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INDIGENOUS PLANT-BASED PESTICIDES IN ORGANIC FARMING: LOW-COST SOLUTIONS FOR SUSTAINABLE CROP PROTECTION

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In recent decades, excessive dependence on synthetic chemical pesticides has become a major concern in Indian agriculture. While these chemicals initially provided quick and visible results, their continuous and indiscriminate use has led to serious problems such as pest resistance, resurgence of secondary pests, environmental contamination, and harmful residues in food products (Pimentel, 2005; Isman, 2006). Rising input costs have further increased the burden on small and marginal farmers, making crop protection an expensive component of cultivation.

At the same time, growing awareness about food safety, ecological balance, and sustainable farming practices has renewed interest in traditional and eco-friendly pest management approaches. Long before the introduction of synthetic pesticides, farmers relied on locally available plant materials such as neem, garlic, tobacco, papaya leaves, and cow urine to protect crops from insects and diseases. These indigenous plant-based preparations were affordable, biodegradable, and relatively safe to humans and beneficial organisms (Isman, 2006; FAO, 2018).

In the context of organic farming, where the use of synthetic chemicals is restricted, these botanical pesticides offer practical and sustainable alternatives. Reviving and standardizing indigenous plant-based formulations can empower farmers to reduce production costs, minimize environmental risks, and promote healthier agricultural systems. This article highlights some commonly used plant-based pesticides that can be prepared easily using locally available materials and applied effectively in organic crop production.

Why Indigenous Plant-Based Pesticides?

Indigenous plant-based pesticides occupy an important place in organic farming because they combine traditional knowledge with ecological sustainability. Unlike synthetic

chemicals that often act as broad-spectrum toxins, botanical extracts generally function as repellents, antifeedants, growth regulators, or mild contact poisons (Isman, 2006; Pavela, 2016). This means they interfere with pest behaviour and life cycles without causing severe disruption to the agro-ecosystem.

One of the primary advantages of plant-based pesticides is their local availability. Materials such as neem seeds, garlic, chillies, papaya leaves, tobacco leaves, buttermilk, and cow urine are easily accessible in rural areas. Farmers can prepare these formulations at home with minimal investment, reducing dependence on costly commercial pesticides. For small and marginal farmers, this significantly lowers the cost of crop protection.

Another major benefit is environmental safety. Botanical pesticides are biodegradable in nature and break down rapidly in soil and water, leaving minimal harmful residues. This reduces the risk of contamination of groundwater, soil microflora, and non-target organisms such as pollinators and natural enemies. Their use aligns well with the principles of organic certification and sustainable agriculture.

In addition, indigenous formulations often strengthen plant health. Some extracts, particularly those based on neem and cow urine, not only suppress pests but also enhance plant vigor and resistance. Regular application can contribute to balanced pest management rather than complete eradication, which is more ecologically sound.

However, these botanical pesticides require proper preparation, timely application, and repeated spraying for effective results. When used scientifically and consistently, they serve as reliable, low-cost tools for eco-friendly pest management in organic farming systems.

Major Indigenous Plant-Based Pesticides Used in Organic Farming

1. Neem seed kernel extract (NSKE)

Neem (*Azadirachta indica*) has long been recognized as one of the most effective botanical pesticides in Indian agriculture. The active compounds present in neem kernels, particularly azadirachtin, act as antifeedants, repellents, and insect growth regulators (Schmutterer, 1990; Mordue & Nisbet, 2000). Instead of killing pests instantly, neem disrupts their feeding and reproductive behavior, gradually reducing pest populations.

NSKE can be prepared by crushing shade-dried neem seed kernels and soaking the powder in water overnight. The extract is filtered, diluted appropriately, and sprayed on crops

during early morning or evening hours. A small quantity of mild soap is often added to improve adhesion on leaf surfaces.

It is effective against aphids, whiteflies, jassids, thrips, caterpillars, and pod borers in crops such as vegetables, pulses, cotton, paddy, and tobacco. Regular application at 10–15 day intervals helps maintain pest levels below economic threshold limits.

2. Garlic-chilli extract

Garlic and chilli are common kitchen ingredients with strong insect-repellent properties. Garlic contains sulfur compounds, while chilli contains capsaicin, both of which irritate and repel insects (Pavela, 2016). Together, they act as a natural contact insecticide and feeding deterrent.

The extract is prepared by grinding garlic cloves and green chillies into a paste, soaking the mixture in water, filtering it, and diluting before spraying. A small amount of soap solution improves its effectiveness.

This formulation is particularly useful against aphids, thrips, mites, caterpillars, and whiteflies in vegetable and fruit crops. Due to its strong odor and pungency, it effectively discourages pest infestation when applied regularly.

3. Buttermilk and asafoetida spray

Fermented buttermilk combined with asafoetida (hing) serves as a mild repellent and antifungal spray. The fermentation process enhances its microbial activity, which can suppress certain fungal pathogens and deter insect pests.

Sour buttermilk is allowed to ferment further, mixed with dissolved asafoetida, diluted with water, and filtered before spraying. This preparation is commonly used against powdery mildew, leaf spots, aphids, and whiteflies.

