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Contents

"It is the prime responsibility of every citizen to feel that his country is free and to defend its freedom is his duty. My only desire is that India should be a good producer and no one should be hungry, shedding tears for food in the country"

— Sardar Vallabhbhai Patel

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Use of Botanicals by Farmers for Integrated Pest Management of Crops in Karnataka

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Abstract

Agriculture has been facing the destructive activities of numerous pests like fungi, weeds, and insects from time immemorial, leading to radical decrease in yields. Insect pests are the big enemies of farmers as they destroy crops, stored grains; act as a vector of diseases of livestock etc. Chemical pesticides are used to control these pests, but their indiscriminate use has resulted in development of insecticide resistance in pests, and higher levels of residual toxicity resulting in conversion of fertile lands into infertile and toxic. In addition it also contributes to environmental pollution by contaminating air, soil and water which results in health hazards to human and wild life. Growing public awareness and concern about the adverse effects of pesticides have necessitated the need to look for eco–friendly, safer and effective organic methods of pest control. The best solution for this is to follow indigenous traditional ways of pest control followed by farmers by using plants which were once prevalent all over the world, but with the advent and use of modern synthetic pesticide these have almost vanished from the developed countries and are mow confined to some regions of developing countries. More than 2500 plant species belonging to 235 families have been found to possess the characteristic properties required for an ideal botanical insecticide. Hence an attempt was made during Rural Agricultural Work Experience program (RAWE) to acquire information on the indigenous botanical sprays used by the farmers in Segalapalli, Kamtampalli, and Tadigol Villages of Srinivaspura Taluk, Kolar District of Karnataka.

Insect pests are the big enemies of farmers as they destroy crops, stored–grains; act as a vector of diseases of livestock etc. Indiscriminate use and overdependence on chemical pesticides in pest control also resulted in insecticide resistance in pests, pest resurgence which results in minor pests attaining major status, elimination of natural enemies, higher levels of residual toxicity in soil, environmental pollution by contaminating air, soil, and water which have harmful effect upon human and wild life. Therefore, it has now become necessary to search for the alternative means of pest control, which can minimize the use of synthetic pesticides.

The increasing concern on environmental safety and global demand for pesticide residue-free food has evoked interest in pest control through use of botanicals, biopesticides, and biocontrol agents

The increasing concern on environmental safety and global demand for pesticide residue- free food has evoked interest in pest control through use of botanicals, biopesticides and biocontrol agents (natural enemies) which offers a good alternative to manage the insect pests and diseases in an eco–friendly way.

(natural enemies) which offers a good alternative to manage the insect, pests, and diseases in an eco–friendly way. Botanicals are extracted from various plant parts (leaves, stems, seeds, roots, bulbs, rhizomes, unripe fruits, and flower heads etc.) of different plant species. Plant extracts are also called as Green Pesticides, Botanical Pesticides, Plant Pesticides, Botanicals, Ecological pesticides and the method which utilizes botanicals in insect pest management is called as Indigenous Integrated Pest Management or Ethno–Botanical Crop Protection. Botanical pesticides possess an array of properties including toxicity to the pest, repellent, anti–feedant, insect growth regulatory activities against pests of agricultural importance. These have broad spectrum activity, are less expensive and easily available because of their natural occurrence, have high specificity to target pests, and no or little adverse effect on beneficial insects, resistance development to them is slow or less common, poses least or no health hazards and environmental pollution, have less residual activity and are effective against insecticide resistance species of insects, and have no adverse effect on plant growth parameters. More than 2500 plant species belonging to 235 families have been found to possess the characteristics required for an ideal botanical insecticide. About 350 insecticidal compounds, more than 800 insect feeding deterrents, and a good number of insect growth inhibitors and growth regulators have been isolated from various plant species.

Methodology

The present study was conducted in Segalapalli, Kamtampalli and Tadigol Villages of Srinivaspura Taluk, Kolar District of Karnataka state. Authors had stayed in the village during Rural Agricultural Work Experience program for a period of one month to gather information on indigenous botanical sprays used by the farmers for insect pest management and information was obtained from local farmers through personal contact. Frequent field visits were organized for data collection, confirmation and finalization by repeated visits to the same localities.

