time: 3 days

Method of usage

- 30 to 60 ml of the solution is mixed in a litre of water
- Drench the entire plant from top to bottom with the solution
- This should be done in morning or evening hours

2.2.6 Panch Patti Dava (Five leaves decoction)

Panch patti dava can be used to control sucking pests. Method of preparation is obtained from Samaj Pragati Sahayog, Bagali district Devas-455 227 (MP)

Ingredients

- Neem leaves: ½ kg
- Sapota leaves: ½ kg
- *Ipomoea carnea*: ½ kg
- Datura sp. : ½ kg
- Calotropis: ½ kg
- *Madhuca longifolia*: ½ kg
- Cattle urine 100 litres
- Water: 12 litres

Preparation procedure

1. Chop the leaves into small pieces and add them into the earthen pot
2. Add cow urine and water to the earthen pot and mix thoroughly
3. Leave the content for 5 days with covering the lid with gunny bag
4. After 5 days, boil the content until it becomes half, keep it for cooling
5. After 24 hours, squeeze the content to plastic bottle and store

Shelf life: 3 months

Preparation time: 7 days

Method of usage

- Foliar spray: For spraying 250-500 ml of the solution is mixed /tank. It can be sprayed at 10-15 days interval

2.2.7 Chilli Garlic Solution

Capsaicin and Dihydrocapsaicin present in chillies and allin, allicin and diallyl disulphide in garlic act on the insects through contact. These will create irritation to the insect and insect will fall from the plant and die.

Ingredients

- Green Chillies 3 Kgs
- Garlic 1/2Kg
- Kerosene 250ml
- Soap powder 100gr

Procedure

1. Grind the chillies after removing the petioles and add 10 litres of water to it. Keep this solution throughout the night.
2. Grind the 1/2 kg garlic and add 250 ml kerosene keep it for a night
3. Next day morning filter the chilli solution through a thin cloth
4. Do the same for garlic solution
5. Mix chilli solution, garlic solution and use

Shelf life: To be prepared afresh as and when required

Preparation time: One day

Method of usage

- *Foliar application:* Add soap powder to the solution and make a mixture. Add 100 litres of water to the above solution. This can be applied for one acre

Precautions

- Cover the body while spraying
- Apply this solution only one or two times during cropping season

2.2.8 Char Chatni Dava (Garlic, Onion, Chilli and Ginger paste)

Char Chatni Dava can be used to control leaf eating caterpillars, stem, pod and fruit borers. Due to garlic smell caterpillars come out from the pods and it will fall on the ground. Method of preparation is obtained from Samaj Pragati Sahayog, Bhagali, district Devas-455 227 (MP)

Ingredients

- Garlic ½ kg
- Onion ½ kg
- Green chilli ½ kg
- Ginger ½ kg
- Water 8 litres

Garlic

Onion

Chilli

Preparation procedure

1. Make the paste of garlic onion, green chilli and ginger
2. Mix all the paste with 8 litres of warm water and leave for 12 hours
3. After 8 hours filter or squeeze the content to plastic bottle and store

Garlic

Shelf life: To be prepared as and when required

Preparation time: One day

Method of usage

- *Foliar spray:* For spraying 250-500 ml of the solution is mixed /tank

2.3 Botanicals which primarily serve as antimicrobials (To manage disease)

Antimicrobials are the formulations majorly used to control the disease causing microorganisms such as fungi, bacteria and virus.

2.3.1 Sothastra

It is a fungicide and it can also be used against viral disease. Ingredients required and method of preparation is obtained from Gram Sudhar Samithi, an NGO located in Madhya Pradesh

Ingredients

- Milk 1 litre
- Water 1 litre
- Ginger powder 200 grams

Milk

Preparation procedure

1. Take all the ingredients in earthen pot
2. Boil until the mixture becomes half
3. Keep the pot in shade for two days
4. Filter the content using cotton cloth

Ginger powder

Shelf life: Has to be prepared afresh as and when needed

Preparation time: 48 hours

Method of usage

- *Foliar spray:* Based on the height of the plant 30 to 60 ml of the solution is mixed in a litre of water and sprayed.

