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WEEDS: SOURCES OF POTENTIAL BIOPESTICIDE

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ABSTRACT

Biopesticides are termed as naturally or biologically derived substances used to control pests and diseases. For decades the farmers in India have been using chemical pesticides, however overuse of these pesticides have caused enormous harm to the ecosystem, which has led to soil salinity, soil infertility, disturbed soil microflora, etc. This has given rise to the need to introduce biopesticide as an alternative in the Indian farming system. Weeds are the undesirable plants which grow on cultivated land to compete with cultivated plants for nutrients and space. They are proven to possess bioactive compounds that act as a toxin for pests and kill them by acting on their CNS (central nervous system) and gut. There are many pests that attack plants and vegetables, such as aphids, beetles, moths, flies, bees, and termites. There are various weed species that can be used as biopesticides, such as *Lantana camara*, *Ricinus communis*, etc. The use of biopesticides will contribute to sustainable agricultural practices and reduce barren land and reduced soil salinity.

KEYWORDS: Biopesticide, weeds, sustainable agriculture, *Lantana camara*, *Ricinus communis*, eco-friendly.

INTRODUCTION

The review focuses on the biopesticides- importance of them, applications, its sustainable sources, challenges, and future of the Indian agriculture system. India is an agricultural land, known for its traditional agricultural practices. The country's economy relies primarily on agriculture. Due to increasing population, there arises a greater demand for food supply, which forces farmers to use chemically derived products that give faster results in minimal time. On the contrary, the overuse of chemical-based pesticides has caused detrimental effects on the soil, water supplies, foods, animals, and even people.[1] It leads to a decline in soil organic matter content, soil acidification, and soil physical degradation, leading to increased soil erosion and toxification of the physical environment, particularly its water resources.[2] Exposure to chemical pesticides is thought to be linked to numerous health disorders such as Hodgkin's disease (HD), non-Hodgkin lymphoma (NHL), Parkinson’s disease, endocrine disruption, and respiratory and reproductive disorders. Pesticides are also known to cause cancers in humans, e.g., glyphosate – a widely used herbicide, is associated with breast cancer. The pesticides that contain alkyl urea and amines are found to be associated with brain tumors. Dieldrin – an organochlorine insecticide, causes tumors of the lung, liver, lymphoid tissue, uterus, thyroid, and mammary gland in test animals at doses as low as 0.1 ppm. Several pesticides are proven to be endocrine disruptor compounds (EDCs), which were first recognized by the WHO in 2002. These are exogenous substances, natural or synthetic, that interfere with endocrine systems and therefore may cause adverse effects on physiological processes, including growth, development, and reproduction in organisms and/or in their progeny. Transcriptional activity of nuclear receptors is one of the prime targets of EDCs, and several pesticides, including organochlorines, diphenyl ethers, organophosphorus pesticides, pyrethroids, carbamates, acid amides, and urea were found to act as agonists of these nuclear receptors.[3]

Biopesticide

Biopesticides are bio-based formulations derived from natural sources that control pests through different mechanisms. The primary sources of biopesticides are plants, insects, and microorganisms. They are products or by-products derived from sources such as microorganisms (E.g. *Bacillus thuringiensis*, *Verticillium lecanii*, *Neodiprion sertifer*), insects (E.g. *Trichogramma* spp.), animals (E.g. nematodes, *Heterorhabditis* spp.), and plant parts or extracts (E.g. *Chrysanthemum cinerariafolium*, *Azadirachta indica*).[19]

Benefits of Biopesticide

Research has shown that biopesticides are environmentally friendly, exhibit low toxicity, are biodegradable, and specifically target pests with minimal adverse effects on non-target organisms. They may potentially serve as effective and safer alternatives for pest control;

they have lesser environmental impact compared to synthetic pesticides and are highly targeted, which helps avoid bioaccumulation. Made from natural materials such as plants, microorganisms, and biological nanoparticles, biopesticides represent a sustainable approach to managing pests. Their effectiveness stems from various mechanisms of action, including disrupting gut function, influencing pest growth, and altering pest metabolism. Biopesticides function by denaturing proteins, inducing metabolic disorders and paralysis, activating toxicity pathways, performing multisite inhibition, and releasing neuromuscular toxins and bioactive agents. These diverse actions enable biopesticides to change the dynamics of pest resistance more effectively than chemical pesticides. In contrast, traditional pesticides contribute significantly to environmental pollution, promote resistance in pests, and result in high levels of residue on harvested crops along with bioaccumulation in food.[18]