Results and discussion

All the available efficient indigenous botanical sprays commonly used by the farmers are presented in table1. Overall study indicated that farmers used locally available natural resources for the management of insect pests. There were 14 types of indigenous botanical sprays used by the farmers in different crops against

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different insect pests like *Helicoverpa armigera* (fruit borer), *Spodoptera litura* (Leaf eating caterpillar), *Leucinodes orbonalis* (Brinjal fruit and shoot borer), Amsacta *albistriga* (Red headed hairy caterpillar), pod borers of pulses, tobacco caterpillar, Tea mosquito bug, Thrips, Jassids, Aphids, Termites, Spider mites, Beetles, leaf miners, defoliators, whiteflies, scales etc. All these sprays have been used since ancestral period. The information on methods of preparation of these botanical sprays was also collected from the farmers.

Table 1. Indigenous botanical sprays used by the farmers to control insect pests in crops.

Botanical	Target pests
Neem leaf extract	Defoliators and Sucking pests
Garlic extract	*Spodoptera litura* (leaf eating caterpillar), *Helicoverpa armigera* (fruit borer), and other lepidopteran pests
Garlic-Chilli-extract	*Helicoverpa armigera* (fruit borer), *Spodoptera litura* (leaf eating caterpillar), *Leucinodes arbonalis* (Brinjal fruit & shoot borer), *Amsacta albistriga* (red headed hairy caterpillar)
Fermented botanical spray	*Leucinodes orbonalis* (Brinjal fruit and shoot borer), Pod borers of pulses, Tobacco caterpillar (*Spodoptera litura*)
Adathoda vesica leaf extract	Defoliators and Sucking pests
Datura plant extract	Tea mosquito bug, Thrips, Jassids, Aphids
Ekka leaf extract	Termites
Lantana leaf powder	Aphids
Lantana leaf extract	Beetles, Leaf miners, Defoliators
Mixed leaves extract	Defoliators like Spodoptera litura, semi loopers
Panchapatre	Defoliators, Fruit borers, Sucking pests like Aphids and Whiteflies
Nilgiri leaf extract	Jassids, Aphids, Scales
Chilli – Neem– Garlic exract	Lepidopteran pests in Pigeon pea
Multiple plants leaf extract	Major pests and diseases

Methods of preparation of different indigenous botanicals by farmers

Neem (*Azadirachta indica*) leaf extract

Materials required: Neem leaves (80kg/ha).

The fresh neem leaves were collected and soaked overnight in water. Next day, soaked leaves were taken out and ground and the extract obtained was filtered. The filtered extract was diluted @ 2.5–3 L in 50 L water and sprayed.

Garlic (*Allium sativum*) extract

Materials required: Garlic bulbs (30gm).

30g of garlic bulbs were ground thoroughly in grinder with 50ml water. Ground mixture was soaked in little quantity of water over night and squeezed through muslin cloth and the volume was made up to 1L by adding water and sprayed.

Garlic–Chilli (*Capsicum annum*) extract

Materials required: Green Chilli 30g, and Garlic 30g.

Garlic bulbs and green chilli (30g each) were ground separately in a grinder with little water. Grinded material was soaked in water overnight separately and the extract was squeezed using muslin cloth, both were mixed and the volume was made up to 1 L to obtain 3 per cent concentration.

Fermented botanical spray

Materials required: cow dung (6kg), cow urine (6L), Calotropis (*Calotropis gigantea*) leaves (5kg), Vitex (*Vitex negundo*) leaves (5kg), Neem leaves (5kg), Adhatoda (*Adathoda vasica*) leaves (5kg), and Pongamia (*Pongamia pinnata*) leaves (5kg).

A plastic barrel of 200L capacities was taken and above mentioned materials + small quantity of soil below the tree was added. The whole mixture was stirred daily for four weeks. The mixture was filtered through a double–layered muslin cloth. The filtered extract was diluted and sprayed. This preparation is a variant of *kunapajala* described by Surapala in his Vrikshayurveda

Adhatoda (*Adhatoda vesica*) leaf extract

Materials required: Adhatoda leaves (1kg).

Leaves (1kg) of Adhatoda were ground and mixed with 10L water and kept undisturbed for 24h and then filtered through a muslin cloth and sprayed.

Datura (*Datura stramonium*) plant extract

Materials required: Datura leaves (1kg), and Datura pods (1kg).

Leaves and pods of Datura were dried and powdered by pounding. This powder was soaked in 40L water and kept for 24h and then filtered through a muslin cloth and sprayed.

Ekka [Calotropis (*Calotropis gigantea*)] leaf extract

Materials required: *Ekka* leaves (5kg).

Ekka leaves were sun dried and powdered by pounding and the powder obtained was soaked in 50L water and kept for 24h then filtered through a muslin cloth and sprayed.

Lantana (*Lantana camera*) plant powder

Materials required: Lantana branches with leaves and immature fruits (5kg).

