R-2764
[1-15]

REVIEW ARTICLE Agricultural Reviews, Volume Issue : ()

# Harnessing Microbial Properties of Natural Farming Components for Soil and Crop Health Improvement: A Review

Rahemanali M. Surpura[1,2], Aditya P. Rathore[1], Smit K. Patel[1,2], Sudhanshu Jangir[1], Dweipayan Goswami[2], Rakesh Rawal[3], Himanshu A. Pandya[4]

10.18805/ag.R-2764

## ABSTRACT

Natural farming (NF) is an agricultural approach that avoids using chemicals and relies on livestock. It is designed to tackle both environmental and socio-economic issues in the agricultural sector. The foundation of natural farming rests on four key pillers: Beejamrit (seed treatment), Jivamrit (ensuring soil fertility), Aachhadan or Mulching (preventing water evaporation) and Whapasa (ensuring favourable microclimate). various plant protection formulations like Neemastra, Brahmastra, Dashaparni, *etc*., are incorporated into NF practices to shield crops from harmful insects, larvae, sucking pests and diseases. Natural farming inputs like Jivamrit, Ghanajivamrit, *etc*. are generally prepared from cow dung, cow urine, uncontaminated soil, jaggery, pulse flour, *etc*. However, NF plant protection formulations such as Neemastra, Brahmastra, Dashaparni, *etc*. are generally prepared from cow dung, cow urine, specific tree leaves, *etc*. Numerous scientific studies reported that the NF inputs and formulations have contain beneficial microorganisms, amino acids and other substances that not only enhance plant growth but also provide protection against pests and pathogens that impact a wide range of economically significant crops. Therefore, integration of natural farming inputs not only supports the well-being of crops but also fosters a holistic and sustainable approach to agriculture, ensuring a prosperous future for both farmers and the environment.

**Key words:** Beneficial microorganisms, Bio-stimulate, Crop protection, Natural farming, Sustainable agriculture.

The production and use of chemical fertilizers, pesticides and weedicides has increased many times in agriculture. Conventionally managed agriculture used different types of synthetic fertilizers in the farming system to increase productivity. Apart from their intended benefits, the utilization of chemical-synthetic plant protection products (CSPs) poses various hazards to both human health and the environment, including biodiversity. The present application of pesticides has been identified as a primary factor contributing to the decline in biodiversity (Class-Mahler *et al*., 2023). Heavy utilization of pesticides has been associated with risks to both the environment and human health. (Jahnke and Bieling, 2023). Heavy use of pesticides and chemical fertilizers can contaminate the soil profile and leach down to enter groundwater, especially heavy metals like Cd, Cu, Mn and Zn. The uptake of these heavy metals by plants holds in sink parts for a longer time and people who consume these plant products suffer serious health consequences (Alengebawy *et al.,* 2021; Barabasz *et al.,* 2002). According to the WHO reports, more than 50% of foods contain chemical residues that are carcinogenic in nature (Prasad, 2016).

Modern agriculture's expansion and intensification pose one of the biggest risks to global biodiversity and, consequently, food security (Kavitha and Chandran, 2017). Intensively use of agrochemicals is reducing the soil microbial diversity, soil organic carbon and increasing the soil erosion (Schiavon *et al*., 1996; Shaikh and Gachande, 2013) and also cause serious soil degradation through nitrogen leaching, soil compaction and reduction in soil organic matter; resulted crop yields decrement over time. Moreover, these chemicals kill natural soil microflora and pollinators that are useful for higher crop production (Horrigan *et al.,* 2002). Vidyavathi *et al*., (2012) found that continuous chemical nutrient management approaches significantly reduce soil fertility. Presently, there is a need for an alternative and sustainable approach to conventional farming, eliminating the use of chemical fertilizers and

[1]Indian Institute of Sustainability, Gujarat University, Ahmedabad-380 009, Gujarat, India.
[2]Department of Microbiology and Biotechnology, Gujarat University, Ahmedabad-380 009, Gujarat, India.
[3]Medical Biotechnology, Gujarat Biotechnology University, Gandhinagar-382 355, Gujarat, India.
[4]Department of Botany, Bioinformatics and Climate Change Impacts Management, University School of Sciences, Gujarat University, Ahmedabad-380 009, Gujarat, India.

**Corresponding Author:** Rahemanali M. Surpura, Indian Institute of Sustainability, Gujarat University, Ahmedabad- 380 009, Gujarat, India. Email: rahemanali.surpura@gujaratuniversity.ac.in
ORCIDs: 0009-0009-7702-904018, 0000-0002-0738-681016, 0009-0000-3840-855217, 0009-0006-8675-533319, 0000-0003-0165-0294, 0000-0002-7985-118720, 0000-0003-4536-954121

**How to cite this article:** Surpura, R.M., Rathore, A.P., Patel, S.K., Jangir, S., Goswami, D., Rawal, R. and Pandya, H.A. (2025). Harnessing Microbial Properties of Natural Farming Components for Soil and Crop Health Improvement: A Review. Agricultural Reviews. 1-15. doi: 10.18805/ag.R-2764.

**Submitted:** 21-09-2024 **Accepted:** 01-01-2025 **Online:** 05-02-2025

pesticides. In order to mitigate adverse environmental impacts of these chemicals and improve soil quality. We have to focus on sustainable agricultural systems that minimize reliance on external inputs, particularly fertilizers, insecticides and herbicides. (Moonen and Barberi, 2008). Natural farming is the only sustainable way to regenerate soil health and it is also called “Zero Budget Farming”.

Natural farming is an emerging concept that is gaining popularity as an effective method to reduce the usage of pesticides and chemical fertilizers in agriculture to reduce input cost. Natural Farming can be defined as “chemical-free and livestock-based farming”. With the integration of crops, trees and livestock, it is a diversified farming system that makes the best use of functional biodiversity. Natural farming has the potential to increase farmers’ income while also providing many other advantages, including the lowering or reduction of greenhouse gas emissions, the restoration of soil fertility and environmental health. Natural farming is considered as a type of regenerative agriculture internationally- a well-known method of protecting the environment. It has the potential to manage land use and store carbon from the atmosphere in soils and plants, where it will be beneficial instead of harmful (NITI Ayog, 2021; Choudhary *et al*., 2023).

‘Natural farming’ is a term which recently become well-known because of M. Fukuaka, a Japanese agriculturalist. In India, natural farming get popularity due to Subhash Palekar. On the other hand, natural farming methods promote the use of locally available cow dung, cow urine and other materials to make natural manure and plant protection. Therefore, farmers need not borrow money from money leaders to purchase fertilizers and pesticides. This way, NF supports farmers economically and called Zero Budget Natural Farming (ZBNF) (Ipsita Ojah *et al*., 2023). Only nature-based product used in natural farming which can produce healthy food, keep us healthy and maintain the health of soil too. The key to natural farming is minimizing the external inputs which negatively impact the soil composition on the farm (Devarinti, 2016).

Previous literature often overlooks the scientific intricacies behind Natural Farming (NF), concentrating primarily on its historical context and impact on farmers’ livelihoods. However, there exists a notable gap in understanding the science driving NF formulations. This review aims to fill this void by presenting a comprehensive exploration of various formulations, encompassing their composition, application techniques, scientific underpinnings and resulting effects.

## Science behind natural farming

Natural farming (NF), established on its four fundamental pillars (Table 1), serves as the cornerstone of this agricultural methodology, providing the essential foundation upon which its efficacy and sustainability are anchored.

Natural farming is a multifaceted approach that encompasses a diverse range of inputs, each play distinct roles as growth promoters, protectors against pests and diseases and contributors to overall soil health. Central to Fig 1, various microbial activities associated with these inputs, which exert both direct and indirect influences on plant growth and protection. Natural farming practices are interconnected and contribute to various mechanisms that improve soil health, nutrient availability and water efficiency, leading to a more resilient agricultural system and potentially higher crop yields with better carbon accumulation in the soil (Mishra *et al*., 2023).

Jivamrit and Beejamrit are one of the natural farming pillar that work as microbial inoculums to the soil through soil application and seed treatment to boost the growth of soil microflora, protecting plant seed and seedling from soil/seed borne disease, pest and enriching the soil with nutrient. Natural pesticide formulations such as Neemastra and Brahmastra made mainly from different leaves, cow dung and cow urine (Devarinti, 2016).

NF Inputs are mainly consists of cow dung, urine, jaggery, pulse flour, uncontaminated soil, *etc*. Cow dung and cow urine are rich in amino acids, that increase the nitrogen percentage and population of beneficial microorganisms (Bindushree *et al*., 2023). Jaggery is a rich source of potassium, containing approximately 1056 mg per 100 g (Nath, A., *et. al*. 2015). Potassium is a quality nutrient for plants and it required in large amounts for growth, reproduction and also help in drought resistance. In natural farming inputs preparation, gram flour is one of the main ingredients which contains huge amount of amino acids. These amino acids help to enhance population of beneficial microflora. This higher beneficial microflora help to healthier root system that protect plant from diseases and maintain effectiveness under adverse conditions (Boye *et al.,* 2010 and Esmat *et al*., 2010).