Biopesticide source

Cow urine

Cow urine is very useful in agricultural practices as a biofertilizer and biopesticide. The total nitrogen (N) content of cow urine is quite significant, ranging from 6.8 to 21.6 g/L. Cow urine generally contains 95% water, 2.5% urea, and the remaining 2.5% is a mixture of salts, hormones, enzymes, and minerals like phosphate of urea, muriate of potash, carbonate and potash ammonia, urea, sodium, potassium, manganese, calcium, sulfur, copper, iron, carbolic acid, hippuric acid, creatinine, lactose, enzymes, and aurum hydroxide. The quality and quantity of the contents may vary as per the cow breed and the cattle feed.[5] Cow urine is considered as one of the ingredients traditionally used for plant growth promotion. It is capable of treating many diseases as it has several medicinal properties. Cow urine is shown to control root knot nematodes in tomatoes, melon aphids, and pickle worms in watermelon cultivation. It has excellent antibiotic and antimicrobial activity. It has been investigated that cow urine is very useful in agricultural operations as a biofertilizer and biopesticide, as it can kill a number of pesticide-resistant and herbicide-resistant bacteria, viruses, and fungi.[6] Cow urine alone or in combination with plants is proven to inhibit a number of phytopathogenic bacteria and fungi.[13] Cow urine is a rich source of macro and micronutrients, which possess disinfectant properties, and help improve soil fertility. Therefore, it is an effective tool to address multi-nutrient deficiencies in most of the soils and helps to provide nutrients to plants at low cost. Hence, it should be considered as an alternative source for plant nutrition, metabolic activation, and pest disease control.[7]

A study conducted showed that cow urine leads to enhanced clover (*Trifolium*) yield. It increases the nitrogen and potassium concentration of clover. Various studies have proven cow urine to be an effective pest controller and larvicide agent whether used alone or in combination with other preparations.[8]

A study was conducted to investigate the impact of two foliar sprays of different concentrations of cow urine (2%, 4%, 6%) at 25 and 40 days after sowing on soybean (*Glycine max*). The findings showed that the concentration of 6% was more effective in enhancing the morpho-physiological, chemical, and biochemical yield-contributing parameters when compared with the control. Cow urine application has also been reported to improve the soil texture and structure. A significant amount of liquid cow manure (LCM) application resulted in increased pH and EC (electrical conductivity) values, nutrients, and dissolved organic carbon content of amended soils.

A study conducted on the effect on soil microbial population showed that after regular use of cow urine in the crops, farmers of Vadodara found that the soil microorganism population increased along with the crop yield. They concluded that cow urine worked as growth promoters. There was no occurrence of any insect, pest, or disease. Incorporation of an increasing dose of LCM resulted in increased respiration activity, C-CO_2 (C-CO_2 "stands for carbon dioxide (CO_2) measured in terms of its carbon content (C).[9]

***Lantana camara* (Ghaneri)**

Lantana camara belongs to the family Verbenaceae. It is an invading species which is not native to India and is considered a noxious weed; however, several phytochemical studies have been performed on *L. camara* and major active compounds like alkaloids, phenolics, flavonoids, and saponins, are found to be present. It has been investigated for its insecticidal and larvicidal activity against mosquitoes like *Aedes aegypti* and *Culex, Musa domestica*, *Artemia salina*, and *Reticulitermes*.

The weed has also shown fumigant effect on Sitophilus spp.(beetles) and *Tribolium* (flour beetles), repellent effect on *Reticulitermes flavipes* (subterranean termite) and antifeedant activity on common vegetable insects *Lepidopteran*, i.e., *Spodoptera litura* (tobacco cutworm or cotton leafworm) and *Crocidolomia pavonana* (moth of the family Crambidae). *Helicoverpa armigera* (Cotton bollworm) *and Plutella xylostela* (Diamondback moth).