Lantana branches with leaves and immature fruits were chopped and dried. The dried material was grinded to prepare powder and the powder was mixed with 100L water and sprayed.

Lantana (*L. camera*) leaf extract

Materials required: Lantana leaves (1kg). Lantana leaves (1kg) were chopped and ground with little water and filtered. This filtrate was diluted in 30L of water and sprayed.

Mixed Leaves Extract

Materials required: cow urine (10L), Custard apple (*Annona squamosa*) leaves (2kg) Papaya leaves (2kg), Pomegranate leaves (2kg), Guava leaves (2kg), Neem leaves (2kg), Pongamia leaves (2kg), and a Copper container of 20 L capacity.

All the leaves were crushed and 10L of cow urine was added. The above mixture was boiled till the mixture became half of the initial. The boiled leaves were kept for 24h without disturbing. The leaves were then squeezed and the extract was collected separately and filtered. The extract was diluted @ 2–2.5L in 50L water and sprayed.

Panchapatre

Materials required: Calotropis (*Calotropis gigantea*) (1kg), Neem (1kg), Adhatoda (1kg), Vitex (1kg).

The above mentioned plant leaves were ground and transferred to a plastic drum in 15L water, 1L cow urine, and 50gm asafetida was added. The mouth of the plastic drum was tightly tied with a cloth. This mixture should be mixed well daily and used after a week after filtration.

Nigeria (*Eucalyptus globules*) leaf extract

Materials required: Eucalyptus leaves.

Boil tender leaves of eucalyptus (1kg in 2L water) for one hour in low flame. Filter it next day and dilute with 20L water and spray.

Chilli–Neem–Garlic extract

Materials required: Chilli, Neem leaves, and Garlic.

Chilli, Neem leaves and fresh Garlic paste was taken in 1:4:1 proportion and boiled with 15 times water for 45 minutes to one hour in low flame and filtered the solution and mix it with 50L of water and sprayed.

Multiple plant extract

Materials required: Cow dung (15kg), Cow urine (5L), Calotropis (3kg), Parthenium (3kg), Lantana (3kg), Datura (3kg), Pongamia oil cake (2kg), Neem seed kernel extract (1L), Jaggery (1kg), Ash

(1kg), and Plastic barrel of 200L capacities.

All the plant materials were chopped and filled in plastic drum with 200 L water. All ingredients were stirred well and the drum mouth was closed with a lid and allowed it to ferment for one week. After a week the whole mixture was filtered. The filtered liquid was used through irrigation water @ 200 L/ha.

Scientific rationale of using botanicals as pesticides

Neem (*A. indica*). Azadiractin, Melantriol, Nimbinin, Nimbidin, Salanin, Nimbin, Nimbolin A, and Nimbolin B are the active principles present in neem leaf extract. These compounds show anti–feedant, repellent, oviposition deterrent and insect growth regulator activity against insect pests (Vijayalakshmi *et al.*, 1995, 1996; Kwasi Opoku Boadu *et al.*, 2011, Subbalakshmi *et al.*, 2012; Misra, 2014).

Garlic (*A. sativum*). Allicin and Diallyl sulfide are the active principles present in garlic extract, which have insecticidal activity (Prowse *et al.*, 2006).

Chilli (*C. annum*). Chilli extract contains Capsacin as the active principles, which has repellent and deterrent activity against insect pests (Madhumathy *et al.*, 2007).

Vitex (*V. negundo*). Vitexin and negundoside are the active principles present in the V. negundo, which show repellent activity against insect pests (Prasad, 2011).

Calotropis (*C. gigantea*). Calatropin and Calotoxin are the active principles present in calotropis, which show anti–feedant, repellent, oviposition deterrent and insect growth regulator activity against insect pests (Rohit Sharma *et al.*, 2012; Baby Josephet al., 2013; Suresh Kumar *et al.*, 2013).

Adhatoda (*A. vasica*). Vasicine, Vasicinone and Adhatodin are the active principles present in the Adhatoda, which show repellent and insecticidal activity against insect pests (Emimal Victoria, 2010; Nandre *et al.*, 2012).

Pongamia (*Pongamia pinnata*). Karanjin is the active principles present in the *P. pinnata,* which shows anti–feedent, Juvenile Hormone Analogue (JHA) and insecticidal activity against insect pests (Vishal Kumar *et al.*, 2006).

Datura (*D. stramonium*). Hyoscyamine, Atropine and Scopolamine are the active principles present in Datura, which show repellent and oviposition deterrent activity against insect pests (Devil *et al.*, 2011).