Scientific studies on use of Sonthastra (Ginger products)

Results of Syed Arif et al., (2016) indicated that overall minimum infestation of cabbage looper was recorded from the plot treated with garlic extracts @3 % followed by ginger extract @ 3 % and tobacco extract @ 3% while maximum infestation was recorded from the check plot.

The Pesticidal potentials of ginger (*Zingiberofficinale*) was evaluated for the control of bean weevil (*Callosobruchus maculatus*) and maize weevil (*Sitophilus zeamais*) (Edu et al., 2019). The results showed that the efficacy of ginger on the control of weevil was proportional to the concentration used. High concentration of 60g gave a high percentage mortality (49%) of *Sitophilus zeamais* and also reduced the total grain weight lost in beans from 38% in control to 11% for those treated with ginger in *A. obtectus*

Alka rani, 2017, attempted to determine the effectiveness of extracts prepared from turmeric and ginger against Sitophilus oryzae. It has been found that both turmeric and ginger have the potential to control the pest. It was observed that both are more effective in lower concentration and effectiveness of turmeric is more as compared to ginger.

Inference

- The powder of ginger can be used as an alternative to synthetic insecticide for the control of beans and maize weevil.

References

Syed Arif Hussain Rizvi, Shahid Hussain, Suhail Ur Rehman, Saleem Jaffar, Muhammad Farooq Ur Rehman, 2016, Efficacy of ecofriendly botanical extracts of Ginger (*Zingiber officinale*), Garlic (*Allium sativum*) and Tobacco (*Nicotiana tabacum L*) for the control of cabbage looper (*Trichoplusia binotalis*) under agro ecological conditions of Peshawar, Pakistan, *Journal of Entomology and Zoology Studies*, 4(1): 88-90

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Alka Rani, 2017, Bioefficacy of extract of turmeric and ginger as potential biopesticides on *Sitophilus oryzae*, *Advanced Scientific Research*, 2(1):10–11

http://advancedscientificresearch.in/imageGal/6797ASR%202017%202(1)%2010-11.pdf

2.3.2 Bael Patti ki Dava (Stone Apple Leaf Extract)

Presence of many alkaloids in Bael leaves will help in disease management. This decoction is effective against blast diseases occurring in cereals, sheath blight and other fungal diseases

Ingredients

- Stone apple tree leaves 5 kg
- Detergent powder 50 gm
- Cow urine 5 litres

Preparation procedure

1. Grind and make the paste of stone apple leaf
2. Add cow urine to the paste and make it into a solution
3. Heat the mixture till it attains 4 boils
4. Keep the content and let it cool

Shelf life: Prepare afresh whenever needed

Preparation time: One day

Method of usage

- *Foliar application:* Add 50 gram of detergent powder and 100 litres water to it. Quantity prepared using the above given ingredients can be used for spraying one acre.

Scientific study on use of Stone Apple Leaf Extract

Kumari S., *et al,* 2018 reported on efficacy of *Aegle marmelos* as potent ovicide and larvicide against *Ostrinus nubilalsis*, *Spodoptera littoralis, Callosobruchus maculatus* and *Tribolium confusum*. *Aegle marmelos* extract may be used as botanical insecticide against different stored grain insect pests causing infestation in stored maize, rice, cowpea and wheat flour.

Highest oviposition deterrence was found in petroleum ether extract (59.74%), followed by methanol (57.32%), ethanol (56.07%) and water extract (55.28%) respectively at 5% concentration after 7 days of seed treatment. In terms of inhibition rate, petroleum ether extract at 5% concentration was found to be most effective (75.91%), followed by methanol (74.50%), ethanol (73.87%) and water extract (70.28%) respectively from 1st day to 10th days of adult emergence. The leaf extract at different doses significantly reduced oviposition and adult emergence of *C. chinensis* in treated green gram seeds (Murasing et al., 2017).