Effect of *L. camara* extract was studies on *Crocidolomia pavonana*, commonly known as the cabbage cluster caterpillar. Due to the overuse of synthetic chemical pesticides, this pest has developed resistance and is one of the major pests affecting the Indonesian cabbage. Ethanolic leaf extract of *L. camara* showed antifeedant activity on the larvae. It was also observed that the active ingredient was exposed to the larvae via the oral route. The objective of the research was to investigate the chemical compounds present in the ethanolic extract of *L. camara* leaves and the insecticidal properties with powder application for a preliminary study of *L. camara* as eco-friendly biopesticides that are expected to control *C. pavonana* larvae.[10] However, further development needs to be complemented with an investigation of its chemical and physical characteristics that are important for enhancing bioactivity as well as being an indirect toxicant, such as an antifeedant, as well as insecticidal larvae of *C. pavonana*. It is one of the promising biopesticides in controlling Lepidopteran in cabbage as well. A number of biological control efforts and biopesticide applications have been investigated on *C. pavonana*, but the use of *L. camara's* extract to control *C. pavonana* would open new avenues to enhance the utilization of this notorious weed that is still underused. Thus, eco-friendly biopesticides from natural plant metabolic products can be an alternative for controlling insects.[11]

In a study conducted for *L. camara* solvent extraction, the methanol fraction of *L. camara* leaves has been reported to have significantly higher mortality and repellent activity against *Sitophilus zeamais* (Maize weevil) followed by ethanol and ethyl acetate extracts. 5% chloroform extracts of *L. camara* leaves have shown interesting termiticidal activity against the workers of *Microcerotermes beesoni* (termite).[11] Ethanol extracts are also reported to cause developmental defects (IGR activity) against the fourth instar larvae of *Helicoverpa armigera* (cotton bollworm) one of the polyphagous insects on field crops.[11]

Mechanism of Action

Lantana contains a variety of phytochemicals such as terpenoids, flavonoids, alkaloids, and phenolic compounds, which all demonstrate strong insecticidal effects. These substances disrupt cellular respiration, create oxidative stress, damage mitochondria and initiate apoptosis at molecular level, leading to insect death. Additionally, Lantana's antifeedant properties interfere with insect gustatory receptor altering neurohormonal signaling and modulating neurotransmitter synthesis, drastically reducing feeding behavior, as fumigant Lantana's essential oils target the nervous system by inhibiting acetylcholinesterase (AChE), blocking nerve impulse transmission and causing neurotoxicity, paralysis and death. With its multifaceted modes of action like oxidative stress, neurotoxicity and feeding inhibition, Lantana offers a potential solution as a natural insecticide for eco-friendly pest management.

Pigeon pea (*Cajanus cajan (L.) Millsp*.) is a valuable multipurpose legume in tropical and subtropical regions. Its seeds are highly nutritious, containing protein levels that range from 21% to more than 25%, making it a crucial source for enhancing food security and nutrition for numerous low-income families who are unable to afford diets based on dairy and meat[12]

A combination of *L. camara* and cow urine were studies on different insect species, and a significant mortality rate was observed. Following is the table showing the mortality.

Table 1: Efficacy of *L. camara* and cow urine on plant insects.[12]

Insect	Material	Concentration	Mortality
Tur pod bug (*Clavigralla gibbosa Spinola*)	*L. camara* + cow urine	5% (w/v)	4.11 bugs per 5 plants
Gram pod borer (*Helicoverpa armigera Hub)*	Lantana + Cow urine	5% (w/v)	3.19 larvae per 5 plants
Green stink bug (*Nezara viridula Linn)*	Lantana + Cow urine	5% (w/v)	8.0 bugs per 5 plants
Tur plume moth (*Exelastis atomosa Wals)*	Lantana + Cow urine	5% (w/v)	2.07 plume moth larvae + pupae per 5 plants

***Ricinus communis* (castor oil plant)**

Ricinus communis is a type of perennial plant that belongs to the spurge family, Euphorbiaceae. It possesses insecticidal activity against *Callosobruchus* (pulse bettle) *Coleoptera Bruchidae* (bean weevil), *Cosmopolites sordidus* (banana weevil), *Coleoptera* (snout bettles), *Culex* (Common house mosquito), *Aedes caspius* (Caspian floodwater mosquito), *Culiseta longiareolata* (Culiseta), and *Anopheles maculipennis* (European maleria mosquito).

