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Phytosources in Sustainable Agricultural Environment: A Review

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ABSTRACT

Plants their product and by-products are the good remedy of worst agricultural environment. The need of the day is to sustain food production which will mention the cycle of input-output and ecosystem balance. Thousands of plant species reported to have pest management properties. Only 10% of which have been examined chemically. The secondary metabolites present in the plants, protect the plants from pests and pathogens. Despite, the most exploited pesticidal promising plant and their by-product is neem in which bioactive components "azadirachtin" is found. The alternatives of synthetic fertilizers viz. green manure, crop/plant residues, industrial wastes proved in sustaining soil fertility and productivity at greater extent. Identification and use of indicator plants for waste lands are very helpful for their optimum use and their gradual transformation into productive soil.

Keywords: Agricultural, Environment, Botanicals, Sustainable

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INTRODUCTION

Agriculture is the backbone of India's economy. Agriculture sector in India holds over 65 % of employment, but only makes up about 18% of the nation's GDP (Bais and Bahadur, 2023). There is urgent need to develop farming techniques which are sustainable from environmental, production and socioeconomic point of view. The means to guarantee sufficient food production in the next decade and beyond is critical because modern agriculture production throughout the world does not appear to be sustainable in the long term. The agricultural community is thus setting it hopes on sustainable agriculture, which will mention the cycle of input-output and ecosystem balance. Last few decades excessive chemicalisation of agriculture have led to poor sustainability of farm production. Besides several ill effects i.e. development of resistance in pests, toxicity to non-target organisms (pollinators, predators, parasitoids etc.), polluting soil, water, air and health hazards are the major concern. The toxicants we use remains in environment (viz. soil, water, and plant harvested produce etc.) after application. Only 1% of the pesticides applied to crop reach the target and remaining 99% contaminate soil, water, air, food, forage etc. When surveyed in India 20% of market samples of food commodities were having residues above legal MRL (Minimum Residual Limit). Around 37% of milk samples contaminated with DDT above MRL (0.05 mg/kg). Due to persistent nature of pesticides tritrophic relationship of agri-environment is badly disrupted. Role of plants in soil fertility, composition and productivity is another important aspect to sustaining the agro-environment. The main aim is to improve production system which favour maximum use of organic materials. Green manure, crop by-product, wastes are best alternatives of chemical resources. They have active role in water holding, ion exchange, weed control, reducing soil erosion and uniform distribution of nutrients.

Importance of Herbs in Pest Management

The growing awareness on toxicological and environmental problems involved in excessive use of synthetic pesticides invited attention towards safer methods of pest control. Investigation on such lines once again turned the attention to the plant products which possess compounds that can be considered as weapons to protect plants against pests. Intensive research during the last three decades identified several plants which are most promising source of compounds. As many as 2121 plant species are reported to possess pest management properties, 1005 species exhibiting insecticidal properties, 384 with antifeedant properties 297 with repellent, 27 with attractant and 31 with good inhibiting properties have been identified (Purohit and Vyas, 2004). Plant extract & their formulations are considered safe to environment and to consumer, firstly because they are biodegradable and secondly because they do not leave any toxic residue on the harvested produce unlike synthetic pesticides. In India last two decades more emphasis has been given on neem as a pesticide to overcome pest problems and other ill effects of the environment. Kumar et al. (2006) observed a significant reduction in population of whitefly as well as MYMV (Mung bean Yellow Mosaic Virus) when compared with untreated check (control). Although, Dimethoate (0.03%) showed most effective but the

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effectiveness of neem-based formulation was comparable. The efficacy neem products against linseed budfly also indicates similar trend. Phosphamidon (0.05%) reduced maximum bud infestation followed by neem products. All the treatments were found significantly superior over control in all respects (Ali et al., 2002). It is said that all parts of neem tree are biologically active, though the maximum activity is in the seed kernels. Neem is rich in terpenoid. Azadirachtin a tetranortriterpenoid isolated from neem seed kernels is most effective (Butterworth and Morgan, 1968). Several isomers of azadirachtin (A-H) occur in neem seed, out of which azadirachtin A constitutes the bulk (Ley et al., 1993). Neem trees found in India contain 3.5-3.9% azadirachtin. Neem has been evaluated against more than 100 species including important pests of agriculture (Singh and Kataria, 1991). The evaluation revealed that it has varied effects on pests. These effects include repellency, deterrency against feeding and oviposition, pest growth regulatory, physiological, sterilant, ovicidal activity, besides systemic action.