Moutushi Modak *et al.,* (2023) studied the ovicidal potential of crude *A. marmelos* leaf extract at five concentrations (1.25%, 2.5%, 5%, 7.5%, and 10%). The results indicated that a maximum of 30% ovicidal action was achieved at the 10% concentration. The extract also exhibited deterrence activity against adult bugs. At all concentrations, significant deterrence was observed in terms of time spent on the treated surface and the frequency of visits. Bug activity decreased with increasing concentrations, spending only 2.5% of time on the treated surface at 10% concentration. Bug preference for the treated surface also decreased with concentration, with only 14% of visits on the treated surface at 10% concentration.

ICAR-NRRI: Severe leaf blast occurred in the rice field of a farmer from village Bhairpur in Cuttack district. The intensity of the disease ranged between 65% and 75% on rice variety Lalat. The environmentally safer technology, developed at NRRI to control rice blast disease, comprising of the

aqueous extract of Bael leaf @ 25 g/litre of water and steamed aqueous extract of Tulsi leaf @ 25 g/litre of water was sprayed in the blast infested field. The farmer repeated this spray after 10 days. On the subsequent visit after 15 days, it was observed that the blast disease was successfully and effectively controlled. The rice crop had registered, an 80% to 85% recovery as compared to 45% recovery in ediphenphos (Hinosan) sprayed field.

References

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C. Murasing, P. Das, K. Sathish and L.K. Hazarika, 2017, Bio Efficacy of Bael (*Aegle marmelos*) Correa (*Rutaceae*) Leaf Extracts against Pulse Beetle (*Callosobruchus chinensis* L.) in Stored Green Gram Seed (*Vigna radiata L.*), *Int. J. Curr. Microbiol. App. Sci.*, 6(8): 2067-2075

Moutushi Modak, Rubina Azmeera Begum, Santana Saikia and Anjana Singha Naorem, 2023, Efficacy of aqueous *Aegle marmelos* leaf extract for the control of *Megacopta cribraria*, *Research Square*, DOI: https://doi.org/10.21203/rs.3.rs-3173213/v1

Paddy blast: https://icar-nrri.in/bael-and-tulsi-aqueous-control-blast-disease-in-farmers-field/

3. Non botanicals

3.1 Primarily bioinsecticides

3.1.1 CVR Technique

This is a low-cost pest management technique discovered by Shri Chintala Venkata Reddy. The same technique can be used for supplying nutrients to crops by changing the ingredient from subsoil to top soil. Shri Chintala Venkata Reddy is the first independent farmer in India to receive an international patent for his technique in soil swapping and soil fertility. He was awarded a Padma Shri award in 2020 for his contributions.

Ingredients

- Sub surface and sub surface soil 15 kgs
- Water 200 liters

How to get soil

- Sub soil: Dig the pit of 3-4 feet collect 15kg of sub soil
- Top soil: Form the top 3 inches layer, collect 15kg of soil in a pot

Collecting sub soil

Preparation procedure

1. Take 200 liters of water in a plastic drum
2. Mix 15 kg of subsoil/topsoil in this water.
3. Stir the content with the help of wooden stick till clods are broken.
4. Keep solution undisturbed for 15-30 minutes.
5. 200 litres spray solution can be used for an acre crop.

Sub soil mixed in water

Preparation time: 2 hours

Shelf life: To be prepared afresh each time

Method of usage

- Filter the solution to remove the dirt particles
- No further dilution is needed.
- Solution can be sprayed on the plants as preventive mechanism to control pest infestation.
- Soil solution prepared using subsoil helps in managing pests. It has to be applied twice in a week as preventive/ curative spray.
- Soil solution prepared using top soil act as source of nutrients

How it works

- The above solution prepared using subsoil when sprayed on the stem and leaves of a crop results in a layer of soil on these plant parts. Pest which feeds on stems and leaves in the sprayed field happen to consume clay-rich soil and dies due to indigestion.
- When the solution prepared using the top soil is sprayed on plants nutrients present in the soil solution will be directly absorbed by the plants.

Benefits

- Helps in controlling the infestations of mealybugs, aphids, defoliating caterpillars and stem borer at no cost/ low cost
- Helps in boosting the growth of the crops.

Precautions

- Avoid spraying in rainy days, as rain washes the soil from the leaf surface.
- Both the solutions have to be applied as foliar sprays.