Aerial parts of *R.Communis* plant have been found to contain ricinine, N-demethyl ricinine, and six flavonoids: glycosides. kaempferol-3-D-xylopyranoside, kaempferol-3-D-glucopyranoside quercetin-3---D-xylopyranoside, quercetin-3---D-glucopyranoside, gentisic acid, and rutin. Also, it was found that the seeds contain castor oil, ricin, and the protein allergens Ric c1 and Ric c3.

A study was conducted comparing the extracts of seeds and leaves of the plant and tested along with castor oil and ricinine against *S. frugiperda* (Fall armyworm) also known as fall armyworm. Extracts of both the parts were made in methanol, hexane and ethyl acetate. It was found that the seed extracts showed significant insecticidal than the leaf extracts. The active ingredients of *R. communis*, castor oil and ricinine are effective against *S. frugiperda*, with each seed extracts exhibited better insecticidal and insectistatic activity compared to the leaf extracts. This supports the conclusion that insectistatic activity is the primary mechanism by which *R. communis* influences *S. frugiperda*.[13]

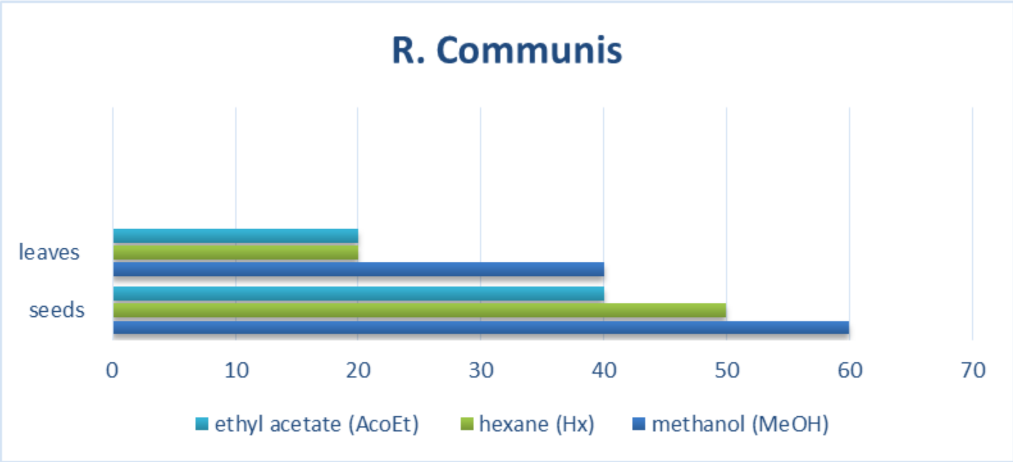

Fig.2: Activity of *R. communis* on plant leaves and seeds.[14]

Pulses are prone to heavy losses during storage, particularly in tropical countries, by the pulse beetle, *Callosobruchus chinensis L.* (Coleoptera, Bruchidae). In a study focussed on *C. chinensis*, the findings indicate that both aqueous and methanolic extracts from *R. communis* leaves exhibit significant insecticidal properties. These extracts contain flavonoids and demonstrate impressive ovicidal and oviposition deterrent effects against *C. chinensis.* A partial characterization using four different analytical methods revealed quercetin as the predominant flavonoid in the extract. Since *R. communis* is the cultivated species, it may serve as a viable source of biopesticide for economical and environmentally sustainable pest management approaches against *C. chinensis* during pulse storage.[14]