It is inexpensive, safe, and suitable for use in vegetable crops and orchards, particularly during early stages of pest or disease incidence.

4. Tobacco leaf extract

Tobacco contains nicotine, a naturally occurring alkaloid (Ware & Whitacre, 2004) that acts as a strong contact poison against insects. Though natural, it is potent and must be handled carefully.

The extract is prepared by soaking crushed dried tobacco leaves in water, boiling the mixture briefly, cooling, filtering, and diluting before application. A small amount of mild soap can be added to improve spreading on leaf surfaces.

Tobacco extract is effective against aphids, caterpillars, leaf miners, thrips, and whiteflies in vegetable and ornamental crops. However, it should not be sprayed close to harvest due to its toxicity. Protective handling is essential during preparation and spraying.

When used cautiously and in recommended dilution, it serves as a powerful botanical alternative in organic pest management systems.

5. Cow urine-based extract (gomutra spray)

Cow urine has been traditionally used in natural farming systems as both a plant growth enhancer and pest repellent (NCOF, 2015). When fermented and combined with botanical ingredients such as neem leaves, garlic, or chillies, its effectiveness increases.

Fresh cow urine is stored in a closed container for several days to enhance its potency. Crushed neem leaves or other plant materials may be added and soaked before filtering and dilution. The solution is then sprayed uniformly on crop foliage.

This preparation acts as a repellent, mild insecticide, and antifungal agent. It is commonly used against aphids, whiteflies, thrips, and caterpillars. In addition to pest control, it has been reported to improve plant vigor and resistance.

Its low cost and easy availability make it especially valuable for small and marginal farmers practicing organic agriculture.

6. Papaya leaf extract

Papaya leaves contain bioactive compounds that act as insect repellents and growth regulators. The extract is prepared by crushing fresh leaves, soaking the paste in water, filtering, and diluting before spraying.

Papaya leaf extract is effective against sucking pests such as aphids, mites, and whiteflies, as well as certain leaf-eating caterpillars. It is suitable for vegetables, fruit crops, and ornamental plants.

Being biodegradable and locally available, papaya leaf extract represents a simple yet effective component of indigenous pest management practices.

Table 1: Comparative overview of indigenous botanical pesticides

Botanical extract	Major target pests	Mode of action	Recommended spray interval
Neem (NSKE)	Aphids, whiteflies, caterpillars, jassids	Antifeedant, growth regulator	10-15 days
Garlic-chilli extract	Thrips, mites, aphids	Repellent, contact action	7-10 days
Buttermilk + asafoetida	Powdery mildew, leaf spots	Antifungal, repellent	7-10 days
Tobacco extract	Caterpillars, leaf miners	Contact poison	10-15 days
Cow urine extract	Sucking pests, fungal pathogens	Repellent, mild insecticide	7-10 days
Papaya leaf extract	Aphids, mites, leaf-eating insects	Repellent, growth regulator	7-10 days

Advantages and Practical Considerations

Indigenous plant-based pesticides offer several advantages in organic farming systems. First and foremost, they are cost-effective. Since most of the raw materials such as neem seeds, garlic, chillies, papaya leaves, and cow urine are locally available, farmers can prepare these formulations with minimal expenditure. This significantly reduces the overall cost of crop protection.

Secondly, these botanical preparations are biodegradable and environmentally safe. They decompose rapidly without leaving harmful residues in soil or water. Compared to synthetic chemicals, they pose relatively lower risks to non-target organisms such as pollinators, earthworms, and natural enemies of pests. This makes them highly suitable for organic certification and sustainable agricultural practices.

Another important advantage is reduced risk of pest resistance. Synthetic pesticides often act on a single target site, leading to rapid resistance development. In contrast, plant-based extracts contain multiple bioactive compounds that affect pests in different ways, such as repelling, inhibiting feeding, or interfering with growth and reproduction. This multi-action effect slows down resistance development (Georghiou, 1990; Isman, 2006).

However, practical considerations must be kept in mind. Botanical pesticides generally have a shorter shelf life and should be used soon after preparation. Proper filtration is essential

to prevent clogging of sprayer nozzles. Spraying should be done during early morning or late evening hours for better effectiveness and to avoid leaf burn. Repeated applications at 7–15 day intervals may be necessary depending on pest intensity (FAO, 2018; ICAR, 2018).

Farmers must also understand that these formulations are preventive and suppressive rather than instant killers. Consistent and timely application is the key to achieving satisfactory results.



Fig. 1: Step-by-step preparation cycle of indigenous plant-based pesticides used in organic farming

Conclusion

Indigenous plant-based pesticides represent a valuable blend of traditional wisdom and ecological science. At a time when agriculture faces challenges such as rising input costs, environmental degradation, pesticide resistance, and food safety concerns, these locally prepared botanical formulations offer practical and sustainable solutions.

Reviving and promoting such indigenous practices can empower farmers to reduce dependency on synthetic chemicals while maintaining crop health and productivity. When used scientifically and systematically, plant-based pesticides not only protect crops but also preserve soil health, biodiversity, and environmental balance.

Strengthening awareness, training farmers in proper preparation methods, and integrating these botanical extracts into organic farming systems can contribute significantly to sustainable crop protection and long-term agricultural resilience.

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