Videos on preparation: https://youtu.be/BxnlTyXE6UU
https://www.youtube.com/watch?v=C0H6jUWq5ys
https://www.youtube.com/watch?v=5oA6Q9jHeBw

References

J Dahiya, 2022, What is CVR soil technology? Can insect pests be destroyed by soil sprinkling? Jaivaik Kheti.

https://www.agricultureinformation.com/forums/threads/chinthala-venkat-reddy-soil-swapping-to-improve-productivity.188006/

https://en.wikipedia.org/wiki/Chintala_Venkat_Reddy#Soil_Spray_as_nutrient

3.2 Primarily Antimicrobials (to manage disease)

3.2.1 Katta Matta (Spoiled buttermilk)

Buttermilk is a good growth promoter along with being the world's largest fungal disease preventer. Buttermilk base alone could reduce virus concentration but was more effective when used in combination with Bacillus formulations (Suresh., 2018).

Ingredients

- Curd: 6 litre
- Water: 100 litre

Curd

Drum

Procedure

1. Keep 6 litres of curd for 8 days (Spoil)
2. In 100 litres of water mix spoiled curd and used for spraying

Shelf life: To be prepared afresh whenever needed

Preparation time: 8 days

Method of usage

- Spraying katta matta during flowering stage will increase the percentage of fruit set
- It is effective against fungal diseases occurring in crops and all sorts of scorching diseases such as stem and leaf blast in paddy, leaf blast in tomato, etc.)

Paddy Stem blast

Paddy leaf blast

Tomato leaf spot

Scientific studies on usage of buttermilk

Scientists at Coimbatore-based Tamil Nadu Agricultural University (TNAU) have found that a plant growth promoting rhizobacteria called Bacillus amyloliquefaciens can be used to fight Tobacco Streak Virus (TSV) in cotton crop. The formulation, prepared in buttermilk, was tested against the plant virus and found effective. Experiments were conducted during 2015 and 2016 in two different locations in Tamil Nadu to assess the efficacy of Bacillus species and phyto-antiviral principles against TSV infecting cotton. Buttermilk was used as a carrier base for application of bacterial inoculation. It was found to effectively colonize rhizosphere and phylloplane of cotton plant and produce anti-microbial peptides and fatty acids, which curbed the virus (Suresh Ramanan, 2018).

Virender singh, 2019 reported that sprinkling 1.5 litres of buttermilk (at least 15 days old) per crop for the prevention of fungal diseases such as yellow rust, caterpillar, etc. Spraying of Buttermilk is good for growth of crops. By adding 15-20 litres of Buttermilk per acre, putting them in the field protects the roots from the fungi

References

S Suresh Ramanan, 2018, Buttermilk-based bioformulation helps in cotton disease control, https://www.thehindubusinessline.com/news/science/buttermilk-based-bioformulation-helps-in-cotton-disease-control/article25598896.ece

Virender singh, 2019, Butter milk is world's largest fungal disease preventer, https://blog.apnikheti.com/butter-milk-worlds-largest-fungal-disease-preventer/

3.2.2 Cooking Oil and Yolk (COY)

Egg yolk is a natural emulsifier. An emulsifier is something that mixes two oil and water-based components together. It also acts as sticker and supply nutrients for plant growth.

Oils are often the best pesticide choice for controlling soft-bodied insects and mites as well as powdery mildew. Not only do oils leaves no toxic residues, they are safe to use around people, pets and wildlife, have low impact on beneficial insects, won't harm honey bees unless applied directly to flowers during the time of the day that bees are foraging. Oil kill insects and mites by suffocation. Insects breath through structures called spiracles. Oil block spiracles, reducing the availability of oxygen and interfering with various metabolic processes. When applied to insects or mite eggs, oil can penetrate the shells and kill the developing embryo.

For diseases such as powdery mildew, oil can act as both a preventive and a curative fungicide, smothering fungal growth and inhibiting spore production. In many cases, oils are more effective than standard fungicides in reducing existing powdery mildew infections.