***Calotropis gigantea* (Giant Indian milkweed)**

C. gigantea is an invasive species found in Southeast Asia, the Pacific Islands, Australia, South America, and Africa. The leaf extract of *C. gigantea* contains various compounds, including alkaloids, steroids, flavonoids, tannins, and phenols. The leaves of *C. gigantea* exhibit insecticidal properties and have been shown to effectively control *Plutella xylostella* (Diamondback moth) in cabbage and *Tribolium castaneum* (Red flour beetle) In a study on *S. frugiperda* (Fall armyworm), various concentrations of *C. gigantea* were utilized. Each concentration of the leaf extract demonstrated significantly different abilities in antifeedant activity, and as time progressed after application, all concentrations tended to show an increase in the antifeedant index. Among the different extracts, *C. gigantea* leaf extract exhibited the highest antifeedant activity against *S. frugiperda.*

In phytotoxicity assessment targeting maize, the absence of adverse effects from the leaf extracts of *V. negundo* (Chinese chastetree), *A. conyzoides* (whiteweed), *and C. gigantea* suggests that these three plants are excellent candidates for use as botanical insecticides. It was found that the leaf extracts of *V. negundo, C. gigantea, and A. conyzoides* were effective antifeedants against *S. frugiperda*, with *C. gigantea* leaf extract demonstrating the greatest antifeedant activity. Furthermore, none of the three leaf extracts caused any phytotoxic effect on maize and continued similar composition of active compounds, including tannins, alkaloids, phenols, flavonoids, saponins, and terpenoids. Consequently, the extracts from *V. negundo*, *C. gigantea*, and *A. conyzoides* show promise as botanical insecticides against *S. frugiperda.*[15]

Table 2: Compound Composition of Leaf Extracts of *Calotropis gigantea*, *Ageratum conyzoides* and *Vitex negundo.*[15]

Composition	Value % (w/w)		
	C. gigantea	***A. conyzoides***	***V. negundo***
Alkaloid	0.11	0.13	517.36
Tanin	6.06	7.42	16.48
Phenol	2.43	3.21	10.75
Flavonoid	0.53	1.19	2.26
Saponin	0.64	0.60	1.60
Terpenoid	Positive	Positive	Positive

***Ageratum conyzoides* (Billygoat weed)**

A.conyzoides L. (Asteraceae) is native to South America and has now spread across various tropical regions, including areas where it is considered as an invasive weed. In Africa, *A. conyzoides* is commonly used as a multi-purpose plant and is effective in pest management. It contains flavonoids, which are believed to serve as a source of botanical pesticide and exhibit antifungal and anti-insect properties. The extract from *A. conyzoides* has been shown to inhibit egg laying, repel adult insects and promote ovicidal longevity in *Paraeucosmetus pallicornis* (black ladybug). Also, it is capable of generating repellent effects and inhibits feeding in *Tribolium castaneum* (Red flour beetle) and *Sitophilus oryzae* (Rice weevil).[15] *A. conyzoides Linn* contains alkaloid compounds with chemical structures in the form of lycopsamine and echinatin, which have been developed as natural pesticides. Both of these compounds are toxic against Lepidoptera (butterflies and moths) insects and *Aedes aegypti* (mosquito larvae) and are able to eradicate pests in mahogany shoots. *A. conyzoides* plant possess a variety of secondary metabolites including saponins, polyphenols, coumarins, eugenols, essential oils. Research on the leaf demonstrated that at a concentration of 0.5%, it was able to cause mortality in over 90% of *Spodoptera* (Tobacco cutworm) caterpillars. A study conducted indicated that essential oils derived from *A. conyzoides L*. can be effective against *Tribolium castaneum.* A study showed that application of *A. conyzoides* extract at 12% concentration produced the best result in inducing *S. litura* (Tobacco cutworm) 95% mortality. Methanol extract of *A. conyzoides* was also studied on *S. litura* larvae. The LC_{50} value was found to be 3.61% and LC_{80} value was found to be 7.91% which led to mortality of *S. litura* larvae.[17]