Among these jivamrit and beejamrit are the one of the best, which contains almost essential plant nutrients (nitrogen, phosphorus, potassium, zinc, copper, manganese *etc*.), enzymes (acid phosphatise, alkaline phosphatise, dehydrogenase *etc*.) and microbes (bacteria, fungi, actinomycetes, free living nitrogen fixers and phosphorus solubilising organisms), which directly enhances plant metabolism resulting better growth and development (Bhadu *et al*., 2023). These natural farming formulations support microbial growth, soil health maintenance and improved crop yield. To maintain soil health, it is essential to maintain a healthy microbial population and this is where natural farming is so important. In natural farming, various formulations help to control pest infestations like Neemastra, Brahmastra, Agniastra, Dashaparni ark, *etc*. By avoiding the use of chemicals fertilizers and pesticides, natural farming fosters a healthy soil ecosystem where diverse microorganisms thrive, enhancing both plant growth and overall soil fertility (Ipsita Ojah *et al*., 2023). Natural inputs can improve soil aeration, organic carbon, microbial activity and water holding capacity (Korat and Mathukia, 2022).

## Natural farming components

Natural farming comprises various components including Beejamrit, Jivamrit, Whapasa, Mulching and Plant Protection Formulation (Fig 2). These components serve multiple purposes such as seed treatment, growth promotion and plant protection. Jivamrit and Ghanajivamrit are utilized as growth promoters, Beejamrit is employed for seed treatment, while Neemastra, Brahmastra, Agniastra, Dashaparni Ark, *etc*., are utilized for plant protection (NITI Ayog, 2021).

### Beejamrit

Beejamrit is an ancient, sustainable agriculture technique for treatment of seeds, seedlings, or any other planting material. Young roots are effectively protected from fungus by it. As a seed treatment, Beejamrit is a fermented microbial solution that is rich in microbes that are beneficial for plants. It is expected that the helpful microbes will colonize the seeds, roots and leaves and support in the plants' healthy growth (NITI Ayog, 2021). In various websites and research/review papers different terminology has been used like beejamrit, bijamrita, beejamrutha, *etc*. (Badwal *et al*., 2019; Devakumar *et al*., 2014; NITI Ayog, 2021 and Goveanthan, 2020).

### Ingredients

- 5 kg cow dung,
- 5 L cow urine,
- 50 g lime,
- 50 g uncontaminated soil,
- 20 L water

### Preparation

To prepare the beejamrit, following the steps given in Fig 3 (Devvrat, 2023).

### Applications

- 20 L of Beejamrit are used to treat 100 kg of seeds.
- **For all crops:** Add beejamrit to the seeds, coat them by mixing by hand, dry them well before sowing.
- **For leguminous seeds:** Dip the seeds quickly in beejamrit and let them dry.

### Function

Beejamrit is used for natural seed treatment that is effective in protecting young roots from soilborne diseases and seedborne diseases that commonly affect plants during germination. It is also helpful in producing IAA (indole-3-acetic acid) and GA (gibberellic acid), which are plant hormones that promote growth and development of plant (Sreenivasa *et al*., 2010).

**Table 1:** Natural farming pillars, their description and components (Duddigan *et al.*, 2022).

| Piller | Description | Components |
|---|---|---|
| Beejamrit | Seed treatment, applied as a coating either to seeds before sowing, or as a root dip before transplanting | Cow dung<br>Cow urine<br>Lime<br>Rhizospheric soil<br>Water |
| Solid Jivamrut (Ghanajivamrit) | Applied either as a top dressing or incorporated into topsoil | Cow dung<br>Cow urine<br>Jaggery<br>Gram (legume) flour<br>Rhizospheric soil |
| Liquid Jivamrit (Jivamrit) | Applied either mix with irrigation water or as a foliar spray. | Cow dung<br>Cow urine<br>Jaggery<br>Gram flour<br>Rhizospheric soil<br>Water |
| Achhadana | Mulching-either as biomass/ cover crops or dried crop residues | Dry crop residues applied as an amendment on the soil surface (paddy straw, groundnut husks *etc*.), or cover crops (often legumes) |
| Waaphasa | Soil microenvironment where air and water molecules are present in 50-50 per cent | |

### Finding

Mukherjee *et al*. (2022) reported that beejamrit was potential sources of enriched microbial niches, including several bacteria that can synthesize plant growth hormones that promote plant growth. Population of beneficial bacteria for plants, such as free-living nitrogen fixers (FNFs) and phosphate solubilizers (PSBs), gradually increase up to 4 and 5 days of incubation, respectively in beejamrit. Additionally, Mukherjee *et al*. (2022) also concluded beejamrit contain indolic content, which includes indole 3-acetic acid (IAA), whose concentration further varies depending on the incubation times required during the beejamrit preparation. Beejamrit also provides crop plants access to a dynamic, microbe-based metabolic network and it act as a plant bio stimulant. Beejamrit capable to enhance seed germination, seedling survival rate and shoot length trait.

Beejamrit had the highest microbial population of bacteria, fungi, actinomycets, N-fixers and P-solubilizers on the day of preparation and thereafter, it gradually decreased until it was at its lowest on the 7th day after preparation also recorded by Devakumar *et al*., (2014). Similarly, Bindushree *et al*. (2023) reported beejamrit's population of plant-beneficial microbes, including bacteria, fungi, phosphate solubilizers and *Pseudomonas*, was 330 $\times 10^5$, $5\times 10^4$, $62\times 10^4$ and $79\times 10^5$ CFU/ml respectively on day of preparation. Up until the 4th day of preparation, the free-living nitrogen fixers gradually increase in population upto $160\times 10^4$ CFU/ml. This liquid formulation not contain only beneficial microorganisms but also has contain macro-micro nutrients, many vitamins, essential amino acids and growth-promoting compounds like indole acetic acid (IAA) and gibberallic acid (GA) because it consist cow dung, cow urine, jaggery, *etc*.

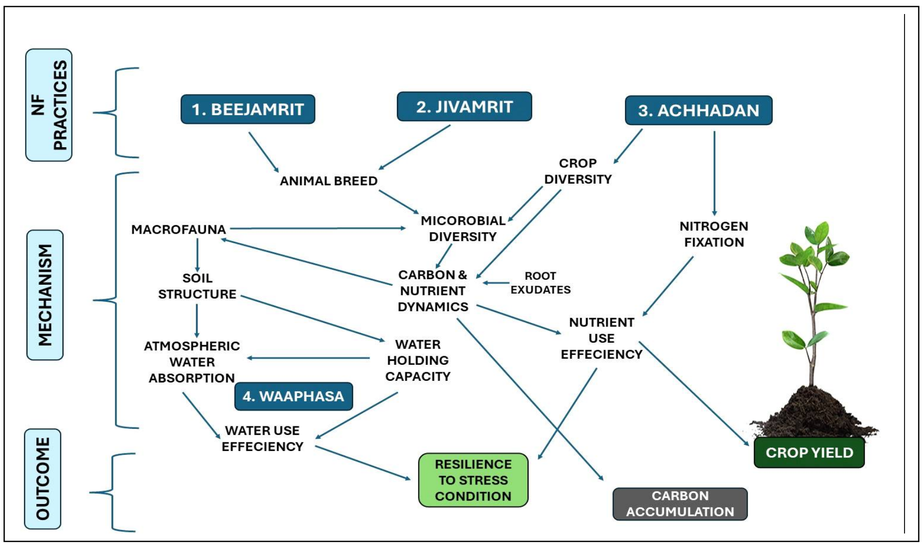


**Fig 1:** Conceptual framework connecting ZBNF operations to biogeochemical processes (Adopted from Mishra *et al*., 2023).

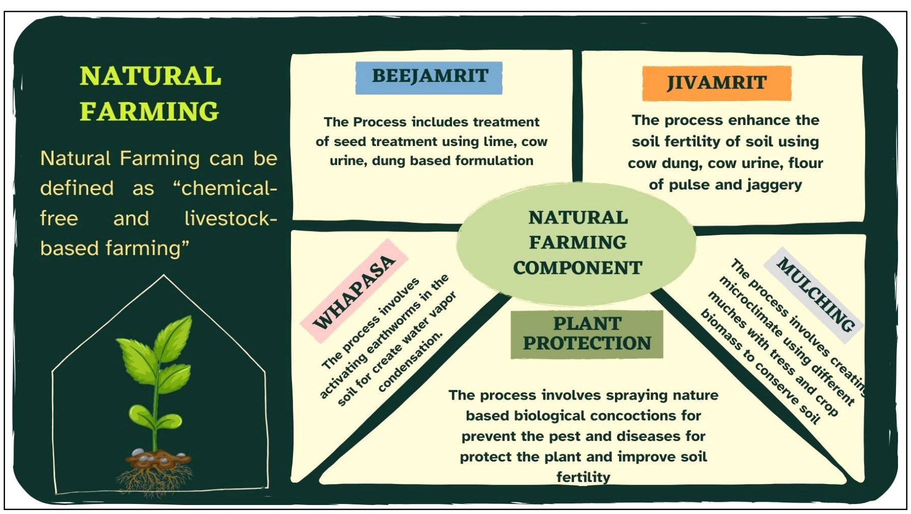


**Fig 2:** Basic concept on Natural farming (Adopted from NITI Ayog, 2021).

Jain *et al*. (2021) also reported higher total bacterial, fungal and actinomycetes count in beejamrit was $5.16 \times 10^8$, $0.7 \times 10^5$ and $0.6 \times 10^5$ CFU/mL respectively. They also estimated of enzyme activities in beejamrit and they found 24.86 µg/mL acid phosphatase, 21.69 µg/mL alkaline phosphatase and 11.90 µg/mL dehydrogenase enzymatic activity.

Kaur and Rana, (2022) observed the inhibitory effect of beejamrit against fungal attack while they studying the efficacy of different organic inputs against *Fusarium ginearum* which cause head scab of wheat under in-*vitro* condition. They found 100% mycelium growth inhibition of *Fusarium ginearum* at concentration of 30% beejamrit.