Ingredients for 15 litres of water

- Egg 1 number
- Any seed oil 60-100 ml
- Water 1 liter
- Blender/ mixer

Egg

Cooking oil

Procedure: Using mixer

1. Put one egg yolk (remove the egg white) in a mixer with 60 ml of water.
2. Stir for 3 minutes at low speed.
3. Add 60 ml of seed oil if the preparation is used for preventive management
4. Add100 ml of seeds oil (soya bean cooking oil, sun flower cooking oil, corn cooking oil, etc.) for reactive management
5. Stir with high speed for another 5 mins.
6. Egg yolk seed oil pesticide is ready for usage.

Preparation time: 30 minutes

Shelf life: Should be prepared fresh every time

Method of usage

Effective against soft bodied insects such as aphids, mites, mealy bugs, thrips, white fly, powdery and downy mildew.

- *For preventive action:* Spray once in a week. Dilute 10 ml of the blended egg yolk seed oil with 1 litre water, shake well and spray upper and lower leaves or infected area Eg., fruits.

Precautions

- As oil kill by suffocating insects, be sure to spray the product both the underside and topside of leaves, buds, shoots and all location where insects and mites may be located.
- Many plants are sensitive to oil damage during water-stress; so be sure that plants have been adequately irrigated before application.
- Spray before 9.30 am or after 4.30 pm to avoid oil burn from hot sun.

Videos on method of preparation: https://www.youtube.com/watch?v=9P4QInh42LY
https://fb.watch/n19LVxKHKV/?mibextid=UVffzb

Scientific studies on use of COY

Powdery and downy mildews caused by *Sphaerotheca fusca* and *Pseudoperonospora cubensis* are the most common and serious diseases of cucumber worldwide. In spite of the introduction of highly effective systemic fungicides, control of these diseases remains elusive. Hence, this study aimed to develop an alternative method to chemicals in controlling the diseases by using different types of cooking oil. Among the different cooking oils used, soybean, canola (rape seed), safflower, sunflower, olive, and corn oils showed over 95% control values against powdery mildew of cucumber in a greenhouse test. In particular, 0.3% canola oil emulsified with 0.08% yolk (1 yolk and 60 ml canola in 20 l spray) was found to be the most effective. The treatment resulted in 98.9% and 96.3% control efficacies on powdery and downy mildews, respectively, of cucumber in the field (Jee, Hyeong-Jin *et al.*, 2009)

This study was conducted to develop an organic control method of two spotted spider mite (*Tetranychus urticae*) by using cooking oil and yolk mixture (COY) through evaluating its acaricidal activity in laboratory and green house. In laboratory, there is no significant difference in acaricidal activity against *T. urticae* within the COY including soybean, canola (rape seed), sunflower and olive oil. The acaricidal activity against *T. urticae* increased from 17.6% to 94.1% as the COY became concentrated between 0.1% to 1%. The COY acaricidal activity was effected by the quantity of treatment according to application methods. The COY dealt with *T. urticae* eggs presented 95% of the ovicidal activity. In rose greenhouse damaged by *T. urticae*, the COY (0.3%) was sprayed three times and resulted in the high control value of mites between 69.0% to 89.6% (Jo-Hong Park *et al.,* 2008).

References

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Jong Ho Park., Kyoung Yul Ryu, Byung Mo Lee and Hyenong Jin Jee, 2008, Effect of COY(Cooking Oil and Yolk Mixture) on Control of Tetranychus urticae., Korean journal of applied entomology, 47 (3): 249-254., https://doi.org/10.5656/KSAE.2008.47.3.249

Nature-Positive Farming & Wholesome Foods Foundation (N+3F)

Nature-Positive Farming And Wholesome Foods Foundation (N+3F) is a Section-8 non-profit support organisation with the mandate to promote N+FFS at scale across India. N+3F builds on the initiatives of NPM Network and focus on a broad spectrum of interventions which includes, i) facilitating adoption of nature-positive farming by a large number of farmers, ii) supporting adoption of post-harvest technologies and practices, iii) market development, iii) supporting adoption of guarantee systems and certification, iv) promoting consumption of pesticide-free wholesome foods and v) policy advocacy. N+3F collaborates with 30+ organisations comprising NGOs, FPOs and market players in Central, Southern and Eastern India.

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