Lantana (*L. camera*). Lantanolic acid and Lantic acid are the active principles present in Lantana, which shows growth inhibition and repellent activity against insect pests (Nirmal *et al.*, 2009).

Custard apple (*A. squamosa*). Anonaine and squamocin are the active principles present in the *Annona squamosa*, which shows feeding deterrent activity against insect pests (Singh and Saratchandra, 2005)

Nilgiri (*E. globules*). Camphene, Limonene, Alpha & Beta pinenes and Alpha terpienol are the active principles present in Nilgiri globules, which show repellent activity against insect pests (Dhumal and Waghmare, 2014).

Parthenium (*P. hysterophorus*). Parthenin is the active principles present in the Parthenium (Veena and Shivani , 2012) which show feeding deterrent and insect growth inhibitor activity against insect pests (Datta and Saxena, 2001; Pandey 2009).

Conclusion

In recent years the use of synthetic insecticides in crop protection program resulted in disturbances of the environment, pesticide residues, pest resurgence, pest resistance etc. This leads to increased importance to naturally occurring plants associated with rich traditional knowledge base available with the highly diverse indigenous communities in India which is the environmental friendly agricultural technology for ensuring food safety and food security. The current trends of modern society towards Green Consumerism desiring fewer synthetic ingredients may favor plant–based products called Green Pesticides or Botanical Pesticides, Plant Pesticides or Botanicals ecological pesticides which are eco–friendly, biodegradable, natural, no residual effect etc. Therefore, this rich heritage of the botanical knowledge should be harnessed, preserved, documented, and developed as modern science such as Indigenous Integrated Pest Management or Ethno–Botanical Crop Protection.

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Indigenous Seed Treatment Methods to Enhance Germination and for Control of Pests and Diseases

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Abstract

Agriculture is the major occupation of the people all over the world. Seed borne infestation of insects and diseases reduce germination percentage and seedling vigor, posing devastating consequences to crop production. Even though several chemical and mechanical seed treatments are predominant, traditional/indigenous seed treatment practices are still followed especially in villages. These indigenous seed treatment practices facilitate enhanced germination, establishment of healthy vigorous plants, good plant stand, uniform seedling emergence, breaking of dormancy, hindering seed ageing, enhanced longevity of seeds, and protection of seeds and seedlings from early season insect pests and diseases which result in better yields. Hence, a study was undertaken to collect and document indigenous seed treatment practices followed by the farmers of Kolar and Chickballapura districts of Karnataka state in India. Twenty important practices followed by the farmers are documented. These methods have advantages over other methods due to their low cost, easy availability of materials, safe use, and eco-friendly nature.

Agriculture is the major occupation of the people all over the world and more than 70% of the population in India depends on agriculture. Crops have been facing the destructive activities of numerous pests like fungi, weeds, and insects, leading to decrease in yields. Seed borne infestation of insects and pathogens pose devastating consequences to crop production. Even though chemical control is predominant, traditional seed treatment practices are still followed especially in villages. These practices help to improve crop safety, ensure uniform seedling emergence, and protect seeds and seedlings from early season diseases and insect pests thereby improving crop growth which results in better yields.

Rural people have immense knowledge of many aspects of indigenous technologies and adopt them based on their needs to solve local problems in managing agricultural and related activities. Traditional knowledge is gathered over a period of time and

transferred from generation to generation. Indigenous technical knowledge (ITK) is the knowledge of a given population that reflects the experiences based on traditions. It is local knowledge that is unique to a given culture or society and pertains to various cultural norms, social roles, or physical conditions. Such knowledge is not a static body of wisdom; instead it consists of dynamic insights and techniques, which are changed over time through experimentation and adaptation to environmental and socioeconomic changes. Rich biodiversity and a complex system of indigenous knowledge are the two characteristic features of traditional farming systems in developing countries. It is the base for agriculture, education, and environment conservation. Traditional practices followed by farmers should be efficiently used to increase the land fertility, soil conservation, moisture balance, and pest control that subsequently have developed into a wide range of site-specific technologies. Eco-friendly agricultural practices are appropriate technologies for food safety and also play a major role in ensuring food security. Instead of striving for more "green revolutions" with emphasis on miracle seeds, synthetic pesticides, and chemical fertilizers, we must examine natural ways for augmenting agricultural productivity. Traditional practices are important elements in local life and are found to be excellent for crop improvement.