**Jivamrit**

Jivamrit is a biostimulant to encourage the activity of soil-based microorganisms as well as the activity of phyllospheric microorganisms. It boosts the population of native earthworms and serves as a catalyst for microbial activity. The jivamrit can be stored for up to 15 days from day of preparation (NITI Ayog, 2021). In various websites and research/review paper different terminology was used like jivamrit, jiwamrita, jeevamrutha, dhravajeevamrutham and jeevamrutha *etc*. (Badwal *et al*., 2019; Devakumar *et al*., 2014; Duddigan *et al*., 2022; Goveanthan, 2020 and NITI Ayog, 2021).

**Ingredients**

- 10 kg of fresh cow dung.
- 5-10 L cow urine.
- 2 kg jaggery.
- 2 kg pulses' flour.
- 1 kg uncontaminated soil.
- 200 L water.

**Preparation**

To prepare the jivamrit, following the steps given in Fig 4 (Devvrat, 2023).

**Applications**

- Jivamrit can be used on all types of plants in every two weeks, either by spraying it on the leaves or apply with the irrigation water. A volume of 200 L of jivamrit is adequate for the treatment of one acre of land.
- In fruit crops, jivamrit apply to each tree individually.

**Function**

- Jivamrit is applied to soil as an alternative to chemical fertilizers. Jivamrit stimulates microbial activity in the rhizosphere which helps to convert unavailable form plant nutrients to available form in root zone (Ipsita Ojah *et al*., 2023).
- Jivamrit has ability to increase plant growth and biological control of plant pathogens.

**Finding**

The vast microbial community within jivamrit thrives in the soil, serving as a tonic that enhances microbial activity. This heightened activity potentially contributes to the increased microbial population in the soil. Furthermore, jivamrit includes micronutrients alongside diverse microflora (Palekar, 2006).

Jivamrit formulation given by Subhas Palekar had a higher bacterial count. That mean jivamrit preparation ingredients such as cow dung, urine, jaggery, pulse flour

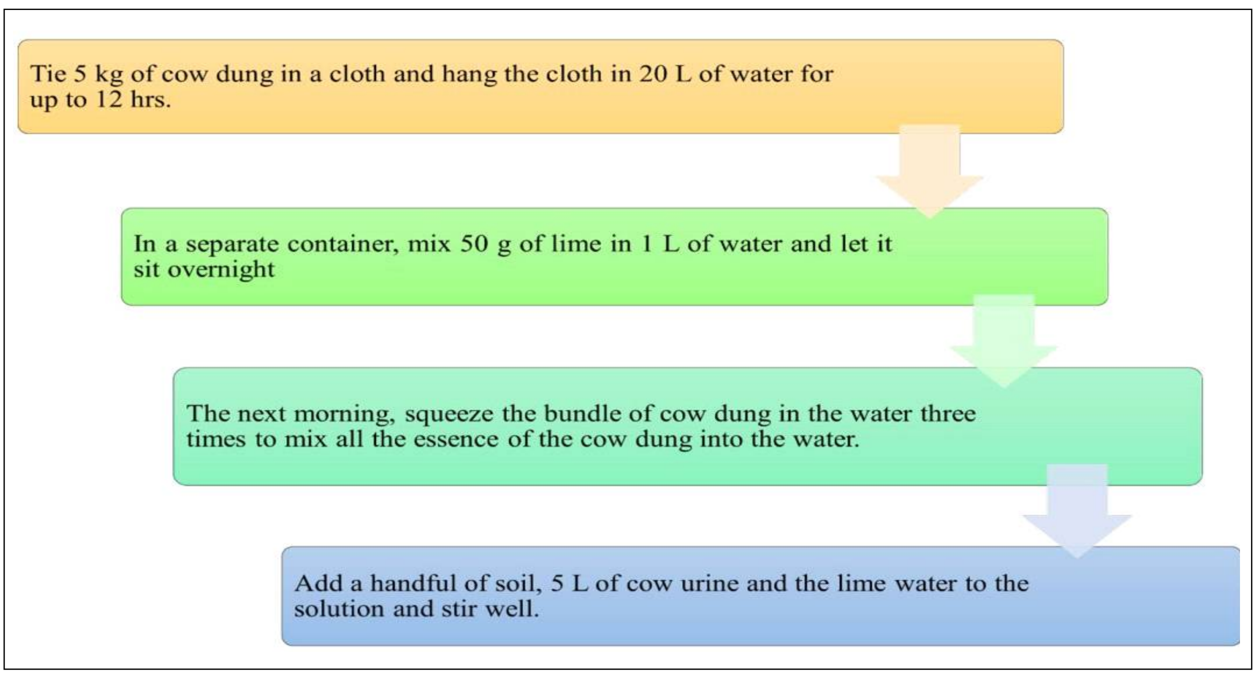


**Fig 3:** Preparation steps of beejamrit.

and live soil direct and indirect take part in increase microbial population. Jivamrit also increase soil quality by increasing organic carbon, available phosphorus, available potassium and micronutrients such as Zn, Fe, Cu and Mn (Saharan, 2023). Jivamrit is best nutrient source which increases crop yield and also reduces incidence of insect pest and diseases (Mohammadi, 2018).

During the fermentation process, the aerobic and anaerobic bacteria found in cow dung and urine. These bacteria are multiply by consuming organic materials like pulse flour and jaggery. Native microbes and organisms can be boosted by adding a small amount of undisturbed soil. Jivamrit aids in the prevention of bacterial and fungal plant diseases. Most of the farmers in Maharashtra, India use drip irrigation to implement jivamrit. Jivamrit application increased crop yield and encouraged the growth of advantageous soil microbes (Shaikh and Gachande, 2015).

Jivamrit is a reservoir of beneficial soil bacteria such as *Azotobacter* sp., Actinomycetes and phosphate-solubilizing bacteria. These microorganisms contribute to enhance crop productivity (Ram and Pathak, 2016). The actinomycetes present in Jivamrit might also possess toxic characteristics, potentially acting as entomopathogens. These actinomycetes are recognized for their ability to generate antibiotic compounds that can be detrimental to the early developmental stages of spider mites (Meltzer, 1972). Jivamrit had higher microbial population between $9^{th}$ and $12^{th}$ day after preparation. Jivamrit contain higher numbers of bacterial population, including *Azatobacter* sp., *Bacillus* sp., *Beijerinckia* sp., *Chromatium* sp., *Chromobacterium* sp., *Pseudomonas* sp., *Rhodomicrobium* sp., *Serretia* sp. and *Xanthomons* sp. (Devakumar *et al*., 2014).

Jain *et al*. (2021) reported higher microbial number and enzymatic activities in jivamrit. They found higher bacterial, fungal and actinomycetes count in jivamrit $6.33 \times 10^8$, $0.51\times10^5$ and $3\times10^5$ CFU/mL respectively. They also estimated enzyme activities of jivamrit and they found that 6.72 µg/mL acid phosphatase, 13.34 µg/mL alkaline phosphatase and 2.77 µg/mL dehydrogenase enzymatic activity.

Meenakshi Dhiman *et al*. (2023) isolated 43 different bacteria from jivamrit. Among selected bacterial isolates 67.78% were P- solubilizers, 60.37% were Nitrogen fixer, 62.37% were siderophore producer, 34.29% were HCN producer, 45.88% were IAA producer and 78.22% showed antagonism against *Pythium ginicolum* and 74.81% showed antagonism against *Collectotrichum capsici*. Among them, *Bacillus* sp. and *Pseudomonas* sp. gave maximum plant growth promoting activity which can be used as biofertilizer.

Different doses of jivamrit application also affected microbial population of soil. Kumber and Devakumar (2016) reported $47.44\times10^6$ CFU/g of soil bacterial population, $31.22\times10^4$ CFU/g of soil fungal population and $31.44\times10^3$ CFU/g of soil actinomycetes at the dose of at 2000 L/ha. Similarly, when jivamrit dose was 1500 L/ha than bacterial, fungal and actinomycetes population was $42.22\times10^6$, $26.33\times10^4$, $29.89\times10^3$ CFU/g of soil, respectively. Jivamrit dose was 1000 L/ha than bacterial, fungal and actinomycetes population $35.78\times10^6$, $21.33\times10^4$ and $28.44 \times10^3$ CFU/g of soil, respectively. While no application of jivamrit occurred than bacterial, fugal and actinomycetes population was only $24.81\times10^6$, $15.11\times10^4$ and $21.11\times 10^3$ CFU/g of soil, respectively. Among four treatment 2000 L/ha dose of jivamrit had higher microbial population. They