Botanical products have been claimed to be effective in managing insect-pests in several crops because they possess repellent, knock-down and antifeedant properties that are less hazardous, biodegradable and promote biodiversity of insect-pests. The plant derived bioactive compounds are though to be important factor in recent plant protection efforts. A study conducted by Singh et al. (2021) to know the efficacy of botanical insecticides against major sucking pests of brinjal. The study revealed that neem oil 5%,3%, NSKES 5% were superior in reducing whitefly, jassids and aphid population remained at par to synthetic insecticides. Although other treatments viz. neem leaf extract and Aak leaf extracts were comparatively lower efficacy but was significantly superior to untreated check. Singh et al. (2021) observed NSKE 5% and Neem oil 5% showed less effective than synthetic insecticides against fruitfly (B. cucurbitae) in cucurbits in reducing fruit infestation and fruit yield but was significantly superior over untreated check. These botanicals were also recorded as profitable treatments when economics of pest control was calculated. In an investigated by Morya and Kumar (2022) and they reported Neem oil + Bt are the biological insecticides(biorationals) hence it would be the best choice before imidacloprid and cartap hydrochloride for the ecofriendly management of major insect-pests of rice. The efficacy of botanicals particularly neem oil 3% and neem gold 0.15% studied by Saini et al. (2023) revealed least effective against whitefly and jessids in okra in comparison to synthetic insecticides but was significantly superior to untreated check. The efficacy of botanicals viz. neem oil 3% and nimbicidine 2% revealed good control of mustard aphid (L. erysimi) as they reduced the population of aphid up to 70% and 59.63 %, respectively in neem oil 3% and nimbecidine 2% (Mishra et al., 2023). Singh et al. (2024) reported neem gold 2% and neem oil 3% reduced the population of whitefly in mungbean up to 13 days simultaneously reduced the incidence of mungbean yellow vein mosaic virus. In an investigation Vishwakarma et al. (2025) revealed all the insecticides including neem-based botanicals was significantly effective in reducing attack of fall army worm (Spodoptera frugiperda). These particular botanicals restrict the leaf damage (20.61%) and plant damage (3.93%) was found comparable with application of Fipronil and lambda cyhalothrin.

An effort was made to manage one of the most dreaded insect-pests i.e. Helicoverpa armigera in chick pea through botanical sources with standard check (Spinetorum 11.7% @0.25 ml/lit. of water). The result revealed that Spinetorum and neem oil 5% was most promising against H. armigera. Rest of the botanicals viz. neem leaf extract, eucalyptus oil, lemon grass leaf extract and china berry seed extract showed significant effect over control in all respects viz. larval population, pod damage (%) and yield (Singh et al., 2025).

Only 10% of the known bioactive plants have been examined chemically indicating that there is enormous scope for further work (Benner, 1993). Plants are known to produce a diverse range of secondary metabolites such as terpenoids, alkaloids, polyacetylenes, flavonoids, unusual amino acids, sugars etc. many of these chemicals protect the plants from pests and pathogens. These botanical pesticides appear to have a prominent role for the development of future bio-pesticides for a safe, clean and green environment. Some of the pesticidally promising plants along with their bioactive component and type of effects produced in target pests are listed in Table 1.

Table 1: List of plants used as bio-pesticides.

Common name	Botanical name	Family	Biologically active compound	Effective range	Plant part used
Annona	Annona reticulata	Annonaceae	Annonacin, Annonelliptine	Insecticidal, larvicidal, Repellent, antifeedant	Seed
Derris	Derris elleptica	Leguminosae	-	Insecticidal, Repellent	Roots

Common name	Botanical name	Family	Biologically active compound	Effective range	Plant part used
Garlic	Allium sativum	Alliaceae	Diallyl sulphide &diallyl trisulfide	Insecticidal, Repellent, fungicidal, Nematicidal Antifeedant etc.	Cloves
Mammey	Mammea americana	Guttiferaceae	-	Insecticidal, Repellent, Nematocidal	Seed
Dharek	Melia azedarach	Meliaceae	Tetranortriterpenoids	Insecticidal, Repellent, Antifeedant & Growth inhibiting	Leaves
Pyrethrum	Chrysanthemum cinerariifolium	Asteraceae	Polyacetylenic sulfide	Insecticidal Repellent, Antifeedant	Flowers
Quassia	Quassia amera	Simarubaceae	-	Insecticidal, larvicidal, Nematocidal	Roots
Ryania	Ryania speciosa	Flacourtiaceae	Rynodine	Contact & Stomach poison	Roots & Leaves
Sabadilla	Schoennocoulon officinale	Liliaceae	-	Contact & Stomach poison, Insecticidal	Seed
Sweet flag	Acorus calamus	Araceae	Trans-asarone	Insecticidal Repellent, Antifeedant	Dried rhizome
Turmeric	Curcuma domestica	Zingiberaceae	Curcumin	Insecticidal Repellent,	Root
Andean lupin	Lupinus mutabilis	Leguminosae	-	Antifeedant Nematocidal, Fungicidal	Seeds
Basil	Ocimum basilicum	Lamiaceae	Juvacimene I, II	Insecticidal Repellent, Growth inhibiting against ticks	Leaves, ripe seed, Oil
Phsic nut	Jatropha curcas	Euphorbiaceae	-	Molluscicide, rodenticide	Leaves, Seeds
Malabar Nut	Adhatoda vasica	Acanthaceae	-	Insecticidal Fungicidal	Leaves
Oleander	Nerium oleander	Apocynaceae	Neridin, Cordiotonic	Rat poison, grain proctant	Leaves
Mungwort	Artemisia vulgaris	Asteraceae	Capillin, Capillarin	Bactericidal, fungicidal	Leaves
Sweet pigweed	Chenopodium ambrosioides	Chenopodiaceae	-	Grain proctant	Oil
Karanj	Pongammia pinnata	Legiminosae	Karanjiin	Insecticidal	Seed Oil
Wild sage	Lantana camara	Verbenaceae	-	Insecticidal properties	Leaves