Good seed treatment is necessary to increase germination, plant health, crop establishment, and crop protection in early stage of crop growth. Traditionally farmers in India followed various methods of seed treatment as mentioned in ancient texts such as Parashara's Krishi-Parashara, Surapala's Vrikshayurveda, Kautilya's Arthashastra, and Varahamihira's Brihat Jataka (Mathad *et al.*, 2013). These methods were not expensive as farmers used materials available locally. Traditional agricultural practices based on natural and organic methods of farming offer several impressive, feasible, and cost-effective solutions to most of the basic problems being faced in conventional farming systems.

Methodology

The present study conducted in 2011 documents the traditional seed treatment practices in three villages (Thoopalli, Kamatampalli, and Seegalapalli) of Srinivaspura taluk, Kolar district and four villages (Mylandlahalli, Kurubur, Kuratahalli, and Mohamadpura) of Chintamani taluk, Chickballapura district of Karnataka state in India. In total, 129 farmers/respondents (about 15 to 24 in each village) were interviewed. Detailed information given by practitioners and experienced farmers were documented.

Results and discussion

Most of these practices which exist today as indigenous practices have their origin in the distant past; however, some practices have been modified in recent years. The utilization of locally available indigenous practices are meager. These methods protect the seeds and are eco-friendly and do not cause health hazards. They are cheap as locally available materials are used. Some important traditional methods of seed

treatment with different locally available materials followed by farmers of Kolar and Chickballapura districts of Karnataka are discussed.

Cow dung

Half kg of fresh cow dung was diluted with 5 L water. About 10–15 kg of seeds, previously soaked in water, were soaked in cow dung solution for 10–12 hours. The seeds were dried in shade before sowing in the nursery. Cow dung was used with ghee and honey in ancient times for treating sugarcane setts as documented by Kautilya in Arthashastra (Nene, 2002).

Farmer's view. The cow dung covering the seeds protects them from birds and other insects in the nursery and also acts as manure for seeds. Farmers believe that it stimulates germination.

Scientific rationale. Cow dung has several beneficial properties.

- It provides nutrients in small quantities for germinating seeds.
- It increases drought resistance and acts as a seed hardener.
- It helps to maintain the ideal temperature and pH for sprouting during winter.
- It acts as a mechanical barrier and also as a repellent for pests and diseases.
- It is superior to other dung because it is antiseptic and destroys microorganisms that cause diseases.
- Every gram of cow dung can have up to 10 million plant growth promoting microorganisms.

Target crops. Rice (*Oryza sativa*), finger millet (*Eleusine coracana*; *ragi*), minor millets, and almost all pulses.

Cow urine

Cow urine was collected in a mud pot and kept for 48 hours. Seeds were soaked in 10% cow urine (100 ml cow urine in 1 L water) for 30 minutes to 1 hour and dried in shade for half an hour before sowing.

Farmer's view. Increases germination percentage and prevents the crop from seed borne diseases.

Scientific rationale. Cow urine has several beneficial properties.

- It contains sodium, nitrogen, sulfur, vitamins A, B, C, and E, minerals, citric acid, succinic acid, manganese, iron, calcium, phosphorus, salts, carbonic acid, potash, silicon, chlorine, ammonia, urea, uric acid, amino acids, enzymes, cytokine, lactose, carbolic acid, enzymes, hormones, etc. (Bhadauria, 2002).
- It contains 95% water, 2.5% urea, and 2.5% enzymes which are known to break dormancy and improve germination.
- It contains many microorganisms which help in improving nutrients and disease resistance.
- It also contains copper which has the power to kill pathogens.
- Cow urine is antibacterial, antifungal, antiviral, and nontoxic and helps in protecting seedlings against pathogens.

- It has immunostimulant activity in plants.

Target crops. Paddy, finger millet, and vegetables like brinjal (*Solanum melongena*; egg plant), tomato (*Lycopersicon esculentum*), and okra (*Abelmoschus esculentus*; *bhendi*).

Buttermilk

Buttermilk (2–3 days old) was taken and diluted with water at 1:4 ratio. Seeds were soaked in this mixture for 4–5 hours and dried in shade before sowing (Subhashini Sridhar *et al.*, 2013).

Farmer's view. Improves germination.

Scientific rationale. Acidic nature of buttermilk affects growth and development of pathogens and reduces the incidence of wilt and dry root rot diseases. Presence of many microbes in buttermilk helps in controlling several viral and fungal diseases.

Target crops. Finger millet, pigeonpea (*Cajanus cajan*), watermelon (*Citrullus lanatus*), pumpkin (*Cucurbita pepo*), and tomato.

Cow milk

Seeds were treated with 12% or 25% raw cow milk (i.e., 120 ml milk and 880 ml water; or 250 ml milk and 750 ml water) for 6 hours and then sown.