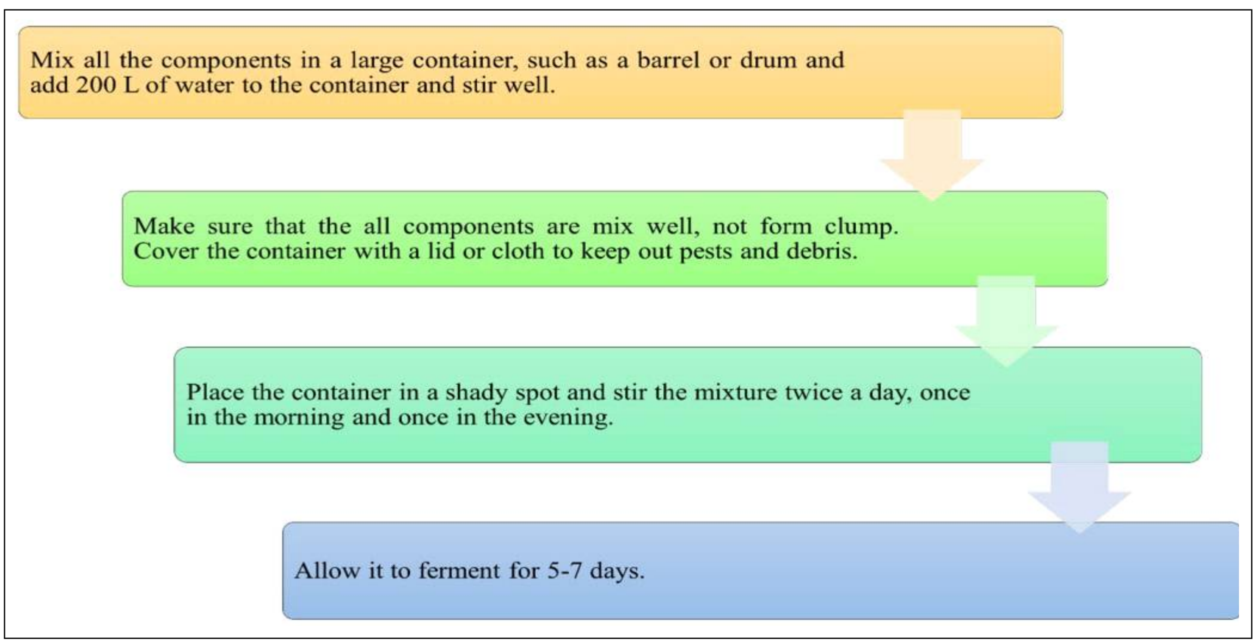


**Fig 4:** Preparation steps of jivamrit.

also found the population of P solubilizer 34.22 $\times 10^5$ and N-fixer 33.00$\times 10^5$ CFU/g of soil at 2000 L/ha dose.

**Ghanajivamrit**

Ghanajivamrit is one type of jivamrit which was the solid form of jivamrit. Ghanajivamrit was made of cow dung, cow urine, jaggery, plus flour and live soil which is a good source of microorganisms. Compared to jivamrit and FYM, ghanajivamrit had higher nutrient content and culturable microbial count. That's microorganism increase soil fertility, organic carbon, availability of primary and secondary nutrients contents and microbial activity in soil (Devvrat, 2023; Bindushree *et al*., 2023). In various websites and research/review paper different terminology was used like ghanajivamrit, solid jiwamrita, ghanajeevamrutham *etc* (Duddigan *et al*., 2022).

**Ingredients**

- 100 kg of fresh cow dung.
- 1 kg jaggery.
- 2 kg pulses' flour.
- 50 g uncontaminated soil.
- Little amount of cow urine.

**Preparation**

To prepare the ghanajivamrit, following the steps given in Fig 5 (Devvrat, 2023).

**Applications**

- 100 kg per acre of ghanajivamrit can be used on any types of crops field.
- Dried ghanajivamrit can be stored up to 6 months.

**Function**

- Ghanajivamrit can be used as an alternative of basal chemical fertilizers dose which can boost the germination and growth of young seedlings.
- Ghanajivamrit can increase organic matter, nutrient content and microbial population in soil (Choudhary *et al*., 2022).

**Finding**

Chaudhary *et al*. (2022) reported that ghanajivamrit application before sowing significantly affect microbial populations. Ghanajivamrit application increase population of bacterial from 16.1$\times 10^6$ CFU/g to 16.7 $\times 10^6$ CFU/g, fungal from 5.2$\times 10^3$ CFU/g to 6.2$\times 10^3$ CFU/g and actinomycetes from 15.4$\times 10^5$ CFU/g to 16.6$\times 10^5$ CFU/g soil within one year. Ghanajivamrit also increase dehydrogenase activity from 2.76 to 2.78 µg TPF $g^{-1}$ soil/hr. Bindushree *et al*., (2023) also reported higher microbial load in ghanajivamrit. Bacterial, fungal and actinomycetes load was 183 $\times 10^5$ CFU/g, 20$\times 10^4$ CFU/g and 56$\times 10^3$ CFU/g of ghanajivamrit. Nitrogen fixer and phosphate solubilizer microorganisms of ghanajivamrit was found 42$\times 10^4$ CFU/g and 28 $\times 10^4$ CFU/g of ghanajivamrit, respectively.

**Achhadana (Mulching)**

Mulching is a method used to protect soil by covering it with a combination of living plants and straw, which is essentially dead plant material. Its purpose is to retain moisture, keep the soil around plant roots cool, prevent erosion, reduce runoff and manage weed growth (NITI Ayog, 2021). By forming a barrier that reduces evaporation and blocks light, mulching effectively maintains soil moisture and inhibits weed growth. The main objective of mulching is to uniformly cover the soil while considering its environmental impact, such as ensuring it is biodegradable to minimize harm to the environment (Jacquiod *et al*., 2023).

**Types of mulch**

**Soil mulch**

Soil mulch prevents tilling from destroying topsoil during farming. It promotes aeration and water retention in the soil. Because of this, deep ploughing can be avoided. This can reduce weed germination, cost of cultivation and increase soil moisture holding capacity (Mishra, 2023).

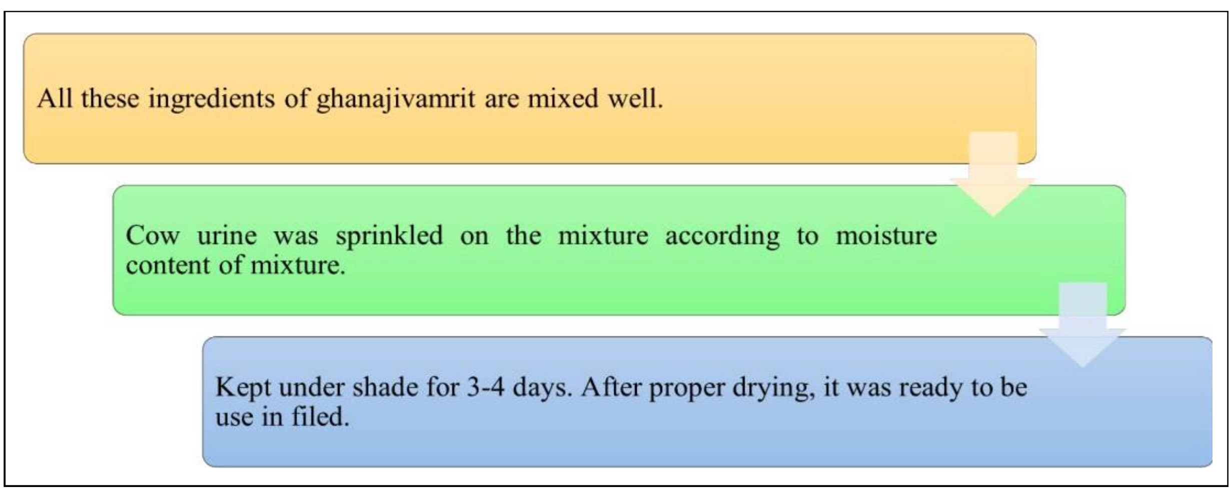


**Fig 5:** Preparation steps of ghanajivamrit.

### Straw mulch

Dried vegetation of any crop, farm stubble, such as dried biomass waste, *etc*., is used as mulch. It protects the soil from direct sunlight, cold, rain, evaporation and other components. Furthermore, seeds are protected from birds, insects and animals by residue mulch. This residue can be increasing organic matters after decomposition (NITI Ayog, 2021).

### Live Mulch

Live mulching is the practice of growing multiple crops or intercropping short-lived crops between the rows of a primary crop. For the plant to provide all the necessary nutrients, it is advised that monocotyledons and dicotyledons be planted together in the same field. While dicots, like pulses, are nitrogen-fixing plants, monocots, like wheat and rice, provide nutrients like potash, phosphate and sulphur (NITI Ayog, 2021).

### Whapasa

Whapasa is the mixture of 50% air and 50% water vapour between two soil particles, is the soil's microclimate, on which soil organisms and roots depend for the majority of their moisture and their nutrients. It also enhances water availability, increases water use efficiency and boosts drought resistance (NITI Ayog, 2021).

Whapasa condition increases the population of microorganisms that help with nutrient solubilization in the root zone and enhance nutrient uptake, which ultimately results in an increase in grain and stover yield. Whapasa improved the soil aeration and reduce the tillage (Kumar *et al*., 2023).

For achieving the whapasa condition following the steps given in Fig 6 (Devvrat, 2023).

### Plant protection

In natural farming, various natural formulation are used for the pest and diseases control of crops like neemastra, brahmastra, dashparni ark, chhasastra and agniastra. These inputs made of different trees leaves and natural ingredients which have antibacterial capabilities like buttermilk, lime *etc*. according to pest or disease incidence (NITI Ayog, 2021). Various plant protection formulations exhibit varying degrees of antifungal efficacy depending on the type of infestation they encounter (Table 2, Table 3 and Table 4).

### Neemastra

Neemastra is made up of water, cow dung, cow urine and neem leaves. Neemastra is used to kill insects or larvae that eat plant foliage and suck plant sap as well as to prevent or treat diseases. Additionally, this helps in reducing the growth of harmful pests. Neemastra work as bioinsecticide and pest repellent for natural farming that is also very simple to prepare. All the sucking pests, jassids, aphids, white fly and small caterpillars are controlled by neemastra (Sarma and Dutta, 2024 and NITI Ayog, 2021).

### Ingredient

- 200 L water.
- 2 kg cow dung.
- 10 L cow urine.
- 10 kg fine paste of neem leaves.