Source: Purohit & Vyas (2004)

Most of these promising herbs and Neem in particular do not have adverse effect on nontargets as they do not affect the emergence of egg parasitoids, activity of predators and pollinators, stopped the production of aflatoxin by fungi, nontoxic to insectivorous fishes and no teratogenic and carcinogenic effects on man.

Importance of Herbs in Soil Fertility and Productivity Management

Another important thing is sustaining agro-environment is maintaining soil productivity by using natural resources viz. plants, their produce or by-products. These are the better substitutes in order to avoid the deleterious effects of synthetic chemical fertilizers. The aim is to improve production system which favour maximum use of organic materials viz. green manure, crop residues, organic industrial wastes etc. for sustaining soil fertility and productivity. Such alternatives enhance humus proportion in soil gives uniform distribution of nutrients. They also offer essential advantages with respect to water retention, ion exchange, weed control, reducing soil erosion and leaching of nutrients. The nutritional potential of the plants or their wastes are presenting in Table 2.

Table 2: Average nutrient content of plants or their wastes.

Crops/plants	Nutrient Contents % on dry bases		
Residues:	N	P	K
(A) Green manure crop			
Sasbania	3.3	0.7	1.3
Crolaria juncea	2.6	0.6	2.0
Perpuria spp.	2.4	0.3	0.8
Phaseolus spp.	2.2	0.5	0.5
(B) Green leaf manuring crops			
Pangamia spp.	3.3	0.4	2.3
Neem spp.	2.8	0.3	0.4
Cassia spp.	1.6	0.2	1.2
(C) Farm residues			
F.Y.M.	0.8	0.4	0.7
Water hyacianth compost	2.0	1.0	2.3
Sugarcane trash	2.7	1.8	1.3

Source: Bala Subramaniyam and Palaniappan (2011)

Besides, edible and non-edible oil cakes can be used as manure especially horticultural crops. A considerable amount of nitrogen, phosphorus, and potassium present in cakes of cotton, karanj, mahua, safflower, groundnut, mustard seed etc. Nutrient present in oil cakes after mineralization are made available to crops 12 to15 days after application. The superiority of these plants, their produce, wastes or by-products over chemical fertilizers can be explained in terms of their efficacy (90%), cost of production (low), accessibility (small and marginal farmers), long term effects and environmentally friendly.

Waste lands are another example of poor agro-environment. In India total waste land is about 25 mha, in which sodic soil alone shared one third of the total (8.0 mha). These conditions are totally nonproductive and impending doom for future. The knowledge of indicator plants and their use for such adverse conditions are very helpful for optimum use of such land resources.

Several species of plants viz. Siris (Albizia lebbeck), Neem (Azdirachta indica). Ber (Zizyphus jujuba), Arjun (Termanalia arjuna), Sisso (Dalbergia sisso), Babul (Acacia nilotica), Eucalyptus (Eucalyptus tereticornis), Aonla (Phyllanthus emblica), Dhank (Butea monosperma), Capparis (Capparis decidua) are showed tolerant to saline-alkaline soil. Planting such tolerant plants helps in gradual transformation in to productive soil, to generate income for livelihood, increased in dimensions of biotic interaction and helps in creating stable agricultural environment.

CONCLUSION

Agricultural environment is badly disrupted due to the excessive chemicalisation. The challenge now a day is to maintain sustainability of food production in the long term without impairing agro environment. Plants, their products and by-products are able to do so. In nature, thousands of plant species having pest management properties. Plant extracts and their formulations are considered biodegradable and safe to environment and consumer. Other phytoproducts i.e. cakes are equally effective in managing pest population. Green manures, crop residues, industrial wastes are the better substitutes of synthetic chemical fertilizers. These crop/Plant residues help in sustaining soil fertility and productivity. Waste land is another cause as it is totally non-productive. Identification and use of indicator plants on such waste land can be gradually transformed into productive soil helps in creating stable agricultural environment.

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