



INDIGENOUS TECHNICAL KNOWLEDGE (ITK) FOR BIOTIC STRESS MANAGEMENT



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Indigenous Technical Knowledge (ITK) for Biotic Stress Management

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FOREWORD

Indigenous Technical Knowledge (ITK) which are being followed in Indian Agriculture have emerged from grassroot level innovations. They have enormous potential and the majority of them have their own distinct traditional knowledge and technological foundation. Many of these skills and technologies are on par with the systems of skills and knowledge used today, and they have helped the agrarian community live comfortably and independently. The entire socio-economic growth of the communities has benefited greatly from these ancient knowledge and skills. It has been noted that there is a dire need to compile and document the Indigenous Technical Knowledge (ITK), being practiced in Indian agriculture especially in biotic stress management, as many of which are on the verge of extinction. The ITKs for biotic stress management are environmental-friendly and ecologically compatible. Fine-tuned ITKs can be used as integral part of the Integrated Pest Management of biotic stress of crops.


(P. K. Ghosh)

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—: संदेश :—

मुझे यह जानकर हार्दिक प्रसन्नता हुई कि छत्तीसगढ़ राज्य स्थित भारतीय कृषि अनुसंधान परिषद् का एकमात्र संस्थान राष्ट्रीय जैविक स्ट्रैस प्रबंधन संस्थान बरौण्डा, रायपुर द्वारा "स्वदेशी तकनीकी ज्ञान" नामक बहुउपयोगी पुस्तक का प्रकाशन किया जा रहा है।

संस्थान के प्रबुद्ध वैज्ञानिकों ने पुस्तक में कृषि संरक्षण के महत्व किसानों, वैज्ञानिकों एवं विद्यार्थियों की आवश्यकता से जुड़े विषयों को प्राथमिकता दी है। मुझे पूर्ण विश्वास है कि इस संकलन से किसानों का ज्ञानवर्धन होगा और अनुसंधानकर्ता एवं विद्यार्थी भी लाभान्वित होंगे।

भारतीय कृषि अनुसंधान परिषद् द्वारा आलेखित पुस्तक के सफलतापूर्वक प्रकाशन के लिए मेरी हार्दिक शुभकामनाएं।


(सुश्री अनुसुईया उइके)

Preface

Since time immemorial, people with their own cultural experiences and religious beliefs have employed numerous crop protection practices to protect crops from various types of pests. They tapped into native practices, including locally available diverse plant species with insecticidal properties. This knowledge is dynamic, continuously influenced by internal creativity and experimentation, and exposure to external systems. These traditional treasures of knowledge have been passed down from generation to generation without being documented. However, in this technologically advanced modern age, some of these ITKs have already been documented, tested, and recommended for future agricultural sustainability and profitability.

In the absence of crop protection, yield losses of up to 70% can occur across many major food crops, with weeds accounting for the highest losses at 30%, followed by animal pests and pathogens at 23% and 17%, respectively. On average, pests account for 20-40% of yield losses worldwide, costing the global economy a combined \$290 billion, according to the FAO. Economically important agricultural, horticultural and ornamental crop plants are attacked by various insect pest and pathogens resulting crop losses. Presently, the most widely used control measures for suppressing the pest and pathogens is the use of pesticides. However, problem encountered, such as development of resistance by the insect pest and pathogen to the pesticides, and requirement of repeated applications, added to the increase cost of chemical have given impetus to alternative measures for control of insect-pest and plant disease. The application of chemicals for pest control leads to food poisoning, soil, water and environmental pollution. These chemicals create ecological imbalance and allow insect-pest to develop resistance. At these

moments, an indigenous knowledge related to plant protection in agriculture would play vital role. If an effort is made towards production of Indigenous Technical Knowledge (ITK) based products on cottage scale, it can be an economically viable option for sustainable development of eco-friendly pesticides/insecticides.

ITK information was collected from primary sources through voluntary disclosure. Simultaneously, an attempt has been made to accumulate and assemble the practices on ITK prevailing among farming community from the available folk tales, literature, books, journals, thesis, etc. with a purpose to cause them to available at one place. The present volume on Indigenous Knowledge in Agriculture is aimed at providing easy access to such information in agricultural and related areas of issues.