### Preparation

To prepare the neemastra, following the steps given in Fig 7 (Sarma and Dutta, 2024).

### Application

Apply the prepared solution directly to the crop using a foliar spray after filtering it through a muslin cloth. Water

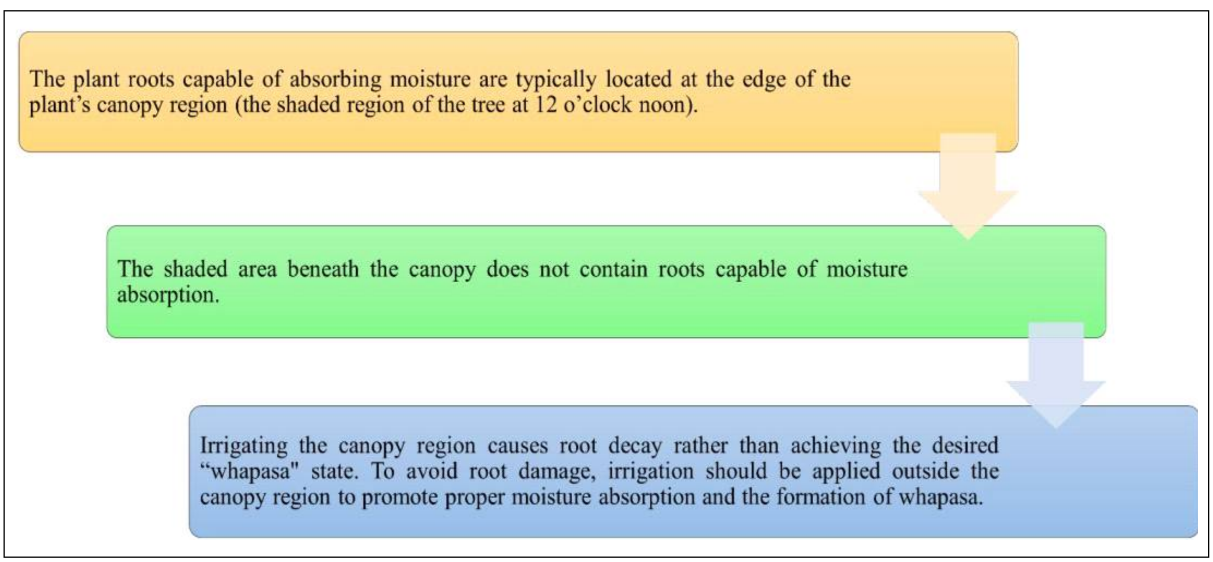


**Fig 6:** Steps for achieving the whapasa condition.

shouldn't be added to dilute it. It can be kept for up to six months before use.

**Function**

Neemastra controls the all type of sucking pests, jassids, aphids, white fly and small caterpillars (Sarma and Dutta, 2024).

**Finding**

The main component of neemastra is neem leaves or seeds. Main chemical compound in neem is azadirachtin, which is well-known for being a key component in several insecticides. Azadirachtin is a complex compound synthesized as a secondary metabolite having wide array of acaricidal activity such as antifeedant, fecundity deterrence, preventing oviposition and halting males' sperm production, it induces sterility in insects and functions as an antifeedant, repellent and repugnant agent (Bezzar-Bendjazia *et al*., 2017; Chaudhary, *et al*., 2017). Sharmila *et al*. (2015) evaluated that azadirachtin showed highest antifeedant effect (100%) against *Pieris brassicae* after 24 hrs of treatment. Badiyala and Sharma (2013) and Thakur and Sood (2019) also reported toxic effect of neem effective against *Helicoverpa armigera* and *Agrotis ipsilon* with $LC_{50}$ value of 0.0045 per cent and 0.0051 per cent, respectively.

**Table 2:** Antifungal activity of natural pesticides against *A. niger* and *P. aphanidermatum* [Charapale *et al*., (2021b)].

| Natural pesticid | | Fungal growth inhibition (%) | |
|---|---|---|---|
| Name | Concentration | *Aspergillus niger* | *P. aphanidermatum* |
| Neemastra | 3% | 77.7 | 72.2 |
| | 4% | 78.8 | 73.3 |
| | 5% | 80.0 | 75.5 |
| | 6% | 80.5 | 76.6 |
| Brahmastra | 3% | 72.2 | 66.1 |
| | 4% | 73.3 | 58.8 |
| | 5% | 74.4 | 60.0 |
| | 6% | 75.0 | 58.8 |
| Agniastra | 3% | 80.0 | 70.0 |
| | 4% | 80.0 | 72.2 |
| | 5% | 80.0 | 72.2 |
| | 6% | 80.0 | 75.5 |
| Dashaparni ark | 3% | 48.8 | 50.0 |
| | 4% | 50.0 | 51.1 |
| | 5% | 50.0 | 51.1 |
| | 6% | 53.3 | 52.2 |
| Control | | 00.0 | 00.0 |

**Table 3:** Antibacterial activity of natural pesticides against *Proteus vulgaris* and *Staphylococcus aureus* [Charapale *et al*. (2021a)].

| Natural pesticide | | Zone of inhibition (cm) | |
|---|---|---|---|
| Name | Concentration | *Proteus vulgaris* | *Staphylococcus aureus* |
| Neemastra | 40% | 1.06 | 0.0 |
| | 60% | 1.3 | 1.0 |
| | 80% | 1.3 | 1.3 |
| | 100% | 1.46 | 1.5 |
| Brahmastra | 40% | 1.6 | 1.0 |
| | 60% | 1.9 | 1.1 |
| | 80% | 2.1 | 1.06 |
| | 100% | 2.7 | 1.36 |
| Agniastra | 40% | 1.73 | Nl |
| | 60% | 1.8 | 0.0 |
| | 80% | 1.9 | 0.0 |
| | 100% | 1.93 | 0.0 |
| Dashaparni ark | 40% | 0.0 | 1.1 |
| | 60% | 0.0 | 1.4 |
| | 80% | 0.0 | 1.4 |
| | 100% | 0.0 | 1.6 |

Neemastra showed significant inhibitory activity against *Staphylococcus aureus* as well as *Proteus vulgaris* (Charapale *et al*., 2021a). Similarly, neemastra had capacity to 80% inhibition of *Aspergillus niger* and 76.6% inhibition of *Pythium aphanidermatum* (Charapale *et al*., 2021b). Neemastra were found effective to manage root knot nematodes and reduce RKI significantly (Maru *et al*., 2021). Neemastra is also effective against some fungi, bacteria and pests as given in Table 2, Table 3 and Table 4, respectively.

**Brahmastra**

It is prepared from different types of bitter leaves. Neem leaves are mixed with other leaves that have a bitter taste, such as custard apples, chilies, *etc*. This is a natural insecticide made from leaves that contain particular alkaloids that keep off pests. It eliminates all sucking insects and hidden caterpillars that inhabit fruit and seed pods (NITI Ayog, 2021).

**Ingredient**

- 20 L cow urine.
- 2 kg neem leaves.
- 2 kg karanj leaves.
- 2 kg custard apple leaves.
- 2 kg datura leaves.

**Preparation**

To prepare the brahmastra, following the steps given in Fig 8 (Sarma and Dutta, 2024).

**Application**

6-8 L of brahmastra diluted in 200 L of water can be used as the foliar spray on the standing crop. Ratio of brahmastra and water can be changed depending upon the severity of pest attack as follows:

- 100 L of water +3 L of Brahmastra (3%)
- 15 L of water + 500 ml of Brahmastra (3.3%)
- 10 L of water + 300 ml of Brahmastra (3%)

The solution can be stored for 6 months.

**Function**

It helps to control sucking pests and hidden caterpillars that are present in pods and fruits.

**Finding**

The presence of some specific alkaloid compounds in the plant extract gives brahmastra its potential to act as a biopesticide by reducing the population of sucking insects.

**Table 4:** Effect of natural pesticides on insect pests in castor during 2016-17 (Kumar and Sarada, 2020).

| Natural enemies | Neemastra (20%) | Brahmastra (20%) | Agniastra (20%) |
|---|---|---|---|
| *Achaea janata* (larvae/ plant) | 2.86 | 2.74 | 2.30 |
| *Spodoptera litura* (larvae/ plant) | 2.70 | 2.44 | 1.90 |
| Shoot and Capsule borer damage (%) | 24.20 | 26.80 | 23.60 |
| Population of Leaf hopper/ leaf | 2.40 | 2.60 | 3.05 |
| No. of Coccinellids/ plant | 1.10 | 1.00 | 0.96 |
| No. of Spiders/ plant | 1.00 | 1.00 | 1.08 |
| No. of *A. janata* larvae with Microplitis cocoons | 1.15 | 1.11 | 1.10 |