Current Status

The concept of using biocontrol for plant diseases has been in practice in India for a long time. The neem tree (*Azadirachta indica A. Juss*) and its products, including leaf extracts, oils, and seed cake, have been utilized as fertilizers to reduce the risk of post-harvest losses in stored cereals. In the 1960s, with the aim of promoting the careful use of pesticides in agriculture, the concept of Integrated Pest Management (IPM) emerged. However, India experienced a significant technological advancement in biocontrol when traditional insecticides were ineffective against pests like *Helicoverpa armigera* (Cotton bollworm) and *Spodoptera litura* (Tobacco cutworm) in cotton crops. Additionally, farmers are increasingly becoming aware of the benefits of biopesticides, making them a favored alternative to chemical and synthetic pesticides. Biopesticides are approved and regulated under the Insecticides Act of 1968.

In India, the yearly growth rate of biopesticides is projected to be 2.5%. The output of biopesticides in India remains quite minimal because of difficulties at both the policy and industrial levels. The usage of plant-based biopesticides in India is less than 1%, whereas on a global scale, it makes up only 12%. To promote sustainable agriculture, the National Farmer Policy 2007 encourages the use of biopesticides. Currently, only twelve varieties of biopesticides have been registered under the Insecticide Act of 1968 in India, indicating a range of biopesticides produced by various industries. The trend in India for biopesticide usage has demonstrated significant growth over the years, with consumption recorded at 8847 metric tons in 2019-20 and 8645 metric tons in 2020-21. Recently, there has been a notable rise in biopesticide utilization, alongside a rapid increase in the area cultivated with these products. In the fiscal year 2020-21, West Bengal, Rajasthan, and Maharashtra emerged as the top users of biopesticides. This data reflects the consumption of biopesticide formulations across various Indian states from 2014-15 to 2020-21 and highlights the cultivation area, as well as the use of both chemical and biopesticides during the same period. The swift expansion of the biopesticide market can be attributed to several benefits, including lower toxicity, reduced environmental impact, specificity to particular pests, biodegradability, decreased exposure to non-target organisms, and effectiveness in minimal quantities, all while being safe for humans.[19]

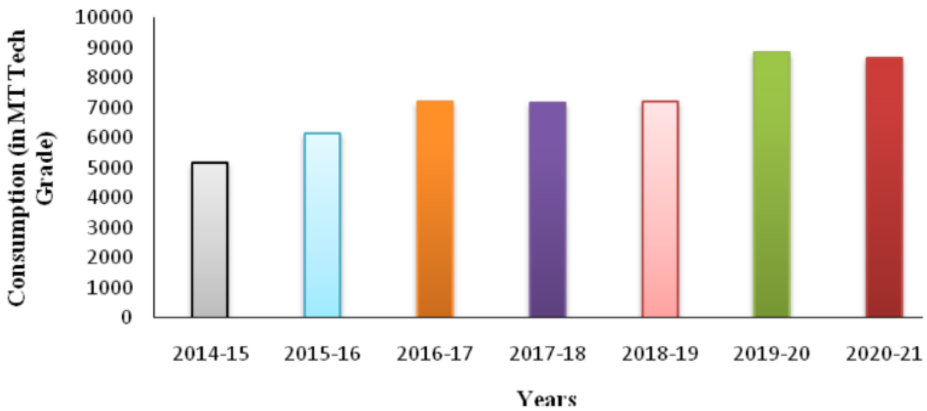

Fig.3: Consumption of biopesticides in India during the last seven years (Source: Data obtained from DPPQS, Ministry of agriculture & Farmers welfare, Government of India).[19]