Farmer's view. Milk enhances germination, seedling vigor, and yield. It reduces the intensity of vein clearing disease and prevents the infection of seed borne diseases.

Scientific rationale. Milk has several beneficial properties.

- It is a sticker (on leaves) and growth promoter.
- It contains a number of proteins such as lactoferrin, lactoperoxidase, glycolactin, angiogenin-1, lactogenin, alpha-lactalbumin, lactoglobulin, and casein. Milk proteins contain amino acids such as proline, which are known to induce general disease resistance in plants (Nene, 2012).
- Lactoferrin present in milk has antifungal, antibacterial, antiviral, and anti-nematode properties. Hence milk has the ability to control phytopathogenic fungi and promote plant growth under field conditions, increases tolerance to abiotic stresses, and solubilizes phosphate under abiotic stress conditions.
- Immunoglobulins, lactoferrin, lysozyme, lactoperoxidase, vitamin B_{12}, and binding protein present in milk have antimicrobial effects.
- Milk fat has antibacterial activity against gram-negative bacteria and fungicidal activity against certain molds.

Target crops. Cereals, pigeonpea, tomato, brinjal, okra, and coriander (*Coriandrum sativum*).

Curd

Curd solution was prepared by mixing curd (made with cow milk) in water at a ratio of 1:5. Sceds were soaked in the solution for 30 minutes and dried in shade and sown

immediately (Subhashini Sridhar *et al.*, 2013).

Farmer's view. Increases germination and reduces seed borne diseases.

Scientific rationale. The *Lactobacillus* in curd lowers the pH and favors the growth of beneficial microorganisms and inhibits the growth of pathogens. Acidic nature of curd affects growth and development of pathogens and reduces the incidence of wilt and dry root rot diseases.

Curd contains billions of bacteria that suppress the growth of other harmful bacteria, fungi, and protozoa. The inhibitor released by these bacteria works against the unwanted pathogens and also contains the useful nutrients for the growth and maturation of the crop plant (Narendra Kumawat *et al.*, 2014).

Target crops. Finger millet, pigeonpea, tomato, brinjal, okra, coriander, and cucumber (*Cucumis sativus*).

Sheep manure

Seeds were soaked in water overnight, dried in shade, and placed in a mud pot containing saw dust and sheep manure. The mud pot was closed tightly. Seeds were removed after two days, dried, and used for sowing.

Farmer's view. Enhances germination.

Scientific rationale. Keeping seeds along with sheep manure in an airtight container creates heat inside the pot which is required for initiation and hastening of germination. Warm conditions are required for chemical reactions to start inside the seed (Mathad *et al.*, 2013).

Target crops. Cereals, pigeonpea, field bean, and groundnut (*Arachis hypogaea*).

Cow dung powder and cow urine

Seeds were treated with dried cow dung powder and cow urine before sowing. For 1 kg seed, approximately 100 g cow dung powder and 250 ml cow urine were used.

Farmer's view. Enhances germination.

Scientific rationale. Cow dung powder protects the seed from humidity and hence improves longevity of seed. Cow urine contains 2.5% urea which is known to break dormancy and improve germination (Kundu *et al.*, 1993). A large number of microbes are present in the cow dung and urine which are useful for controlling many fungal diseases. Nutrients present in the solution are useful for effective plant growth.

Target crops. Cereals, pigeonpea, groundnut, okra, and cucurbits.

Panchagavya

The Sanskrit word *kunapa* means "smelling like a dead body, stinking". The manure *kunapambu* or *kunapajala* (*jala*=water) is a liquid ferment from animal wastes that contains animal flesh, cattle dung, cattle urine, milk, ghee, honey, bones, marrow, and skin. The fermented product contains basic constituents such as amino acids, sugars, fatty acids, keratins, macro- and (almost all) micronutrients in available form. Thus plants respond very well to the nourishment provided by *kunapajala* and flourish with excellent growth, flowering, and

fruiting (Narayanan, 2006). In recent years, *panchagavya* (five products from cow: milk, curd, ghee, dung, and urine) is being used to "purify" polluted premises and to "purify" self. In fact only fresh *panchagavya* has to be used for "purification", and not the fermented one. *Panchagavya* thus recommended and used is a kind of *kunapajala* (Nene, 2012).

Panchagavya was prepared by mixing fresh cow dung (7 kg) and cow ghee (1 kg) thoroughly and incubated for 2 days. Cow urine (3 L) and 10 L of water were added and stirred properly (morning and evening, daily for 1 week). Sugarcane juice (3 L), cow milk (2 L), cow curd (2 L), coconut water (3 L), yeast 100 g, and 12 ripened bananas were added after one week and mixed thoroughly and kept for 4–5 days. Seeds were soaked in this *panchagavya* (35 ml in 1 L water) for 30 hours before sowing (Dhama *et al.*, 2005).