The ITKs compiled in the present volume have been classified under different subject matter areas, *viz* weed management, insect management, disease management in crops, livestock and fishes. The document acknowledges the sources of ITKs and the references and the literature cited have been attempted to record. This book is not only a reference, but also as a guide and inspiration for future research aimed to mitigate biotic stress in agriculture. This book works well in conjunction with seasonal learning of crop pests, diseases and weeds. This preface provides suggestions on how best to use this book.

We are very grateful to Joint Directors, Scientist and contributors of ICAR-National Institute of Biotic Stress Management, Raipur is worth to acknowledge.

Editors

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Indigenous Technical Knowledge in Weed Management

Anil Dixit and P. Mooventhan

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Indigenous Technical Knowledge (ITK)-Concept clarification

“ITK as sum total knowledge and practices which are based on people's accumulative experiences in dealing with situations and problems in various aspects of life and such practices are special to a particular culture” (Wang 1980).

“It is a complex concept that reflects on even more complex set of empirical, intellectual, social and spiritual factors that constitute human culture. It refers to the integrated expression of collective values and customs that guide interaction among peoples and between people and nature. Throughout the centuries, societies evolved by learning from experience and transmitting knowledge to younger generations” (IDRC 1993).

Key features of ITK

1. ITK is dynamic in nature
2. Tradition based (Evolved from time immortal)
3. ITK is collective in nature (Community)
4. Specific traditional information exchange mechanism
5. Locally appropriate and acceptable
6. Symbolizes the respect of nature
7. Flexible for new interventions/innovations
8. Low cost
9. Eco-friendly
10. High validity and reliability (Singh 2007; Gairola 2008)

Importance of documentation of ITK

1. To save the rich indigenous knowledge base from external factors
2. Urbanization and Modernization as tremendous influence
3. Knowledge survives through word of mouth
4. Documentation has great practical utility
5. Policies for conservation of biological diversity
6. Sustainable uses of natural resources
7. Intellectual property purpose
8. To improve the livelihoods of ITK holders
9. To benefit national economy, conserve the environment
10. To prevent bio-piracy (Girach 2007; Gupta 2008)

Role of innovation system in ITK



ITK in Weed Management

1. Sieving paddy seeds: Before sowing, farmers sieve rice seeds in order to separate the seed of weeds. Since most of the weed seeds are smaller than rice seeds, they are filtered out in sieves. This is prevalent in Arunachal (Singh 2003).



(Photo courtesy - www.nzdl.org)

2. Control of wild rice by growing purple rice variety (R - 575):

Wild rice being identical to cultivated rice plants in morphology, it is not possible to distinguish between the two before seed maturity. At maturity, the ripened seeds keep on shattering and therefore, it becomes practically impossible to eradicate this weed. Farmers grow purple coloured rice variety, 'R-575'. This variety has dark purple coloured foliage which is distinctly different from wild rice. Thus wild rice becomes easier to identify and weed out at early stages of growth. This method works wonderfully as there is no other way to control this weed. Once, a field gets infested with wild rice by continuous cultivation, the coloured variety is grown for 3-4 years in that field and all the plants with green foliage are removed manually (Himachal Pradesh) (Singh et al. 1996).



(Photos courtesy - www.extension.umn.edu)

3. Use of *Sirangtheirong* leaves to control weeds in paddy field:

Farmers of Nagainga village of district Ukhrul, in Manipur collect fallen leaves of a local tree, called sirangtheirong (*Juglans regia*) and broadcast the leaves in paddy field. Thickness of layer is up to 1-2 cm. When the decomposition starts, weed growth is suppressed.



(Photo courtesy - www.feedipedia.org/node/38)

Simultaneously many cutting and chewing type of insects are controlled. About 35-40% inhabitants use this old practice Reported by Dr Ranjay K Singh, Assistant Professor (Agricultural Extension and Rural Sociology), College of Horticulture and Forestry, Central Agricultural University, Pasighat (Arunachal Pradesh).

4. Weed management through salt application: Weed control in rice by using common salt. Common salt is dissolved in water and sprayed in rice fields for controlling major weeds. This practice is being used by 40 to 50% farmers of Makarbili village in Nawadpada district of Orissa with 60% effectiveness in controlling weeds (Sarbani Das 2003).