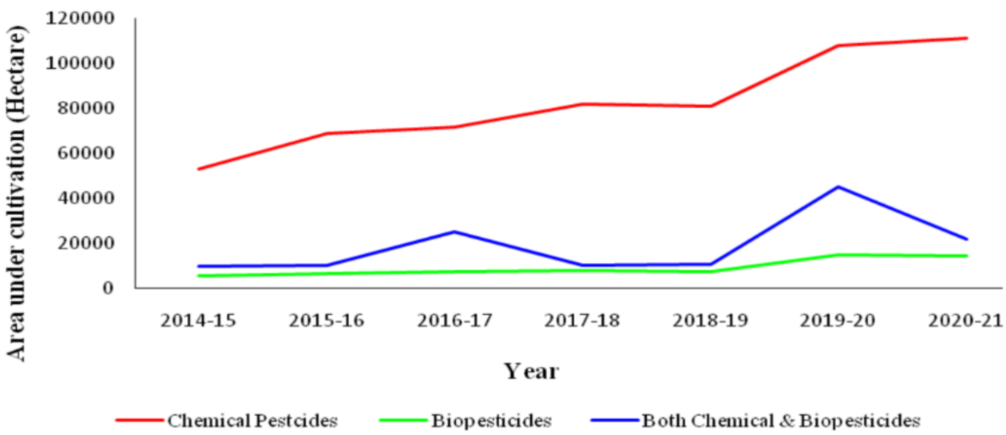

Fig.4: Area under cultivation and use of chemicals & biopesticides during 2014-15 to 2020-21 (Source: Data obtained from DPPQS, Ministry of agriculture & Farmers welfare, Government of India).[19]

Challenges for Biopesticides

Biopesticides are considered safe because they are target-oriented, reduce environmental pollution risk, and eliminate resistance. Biopesticides are becoming increasingly favored because of the demand for food that is safe and free from residues. Despite all these beneficial attributes, in India the biopesticides market is small. The biopesticides market is affected by the decline of large-scale production facilities. In India, the process of registration is lengthy and costly, which hinders the progress of biopesticides. However, the lack of awareness about biopesticides benefits, knowledge about biopesticide products, confidence in farmers, and unreliable supply and inconsistent performance are major challenges in the development of biopesticides. Ecological studies are necessary on the dynamics of diseases in insect populations because environmental factors play a vital role in the outbreaks of the disease to control the pests.[19]

DISCUSSION

The utilization of weeds as biopesticides is a less explored area of research. Until now, many study groups have carried out extraction of *Lantana camara* and *Ricinus communis* by solvent, a less explored extraction method using cow urine. But as we know, the use of solvents in agricultural applications is harmful and lethal for the human population as well as for the entire ecosystem, soil, and water. Cow urine can be a potential alternative, and it has pesticidal and insecticidal properties. It has shown high potency when used as a single ingredient as well as in combination with plants. It is included in "Panchagavya," i.e., 5 products obtained from cows that have immense importance and application in day-to-day life. The application of weeds as biopesticides is emerging as many farmers are trying to get rid of these weed plants, but on the contrary, they have excellent pesticidal/insecticidal properties for agricultural land/crop pests. *Lantana camara* is a notorious weed, but it has broad-spectrum activity in the agriculture sector. The *L. camara* extract has many metabolites that have various biological properties. The ideal concentration of extract used was 5%; good results were obtained at low concentration, and a cidal effect was observed on almost all pests/insects. The ideal extract solvent for *L. camara* is cow urine and methanol. *Ricinus communis*, also known as the castor oil plant, possesses ricinine as an active compound present in the seed, which has insecticidal/insectistatic properties for many pests/insects. The most common extracting solvent used for *R. communis* is methanol and cow urine. In the stated studies conducted, the *R. communis* leaf extract in methanol has good insectistatic activity, whereas the seed extract in methanol, which possesses ricinine and castor oil as active compounds, has insecticidal and insectistatic activity.

CONCLUSION

The need for sustainable agriculture methods or products is the need of today's era. Biopesticide can be a potential and environmentally friendly alternative to the already existing synthetic agricultural products. There have been many studies on traditional sources like neem and turmeric, but weeds are still unexplored territory. Farmers get rid of these weeds from their land by spraying chemical herbicide or weedicides. Rather than wasting its potential, creative exploration of the weeds can be done where their properties can be used as biopesticides. The cow urine was explored many years ago, but the findings are ongoing as to whether it can be a suitable or ideal extracting material for weeds. To date, chemical solvents have been used as extracting solvents for weeds, but fewer studies are carried out for cow urine. The main objective is to get remarkable results when using cow urine as extracting material and also to develop a sustainable, eco-friendly, and potent agriculture solution.