Farmer's view. *Panchagavya* enhances germination, promotes profuse and dense rooting, increases immunity in plants and thereby induces resistance to pests and diseases.

Scientific rationale. *Panchagavya* contains several nutrients, i.e., macronutrients like nitrogen, phosphorus, and potassium and micronutrients which are required for the growth and development of plants (Mathivanan, 2013). It also contains various amino acids, vitamins, growth regulators like auxins and gibberellins, and beneficial microorganisms like azatobacter, phosphobacteria, and *Pseudomonas* which induce resistance to pests and diseases.

Target crops. Almost all crops.

Boojamrita

Five kg fresh cow dung was taken and placed in a cloth bag and suspended in a container filled with water to extract the soluble ingredients of dung. About 50 g lime (calcium hydroxide) was suspended in 1 L water separately. After 12–16 hours the bag was squeezed to collect the extract and 5 L cow urine, 50 g forest soil, lime water, and 20 L water were added. This mixture was incubated for 8–12 hours and then filtered. The seeds were soaked in this *beejamrita* solution and 1–3 hours and dried in shade for 10–15 minutes and then used for sowing.

Farmer's view. Acts as growth regulator and enhances crop vegetative growth. Increases the plant's defense mechanism against pests and diseases.

Scientific rationale. *Beejamrita* has several beneficial properties.

- It provides nutrients in small quantities for germinating seeds.
- It increases drought resistance and acts as a seed hardener.
- It maintains the ideal temperature for sprouting during winter.
- It acts as mechanical barrier and as a repellent for pests and diseases.
- Lime is a repellent and antifeedant and also prevents multiplication of insects.
- *Beejamrita* has hormones and alkaloids, which neutralize the anti-germinating chemicals in the embryo and enhance germination and also protect the seedlings (Sreenivasa *et al.*, 2009).

Target crops. Cereals, pigeonpea, cowpea (*Vigna unguiculata*), field bean, brinjal, and okra.

Salt solution

Seeds were immersed in salt solution [1 kg common salt (sodium chloride) in 10 L water], stirred, and kept aside. After an hour, light and chaffy seeds which floated were removed and hard seeds that settled down were dried in shade and then used for sowing.

Farmer's view. Nonviable seeds can be excluded before sowing.

Scientific rationale. Salt is hygroscopic and has insecticidal property. Adding salt to water increases its density and helps in separation of light and chaffy seeds. This also helps in increasing germination (Johnston *et al.*, 1978). Salt treatment breaks seed dormancy and induces drought tolerance.

Target crops. Pigeonpea, chickpea (*Cicer arietinum*), black gram (*Vigna mungo*), green gram (*Vigna radiata*; mung bean), and other pulses and legumes.

Lime water

About 1 kg lime was dissolved in 10 L water and kept for 10 days (Subhashini Sridhar *et al.*, 2013). The superficial water was collected and seeds were soaked in it overnight. The seeds were then dried in shade and used for sowing (Smith and Secoy, 1976).

Farmer's view. The grains are protected from pest attack.

Scientific rationale. Lime has repellent and antifeedant properties that prevent multiplication of insect pests. It protects the seed against seed borne diseases such as smut and bunt (Smith and Secoy, 1976).

Target crops. Cereals, groundnut, and field bean.

Ash solution

Two tablespoons of ash was added to one liter of water and mixed thoroughly. Seeds were soaked in this solution for 15–30 minutes. Seeds were dried in shade and sown immediately (Krishan Chandra and Sarita Mowade, 2013).

Farmer's view. Controls seed borne diseases and enhances seed vigor and germination.

Scientific rationale. Ash contains silica which acts as defense against biting and chewing insects and also hinders multiplication of some fungal pathogens.

Target crops. Cereals and almost all pulses.

Asafetida solution

Seeds were soaked in asafetida solution [250 g asafetida (*Ferula asafoetida*; *hing*) in 2 L water] for 12 hours and dried in shade before sowing (Krishan Chandra and Sarita Mowade, 2013).

Farmer's view. Prevents diseases.

Scientific rationale. The solution acts as a fungicide due to presence of sulfur in asafetida.

Target crops. Cereals, cowpea, and groundnut.

Turmeric

Seeds were soaked in turmeric solution [1 kg turmeric (*Curcuma longa*) powder in 10 L water], stirred, and kept aside for one hour and dried in shade before sowing (Krishan Chandra and Sarita Mowade, 2013).