- ❖ The optimum dose for effective weed control is 1 kg of salt dissolved in 12 L of water
- ❖ The salt was applied in two sprays, one after sowing and another at active tillering stage
- ❖ Optimum rate as 120 kg/ha



(Photo courtesy - www.ubinig.org)

5. Puddling rice nurseries followed by drying



(Photos courtesy - www.thehindu.com & www.rkmp.co.in)

6. Kopar Technology for weed management: Kopar is a traditional method of farm practice in Chhattisgarh. Mr. P. C. Agarwal a progressive farmer of Kharora has used this technology for the management of biotic stresses (weeds, insect pests and diseases) in his own farm at Kharora and found very encouraging results over chemical control measures. As per Mt Agarwal, the technology could increase the yield by 20-30 per cent depending upon the variety, stage of the crop and number of Kopar operation in the crop. The Kopar technology has been demonstrated at farmer's field, Jaroda (Mr. Santosh Sahu farm) and ICAR-NIBSM farm in the paddy crop during *kharif* 2017. Mr. Sahu has used Kopar technology thrice (20, 30 and 40 DAT) in the paddy crop for the management of weeds in paddy (Cv. Swarna). The number of tillers was more (14-15/paddy plant) and the level of insect pests and diseases were negligible as compared to non-Kopared crop (8-10 tillers/ paddy plant). He recorded 26 q/1.5 acre in Kopared crop as compared to non-Kopared crop (20 q/1.5 acre). Whereas at ICAR-NIBSM farm, the yield was 21.36 q/acre (Cv. Swarna) and 19.82 q/acre (Cv. Mahamaya) in Kopared crop as compared to non-Kopared crop (16 q/acre in Mahamaya and 17.5 q/acre in Swarna) (Dixit et al. 2017).



(Photos courtesy -NIBSM, News-letter July-December 2017)

7. Weed control in transplanted rice: Pine is an integral part of the folklore and mythology of indigenous cultures in Uttarakhand. Dense pine forest are found in Panar, Chitai, Badachhinna, Rayagar and Berinag areas in Almora, Nainital and Pithoragarh districts of Kumaun region of Uttarakhand. Dry leaves of pine (*Pinus kesiya*) are spread in mid June in the fields where rice is to be transplanted. The pine leaves are burnt before transplanting, i.e., in the first week of July. This practice controls the germinating or prevailing weeds in the field. Farmers use this practice as a preventive measure for weed control in rice (Pandey et al. 2006). Another advantage of this technique is that the stalks of wheat left during harvesting are also burnt, which otherwise create difficulties during transplanting and other cultural activities.



(Photo courtesy - <https://www.gardentags.com>)

8. Weed management in rice main field:-Preparing and leveling the main fields uniformly without undulations. Plough the land during summer to economize the water requirement for initial preparation of land. Flood the field 1 or 2 days before ploughing and allow water to soak in. Keep the surface of the field covered with water. Keep water to a depth of 2.5cm at the time of puddling. This practice help to reducing weed through puddling. Courtesy: TNRRI, Aduthurai (T.N.)



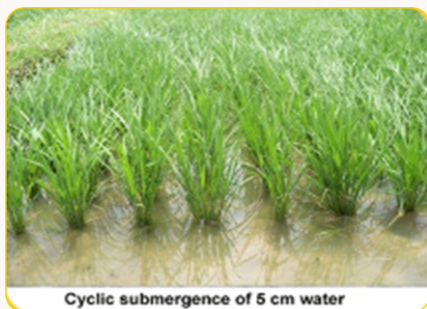
(Photos Courtesy: http://agritech.tnau.ac.in/agriculture/agri_cropproduction_cereals_rice_tranpudlow.html)

9. Maintaining the heights of the field bunds at one inch



(Photo courtesy - www.rkmp.co.in)

10. Storing water continuously up to 15 days from planting



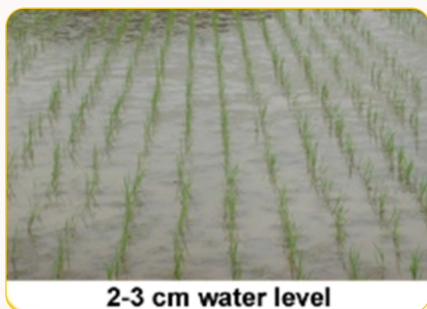
Cyclic submergence of 5 cm water



Continuous Submergence

(Photos courtesy - TNAU, Expert System for Paddy)