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REFERENCES

1. Vidhya Devi and Dr. V. Judia Harriet Sumathy. Production of biofertilizer from fruit wastes.
2. M. Mustapha, J. J. Alasa, A. U. Bashir and B. Mohammed. Study on the use of banana and pineapple peel waste as biofertilizers: enhancing soil fertility, promoting sustainable agriculture and environmental sanitation.
3. Akash Sabarwal, Kunal Kumar, Rana P. Singh. Hazardous effects of chemical pesticides on human health–Cancer and other associated disorders.
4. Tijjani, A., Bashir, K. A., Mohammed, I., Muhammad, A., Gambo, A. and Musa, H. Biopesticides for pests control.
5. R. T. Gahukar cow urine: a potential biopesticide.

6. Savita Jandaik, Preeti Thakur, Vikas Kumar. Efficacy of Cow Urine as Plant Growth Enhancer and Antifungal Agent.
7. Bakang Kedumetse Kgasudi* and Modiri Mantswe. Cow Urine: A Plant Growth Enhancer, Bio Fertilizer, Pesticide and Antifungal Agent.
8. Satyapal Singh. Biochemical appraisal of Gomutra (Cow urine).
9. Swati Swayamprabha Pradhan, Sudhanshu Verma, Sneha Kumari and Yashwant Singh. Bio-efficacy of cow urine on crop production: A review.
10. Melanie, Wawan hermawan, Hikmat kasmara, Camellia Panatarani. Physicochemical characterization and insecticidal properties of Lantana camara leaf ethanolic extract with powder application.
11. Randeep Kumar, Niraj Guleria, Mudagadde G. Deeksha, Nisha Kumari, Ravendra Kumar, Arun Kumar Jha, Neha Parmar, Pritam Ganguly, Eloisa Helena de Aguiar Andrade, Oberdan Oliveira Ferreira Mozaniel Santana de Oliveira, and Chandini. From an Invasive Weed to an Insecticidal Agent: Exploring the Potential of Lantana camara in Insect Management Strategies—A Review.
12. Ajay Kumar Bijewar, Varsha Chouragade and SB Das. Field efficacy of plant leaf extracts, cow urine and in combination against pod borer complex in Pigeonpea (Cajanus cajan (L) Millsp.).
13. M. A. Ramos-López, S. Pérez G., C. Rodríguez-Hernández, P. Guevara-Fefer, M.A. Zavala-Sánchez. Activity of Ricinus communis (Euphorbiaceae) against Spodoptera frugiperda (Lepidoptera: Noctuidae).
14. Shripad M Upasani, Hemlata M Kotkar, Prashant S Mendki and Vijay L Maheshwari. Partial characterization and insecticidal properties of Ricinus communis L foliage flavonoids.
15. J. E. Smith (Lepidoptera: Noctuidae) Burhanuddin Haji Nasir, Nur Khasanah, Idham. Insecticidal Activity of Leaf Extracts of Calotropis gigantea L, Ageratum conyzoides L, and Vitex negundo L. Against Spodoptera frugiperda.
16. G. Erida, C.N. Ichsan, Syamsuddin, T. Kurniawan, Iqra H. Khan and A. Javaid. Potential of secondary metabolites of Ageratum conyzoides L. in weed management: A review.
17. Yuliani, Yuni Sri Rahayu. The Potency of Ageratum conyzoides as Biopesticide.
18. Modupe S Ayilara, Bartholomew S Adeleke, Saheed A Akinola, Chris A Fayose, Uswat T Adeyemi, Lanre A Gbadegesin, Richard K Omole, Remilekun M Johnson, Qudus O Uthman, Olubukola O Babalola. Biopesticides as a promising alternative to synthetic pesticides: A case for microbial pesticides, Phyto pesticides, and nano biopesticides.

19. Rajni Yadav, Siril Singh1, Anand Narian Singh. Biopesticides: Current status and future prospects.