Farmer's view. Prevents ant attack after sowing.

Scientific rationale. The components sesquiterpene, ketone, and ar-turmerone in turmeric repel insects. The strong smell and insecticidal properties of turmeric keep insects away from food grains.

Target crops. Pulses and cereals.

Leaf extract of four plant species

Leaves (3 kg each) of *Vitex negundo*, *tulsi* (*Ocimum sanctum*), neem (*Azadirachta indica*), and pongam (*Pongamia pinnata*) were ground and leaf extract was prepared. Fresh cow dung solution was added to leaf extract. Gunny bag filled with seeds was soaked in the above solution for 12 hours. Seeds were dried in shade for half an hour before sowing.

Farmer's view. Produces healthy and disease resistant seedlings

Scientific rationale. Cholestan-3-one and tannin in *V. negundo*, azadirachtin, melantriol, salannin, nimbin, and nimbidin (tetranortriterpenoid group) in neem (Subbalakshmi Lokanadhan *et al.*, 2012), and karanjin (Shaon Kumar Das, 2014) in pongam have potential insecticidal properties like antifeedant action, insect growth regulatory activity, inhibition of juvenile hormone synthesis, oviposition deterrent effect, and repellent action. Alkaloids present in these plants and in *tulsi* help to control many fungal diseases.

Target crops. Pulses and cereals.

Mint leaf extract

Seeds were soaked in 20% mint (*Mentha arvensis*) leaf extract (200 ml leaf extract mixed with 800 ml water) for 12 hours before sowing.

Farmer's view. Increases germination rate and vigor of seedlings and helps in control of diseases.

Scientific rationale. Menthol, carvane, and menthone in mint leaves have antifungal activity against mold causing organisms.

Target crops. Cereals.

Datura leaf extract

About 1 kg seeds were mixed with leaf extract of datura (*Datura metel*) (500 g of leaves ground with water) and dried in shade before sowing. Datura extract also helps in better nourishment of the crop (Sadhale, 2004).

Farmer's view. Helps in the production of healthy and disease-free seedlings.

Scientific rationale. The alkaloids (hyoscyamine, hyoscine, atropine, scopolamine, saponins), flavonoids, phenols, essential oils, and glycosides present in datura leaves have insecticidal activity.

Target crops. Cereals, field bean, pigeonpea, and groundnut.

Garlic extract

About 30 g garlic (*Allium sativum*) bulbs were ground with 50 ml water. A little quantity of water was added to the mixture and left overnight and then squeezed through muslin cloth. The volume was made up to 1 L to get 3% extract. Seeds were soaked in 3% garlic extract for 5–10 minutes and dried in shade for 15–20 minutes before sowing (Krishan Chandra and Sarita Mowade, 2013).

Farmer's view. Easily available and acts as a repellent.

Scientific rationale. Some beneficial properties of garlic are given.

- Garlic contains a sulfur compound that is an excellent natural antibiotic and a fungicide which helps to control rust, blackspot, and other fungal diseases (Narendra Kumawat *et al.*, 2014).
- It has antifeedant, bactericidal, fungicidal, insecticidal, nematicidal, and repellent properties.
- It also contains the volatile compounds allicin, citral, geraniol and linalool, which are known to have insecticidal properties.

Target crops. Pulses.

Citronella oil

Seeds were treated with citronella (*Cymbopogon nardus*) leaf oil before sowing. About 500 ml oil was used for 100 kg seed.

Farmer's view. Protects seeds from insects and microbes.

Scientific rationale. Some beneficial properties of citronella oil are given.

- The oil contains geraniol as its primary component with lesser amounts of citronellol, citronellal, borneol and other terpenes (Nguefack *et al.*, 2008).
- The strong odor of citronella oil repels storage pests and microbes like *Alternaria* and *Fusarium*.
- The larvicidal activity of citronella oil has been mainly attributed to its major monoterpenoid constituent citronellal.

Target crops. Pulses.

Conclusion

These traditional seed treatment methods have been followed for a very long time by the farmers of our study area and have not changed but improved over the years. These methods were in line with ancient texts which are scientific. The methods were scientifically true and logical. The available literature shows the scientific base for these methods. These methods were cost-effective and viable in small farm situations and can be used as alternative ways for nonchemical seed treatment and short-term seed storage. This collection of knowledge is of great significance in conserving and maintaining sustainability of the environment. The traditional practices discussed have advantages over other methods due to their low cost, easy availability of materials, safe use, and eco-friendly nature.

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