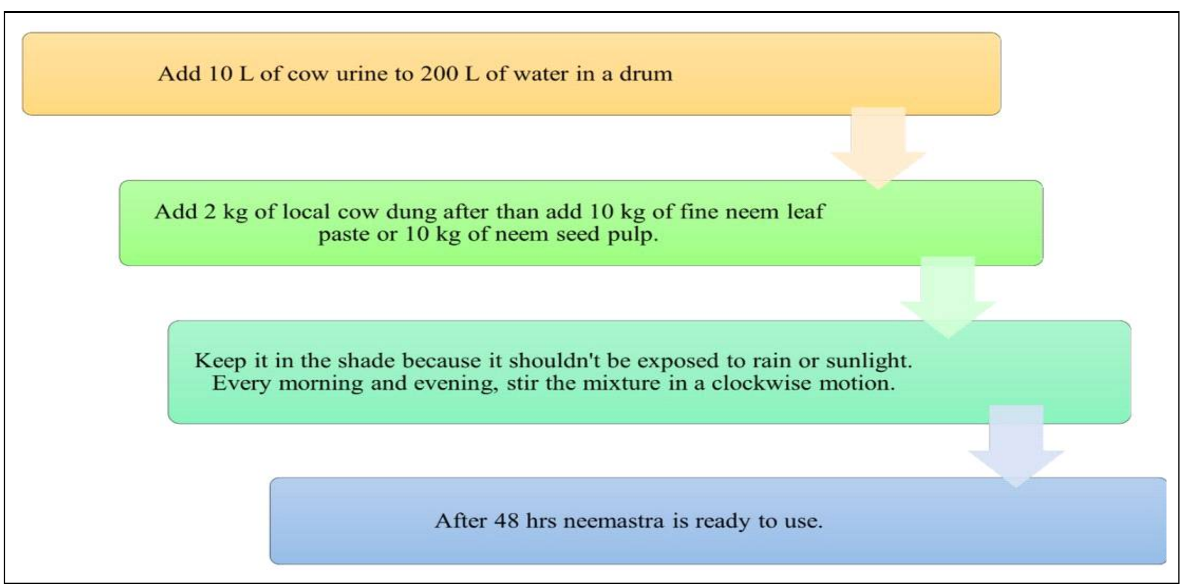


**Fig 7:** Preparation step of neemastra.

It contains various types of plant leaf extracts. This extract contains biologically active organic ingredients that have pesticide and repellent properties used for the management of pest organisms (Asogwaet *et al*., 2010). Bhullar, (2021) reported that 90% reduction in mite population at 5% dilution of brahmastra. Brahmastra is also effective against certain fungi, bacteria and pests, as detailed in Table 2, Table 3 and Table 4, respectively.

**Agniastra**

Agniastra is complete natural pesticide prepared using traditional Indian techniques. Agniastra, a natural product, has the ability to eradicate all pests from crops and plants, including white worms and leaf worms (NITI Ayog, 2021).

**Ingredient**

- 20 L cow urine.
- 2 kg pulp of neem leaves.
- 500 g tobacco powder.
- 500 g green chilli.
- 250 g garlic paste.
- 200 g turmeric powder.

**Preparation**

To prepare the agniastra, following the steps given in Fig 9 (Sarma and Dutta, 2024).

**Application**

6-8 L of agniastra should be taken and diluted in 200 L of water for spraying. The following ratio are to be followed based on the severity of pest attack.

- 100 L of water + 3 L of agniastra.
- 15 L of water + 500 ml of agniastra.
- 10 L of water + 300 ml of agniastra.

The solution can be stored for use up to 3 months.

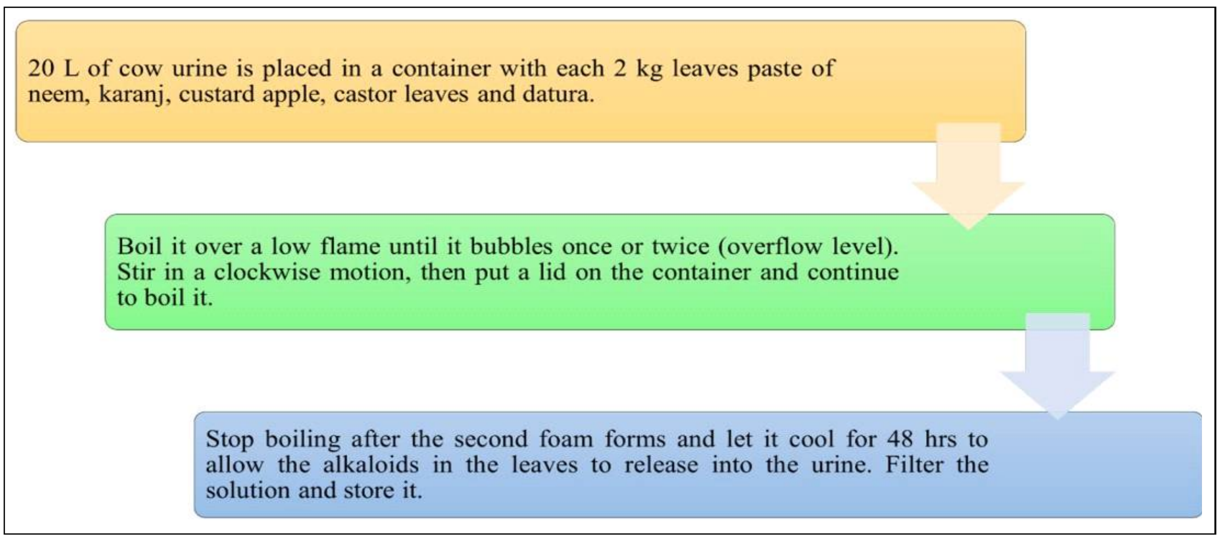


**Fig 8:** Preparation step of brahmastra.

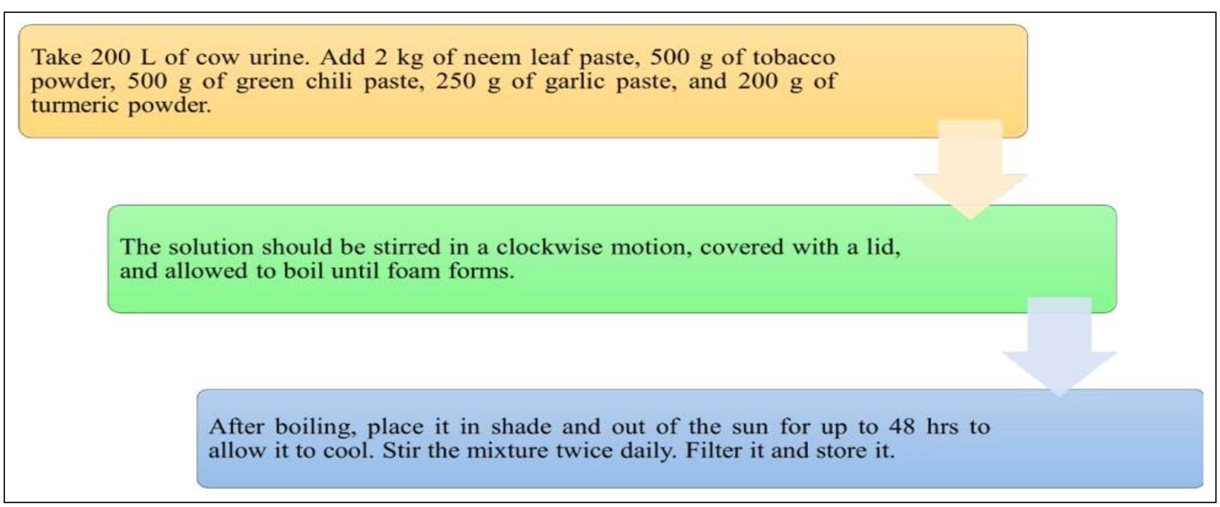


**Fig 9:** Preparation step of agniastra.

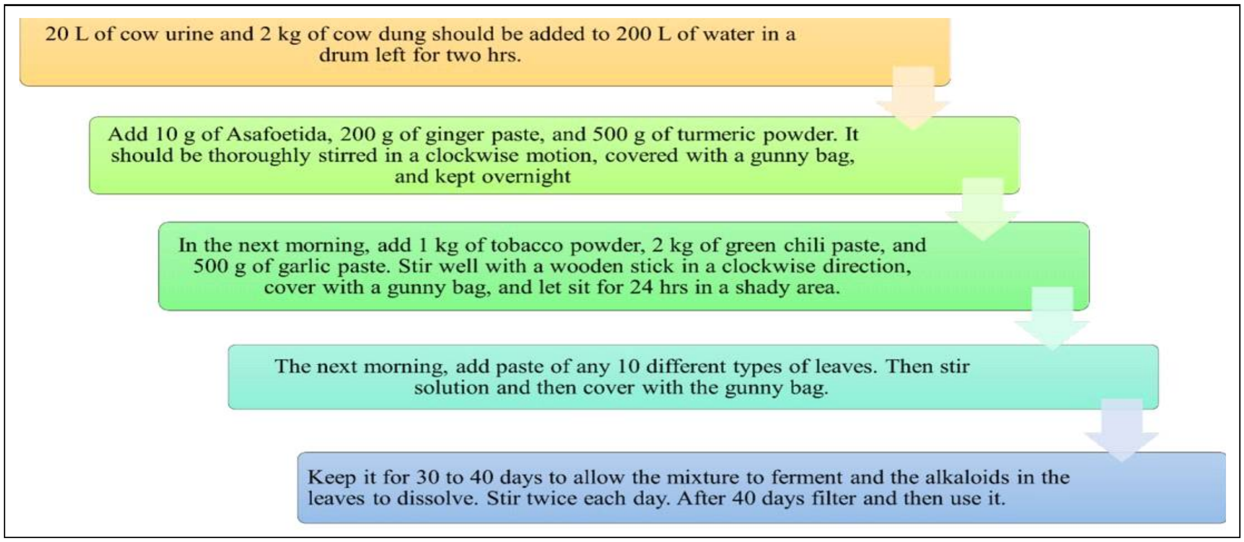


**Fig 10:** Preparation step of dashaparni ark.

**Function**

It is effective in controlling all sucking pests and caterpillars.

**Finding**

According to Gupta *et al.,* (2020), 2% concentration of Agniastra is most effective and gave 91.81% juvenile mortality of *M. incognita*. Agniastra also inhibites the egg hatching of *Meloidogyne incognita* at 2%. Maru *et al*. (2021) reported that agniastra at 800 ml/10 L of water showed the greatest reduction in Root Knot Index (RKI). Because it contains tobacco dust, neem leaf paste, garlic paste, green chili paste and other ingredients that may help to reduce RKI. Several scientists have nematicidal effects of reported tobacco dust's due to nicotine chemical compound. According to Agbenin *et al*. (2005), Neem leaf and garlic bulb presence in agniastra prevented egg masses hatching and killed any larvae that were present. Subba, *et al*. (2022) reported that the spray of agniastra at 25ml/L in pre-kharif crop gave reduction of leaf jassid population up to 65.84% (2.41/leaf jassid population) and it also proved better to suppress fruit borer infestation. Additionally, as listed in Tables 2, 3 and 4, Agniastra works well against particular fungus, bacteria and pests.

**Dashaparni ark**

Dashaparni ark used as alternative for neemastra, brahmastra and agniastra. It is combination of 10 types of tree leaves which are able to kill all types of pests (NITI Ayog, 2021).

**Ingredient**

- 200 L water.
- 20 L cow urine.
- 2 kg cow dung.
- 500 g turmeric powder.
- 10 g asafoetida.
- 1 kg tobacco powder.
- 2 kg chilly pulp.
- 500 g garlic paste.
- 200 g ginger paste.
- 10 types of leaves selected from a specified list [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]

**Preparation**

To prepare the dashaparni ark, following the steps given in Fig 10 (Sarma and Dutta, 2024)

**Applications**

The prepared dashparni ark (6L-8 L) should be diluted in 200 L of water for spraying.

**Function**

It is used to control all types of pests and dilution is prepared depending on the level of infestation.

**Finding**

Joshi *et al*., (2021) reported that dashparni ark provide maximum mortality of potato cut worm *Agrotis ipsilon* Hufnagel which was followed by brahmastra, agniastra, neemastra and a mixture of garlic, ginger and mint. Dashparni ark demonstrates effectiveness against specific fungi and bacteria, as presented in Table 2 and Table 3, respectively.

## CONCLUSION

Natural farming (NF) is an agricultural approach devoid of chemical inputs, relying instead on livestock integration. Its primary objective is to mitigate environmental impact while simultaneously addressing socio-economic challenges within the agricultural domain. The foundational principles of natural farming revolve around four essential components: Beejamrit, which pertains to seed treatment; Jivamrit, aimed at maintaining soil fertility; Aachhadan or Mulching, focused on mitigating water evaporation; and Whapasa, which contributes to fostering a conducive microclimate. Various plant protection formulations, including Neemastra, Brahmastra, Dashaparni and others, are employed within the realm of natural farming practices to safeguard crops against detrimental insects, larvae, sucking pests and diseases. Microorganisms found within NF inputs and formulations contribute to enhancing soil fertility by bolstering nutrient availability. Additionally, they fortify plant resilience against diseases, consequently fostering heightened crop yields. Natural farming offers the potential to augment farmers' income by leveraging locally accessible natural resources such as cow dung and urine for crop cultivation, without the necessity of synthetic fertilizers or pesticides. Consequently, farmers are relieved from the need to procure external inputs from the market, resulting in cost savings while concurrently promoting environmental conservation. Natural farming is natural processes to cultivate nutritious food, ensuring the well-being of both consumers and the ecosystem. This approach harmonizes with nature, fostering healthful dietary choices while promoting land sustainability.

## ACKNOWLEDGEMENT

The present study was supported by Gujarat State Biotechnology Mission (GSBTM), Department of Science and Technology, Government of Gujarat.

### Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

### Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

## REFERENCES

Agbenin, N.O., Emechebe, A.M., Marley, P.S. and Akpa, A.D. (2005). Evaluation of nematicidal action of some botanicals on Meloidogyne incognita *in vivo* and *in vitro*. Journal of Agriculture and Rural Development in the Tropics and Subtropics. 106(1): 29-39.

Alengebawy, A., Abdelkhalek, S.T., Qureshi, S.R. and Wang, M.Q. (2021). Heavy metals and pesticides toxicity in agricultural soil and plants: Ecological risks and human health implications. Toxics. 9(3): 42. https://doi.org/10.3390/toxics9030042.

Asogwa, E.U., Ndubuaku, T.C.N., Ugwu, J.A. and Awe, O.O. (2010). Prospects of botanical pesticides from neem, *Azadirachta indica* for routine protection of cocoa farms against the brown cocoa mirid-*Sahlbergella singularis* in Nigeria. Journal of Medicinal Plants Research. 4(1): 1-6. https://doi.org/10.5897/JMPR09.049.

Badiyala A. and Sharma D.C. (2013). Relative toxicity of some biopesticides and insecticides to second instar larvae of *Helicoverpa armigera* (Hubner) and *Agrotis ipsilon* (Hubner). Insect Environment. 19(3): 199-202.

Badwal, D.P.S., Kumar, M., Singh, H. and Simran, K.K. (2019). Zero budget natural farming in India review. International Journal of Current Microbiology and Applied Sciences. 8(12): 869-873.

Barabasz, W., Albinska, D., Jaskowska, M. and Lipiec, J. (2002). Biological effects of mineral nitrogen fertilization on soil microorganisms. Polish Journal of Environmental Studies. 11(3): 193-198.

Bezzar-Bendjazia, R., Kilani-Morakchi, S., Maroua, F. and Aribi, N. (2017). Azadirachtin induced larval avoidance and antifeeding by disruption of food intake and digestive enzymes in *Drosophila melanogaster* (Diptera: Drosophilidae). Pesticide biochemistry and physiology. 143: 135-140. https://doi.org/10.1016/j.pestbp.08.006.

Bhadu, K., Rathore, R.S. and Shekhawat, P.S. (2023). Jeevamrut and panchagavya's consequences on growth, quality and productivity of organically grown crops: A review. Agricultural Reviews. 44(4): 451-459. doi: 10.18805/ag.R-2239.

Bhullar, M.B., Heikal, H.M., Kaur, P. and Kaur, R. (2021). Efficacy of natural products and birationals against two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) infesting brinjal (*Solanum melongena* L.) under protected cultivation. International Journal of Acarology. 47(8): 677-683.

Bindushree, C., Lakshmipathi, R.N., Nagaraju, M.C. and Siddu, M., (2023). Effect of different farming practices on total beneficial microorganisms in direct seeded rice. The Pharma Innovation Journal. 12(6): 2412-2420.

Boye, Joyce, Zare, Fatemeh, Pletch and Alison. (2010). Pulse proteins: Processing, characterization, functional properties and applications in food and feed. Food Research International. 43(2): 414-431. https://doi.org/0.1016/j.foodres.2009.09.003.

Charapale, S.T., Gaikwad, D.K., Jagtap, R. and Sonawane, K.D. (2021a). Antibacterial activity of Dashparni, Agniastra, Bramhastra and Neemastra the organic formulations. BIOINFOLET-A Quarterly Journal of Life Sciences. 18(2): 262-263.

Charapale, S.T., Satpute, M.D., Kamble, P.P. and Gaikwad, D.K. (2021b). Antifungal activity of organic formulations: Dashparni, Agniastra, Bramhastra and Neemastra. BIOINFOLET-A Quarterly Journal of Life Sciences. 18(3): 390-392.

Chaudhary, S., Kanwar, R.K., Sehgal, A., Cahill, D.M., Barrow, C.J., Sehgal, R. and Kanwar, J.R. (2017). Progress on *Azadirachta indica* based biopesticides in replacing synthetic toxic pesticides. Frontiers in plant science. 8: 610. https://doi.org/10.3389/fpls.2017.00610

Choudhary, R., Kumar, R., Sharma, G.D., Sharma, P., Rana, N. and Dev, P. (2022). Effect of natural farming on yield performances, soil health and nutrient uptake in wheat+ gram inter cropping system in sub-temperate regions of Himachal Pradesh. Journal of Crop and Weed. 18(2): 01-08 0. https://doi.org/10.2227109746315.2022.v18.i2.1566.

Choudhary, S.K., Kumar, R. and Kumar, A. (2023). General overview of zero budget natural farming (ZBNF). Agricultural Reviews. 44(3): 328-335. doi: 10.18805/ag.R-2186.

Class-Mahler, I., Zimmermann, B., Hermann, W., Schwarz, J., Piepho, H.P., Lewandowski, I., Kehlenbeck, H. and Bahrs, E. (2023). Yield potential of cropping systems without chemical synthetic plant protection products in NOcsPS field trials in Germany. Landbauforschung-Journal of Sustainable and Organic Agricultural Systems. 72(1). https://doi.org/10.5073/LBF.2023.01.05.

Devakumar, N. Shubha, S., Gowder, S.B. and Rao, G.G.E. (2014). Microbial analytical studies of traditional organic preparations beejamrutha and jeevamrutha. Building Organic Bridges. 2: 639-642.

Devarinti, S.R. (2016). Natural farming: eco-friendly and sustainable. Agrotechnology. 5: 147. https://doi.org/10.4172/2168-9881.1000147.

Devvrat A., (2023). Natural Farming, Gujarat Natural Farming Science university, Halol-Panchmahal, Gujarat, India. p. 46.

Dhiman, M., Rana, N. and Ghabru, A. (2023). Isolation and Screening of Agriculturally Important Bacteria (PGPR) from Organic Sources of Nutrient (Panchgavya, Jeevamrit and Farmyard Manure) for Future Use. Asian Journal of Advances in Agricultural Research. 22(3): 43-52. https://doi.org/10.9734/AJAAR/2023/v22i3443.

Duddigan, S., Collins, C.D., Hussain, Z., Osbahr, H., Shaw, L.J., Sinclair, F., Sizmur, T., Thallam, V. and Ann Winowiecki, L. (2022). Impact of zero budget natural farming on crop yields in Andhra Pradesh, SE India. Sustainability. 14(3); 1689.

Esmat A., Helmy I. and Bareh G. (2010). Nutritional Evaluation and Functional Properties of Chickpea (*Cicer arietinum* L.) Flour and the Improvement of Spaghetti Produced from its. The Journal of American Science. 6(10): 1055- 1072.

Goveanthan, A.S., Sugumaran, M.P., Gudimetha, G.K., Akila, S., Suganya, K. and Somasundaram, E. (2020). Studies on organic inputs (Jeevamruth and Beejamruth) and their efficacy on fenugreek. The Pharma Innovation Journal. 9: 92-94.

Gupta, H., Kumar, S. Sharma, R. (2020) Eco-friendly management of root-knot nematode, *Meloidogyne incognita* (Kofoid and White) chitwood using seed kernel extracts, cow urine and agniastra. Journal of Entomology and Zoology Studies. 8(2): 1115-111.

Horrigan, L., Lawrence, R.S. and Walker, P. (2002). How sustainable agriculture can address the environmental and human health harms of industrial agriculture. Environmental Health Perspectives. 110(5): 445-456.

Jacquiod, S., Bouchard, E., Roure, F., Cheviron, N., Mougin, C., Coffin, A., Blouin, M. and Martin-Laurent, F. (2023). Effect of mulching on soil properties, microbial diversity and activities and crop yield. Research Square. https://doi.org/10.21203/rs.3.rs-2537775/v1.

Jahnke, M. and Bieling, C. (2023). Factors influencing the acceptance of pesticide-free farming systems by farmers. Landbauf orschung-Journal of Sustainable and Organic Agricultural Systems. 72(1). https://doi.org/10.5073/LBF.2023.01.06.

Jain, D., Jain, P., Bhojiya, A.A., Jain, R.K., Choudhary, R., Sharma, S.K., Yadav, S.K. and Jat, G. (2021). Microbiological and enzymatic properties of diverse Jaivik Krishi inputs used in organic farming. Indian Journal of Traditional Knowledge 20(1): 237-243. https://doi.org/10.56042/ijtk.v20i1.26500.

Joshi, M.J., Verma, K.S., Chandel, R.S., Inamdar, A.G., Kaushal, S. and Rana, A. (2021). Efficacy of Bioformulations Against Cut Worm *Agrotis Ipsilon* Hufnagel in Potato. Indian Journal of Entomology. 83(2021). https://doi.org/10.5958/0974-8172.2020.00203.5.

Kaur, G. and Rana, S.K. (2022). Efficacy of organic inputs against *Fusarium ginearum* causing head scab of wheat. Plant Disease Research. 37(1): 70-74. https://doi.org/10.5958/2249-8788.2022.00012.9.

Kavitha, V. and Chandran, K. (2017). Organic farming in conserving bio diversity in India-A review. Agricultural Reviews. 38(4): 316-320. doi: 10.18805/ag.R-1709.

Korat, H.V. and Mathukia, R.K. (2022). Effect of natural farming, organic farming and conventional farming on soil physical, chemical and biological properties. The Pharma Innovation Journal. 11(7): 924-928.

Kumar, G.S. and Sarada, O. (2020). Evaluation of cow based fermented organic products for non-insecticidal pest management in castor. International Journal of Current Microbiology and Applied Sciences. 9(10): 292-300 https://doi.org/10.20546/ijcmas.2020.910.037.

Kumar, S.P., Latha, M.R., Janaki, P., Parameswari, E., Kalaiselvi, T. and Krishnan, R. (2023). Natural farming practices impact on yield and macro nutrient uptake of sorghum. International Journal of Plant and Soil Science 35(20): 221-227. https://doi.org/10.9734/ijpss/2023/v35i203801.

Kumber, B. and Devakumar, N. (2016). Effect of Jeevamrutha and Panchagavya on Growth, Yield and Microbial Population of French bean (*Phaseolus vulgaris* L.). Advanced Life Sciences. 5: 3619-3623.

Maru, A.K., Thumar, R.K. and Prajapati, M. (2021). Evaluation of Neemastra, Agniastra and Brahmastra for the Management of Root-Knot Nematodes, *Meloidogyne* spp. in Tomato. Environment and Ecology. 39(4A): 1144-1149.

Meltzer, J. (1972). MYC 8005, an antibiotic against spider mites. 2. Growth inhibition and pseudo-sterilization in insects and mites. Netherlands Journal of Plant Pathology. 78(3): 77-88.

Mishra, S., Chaubey, A.K., Gaur, A.S., Tripathi, K.M., Prajapati, D. and Sahu, S. (2023). Effects of zero-budget natural farming on yield, earthworm populations, microbiological activity and the requirement for public policy: A Review. International Journal of Environment and Climate Change. 13(10): 3378-3391. https://doi.org/10.9734/ijecc/2023/v13i103006.

Mohammadi, M.H. (2018). Effect of organic nutrient sources on growth, yield and quality of bell pepper (*Capsicum annuum* L.) under mid hill condition of Himachal Pradesh. International Journal of Multidisciplinary Research and Development. 5(1): 135-138.

Moonen, A.C. and Bàrberi, P. (2008). Functional biodiversity: An agroecosystem approach. Agriculture, Ecosystems and Environment. 127(1-2): 7-21. https://doi.org/10.1016/j.agee.2008.02.013.

Mukherjee, S., Sain, S., Ali, M.N., Goswami, R., Chakraborty, A., Ray, K., Bhattacharjee, R., Pradhan, B., Ravisankar, N. and Chatterjee, G. (2022). Microbiological properties of Beejamrit, an ancient Indian traditional knowledge, uncover a dynamic plant beneficial microbial network. World Journal of Microbiology and Biotechnology 38(7): 111.

Nath, A., Dutta, D., Kumar, P. and Singh, J.P. (2015). Review on recent advances in value addition of jaggery based products. Journal of Food Processing and Technology. 6(4): 1-2.

Niti Ayog, (2021). Natural Farming, Retrieved December 3. (2023) from https://naturalfarming.niti.gov.in/components/.

Ojah, I., Ojah, A., Baruah, B., Borah, D. and Pathak, P.K. (2023). Natural farming- a mode of exploiting beneficial microbes for sustaining soil-plant health. International Conference on Biodiversity, Food Security, Sustainability Climate Change.

Palekar, S., (2006). Textbook on shoonya bandovalada naisargika krushi, published by swamy anand. Agri Prakashana, Bangalore 67.

Prasada, S. "Campaign to reduce use of chemical fertilizers pesticides." The Hindu 28 (2016).

Ram, R.A. and Pathak, R.K., (2016). Organic Approaches for sustainable production of horticultural crops: A review. Progressive Horticulture 48(1): 1-16. https://doi.org/10.5958/2249-5258.2016.00001.4.

Saharan, B.S., Tyagi, S., Kumar, R., Vijay, Om, H., Mandal, B.S. and Duhan, J.S. (2023). Application of Jeevamrit improves soil properties in zero budget natural farming fields. Agriculture 13(1): 196. https://doi.org/10.3390/agriculture13010196.

Sarma, H.H. and Dutta, S.K. (2024). Method of preparation of various inputs used in natural farming. Vigyan Varta. 5(7): 88-94.

Schiavon, M., Perrin-Ganier, C. and Portal, J.M. (1996). The pollution of water by pesticides: state and origin. Agronomie 15(3-4): 157-170. https://doi.org/10.1051/agro:19950301.

Shaikh, N.F. and Gachande, B.D. (2013). Influence of organic and inorganic inputs on soil physico-chemical properties of jowar field. International Journal of Science and Research. 6.

Shaikh, N.F. and Gachande, B.D. (2015). Effect of organic bio-booster and inorganic inputs on rhizosphere mycoflora population and species diversity of wheat. International Journal of Science and Research. 4: 295-302.

Sharmila, M., Devjani, P. and Singh, N.I. (2015). Field density and management of *Pieris brassicae* under the climatic conditions of the valley region of Manipur. International Journal of Tropical Agriculture. 33(2 (Part IV)): 1697-1701.

Sreenivasa, M.N., Naik, N. and Bhat, S.N. (2010). Beejamrutha: A source for beneficial bacteria. Karnataka Journal of Agricultural Sciences. 22(5): 1038-1040.

Subba, B., Chaudhuri, N. and Senapati, S.K. (2022). Evaluation of insecticides against jassid (*Amrasca biguttula* biguttula Ishida) and fruit borer (*Earias vittella* Fabricius) on okra during pre-*kharif* season. The Pharma Innovation Journal. 11(6): 556-560.

Thakur, S. and Sood, A.K. (2019). Lethal and inhibitory activities of natural products and biopesticide formulations against *Tetranychus urticae* Koch (Acarina: Tetranychidae). International Journal of Acarology. 45(6-7): 381-390.

Vidyavathi, V., Dasog, G.S., Babalad, H.B., Hebsur, N.S., Gali, S.K., Patil, S.G. and Alagawadi, A.R. (2012). Nutrient status of soil under different nutrient and crop management practices. Karnataka Journal of Agricultural Sciences. 25(2): 193-198.