11. Maintaining the water level 1 inch



2-3 cm water level

(Photos courtesy – TNAU, Expert System for Paddy)

12. Closer planting is necessary especially during the navarai and sornawari seasons



(Photos courtesy - www.riceseasons.wordpress.com & www.ehow.com)

13. Applying neem cake to control *korai* (Sedges) weeds :



(Photos courtesy - www.psgcoirs.com & www.ishinnorganic.com)

14. Biasi, Halod or Beushening in standing direct sown paddy: A practice called beushening is followed for weeding (Watt 1891; Singh et al. 2002). This old practice is prevalent in parts of Uttar Pradesh, Jharkhand, Madhya Pradesh, Chhattisgarh, and Orissa, especially where the rainfall is uncertain. It involves direct seeding of rice in a well-prepared field, wet plowing of the seedlings 20-30 days after emergence, laddering of the field, and seedling redistribution. The practice has different local names: baug (Jharkhand), bidauni and bidhaini in Uttar Pradesh and Assam, and biasi in Madhya Pradesh.

In this method, furrows of depth ranging from 15 to 20 cm are

opened (when the crop is 30-40 days old) with animal drawn indigenous (desi) plough. This operation helps to maintain plant population, to reduce weed infestation by uprooting and buried into the soil, this will also help in increase to prevent leaching, to induce tillering and to increase organic content. The area of coverage is about 0.5 ha/day. The cost of ploughing operation is Rs. 400 to 500/ha (Sinha et al. 2015).



(Photo courtesy - www.phytojournal.com/archives/2018)



(Photo courtesy - www.chandrikarice.com
& krishibhoomi.in)

15. *Kharif* fallowing for assured *rabi* crop: In *kharif* where raising of successful crops involves risk, farmers keep the land fallow. This practice, besides conserving moisture for *rabi* crops is useful to distribute peak demand of labour, draft power, build up native soil fertility and efficient management of weeds. Prevalent in deep black soils with low rainfall regions of Western Maharashtra and high rainfall areas of Madhya Pradesh (Subba Reddy and Singh 2001).



(Photo courtesy - www.seeds.irri.org)

16. Control of weeds in rice by using leaves of Karada : Leaves of karada (*Cleistanthus collinus*) plants (100-150 kg/ha) are placed in the standing water as a result of which the water becomes blackish in

colour. It is believed that it kills Gundhi bug and some aquatic weeds of paddy (Bhubaneshwar, Orissa) (Panda 1992).



(Photos courtesy – www.thehindu.com)

17. Dhaincha (*Sesbania aculata*) for weed suppression: -

Transplanting of 21 days old rice seedlings in *in situ* dhaincha ploughed fields at vegetative stage (30-35 days after sowing) this technique control of weeds by 57%, weed dry biomass by 37% and increase of yield by 16.4%, besides reducing NPK requirement by 25% (Choudhary and Anil Dixit 2018).



(Photos courtesy – www.shopsy.in)

18. Mendha for controlling weeds in rainfed upland rice:- In the rainfed uplands of the Mid Central Table Land Zone of Orrisa, the farmers practice one cross ploughing (Mendha) 3 days after sowing paddy with the help of a narrow wooden country plough, followed by laddering (Garamai) 3 days after mendha. Again work with a tooth harrow (Bida) 3 days after garamai is useful to control weeds (WCE 50%) compacts the soil, conserves moisture as well as helps in tillering (Sahoo et al. 2002).

19. Malabar nut (*Adhatoda vasica*) as manure: In the Dictionary of Economic Products of India, Watt (1891) detailed the use of the dye- and medicine-yielding Malabar nut (*Adhatodavasica*) as manure both in North and South India, to which attention has also been drawn by Asian Agri History (Watt 1998). Broadcasting the leaves and twigs of this plant (adala, vasaka, basuti, bansa) also gave satisfactory control of Chara and other aquatic weeds common in paddy fields. Recent analyses conducted in Nepal on the traditionally used leaves of *Adhatodavasica* (locally called asuro) revealed that they contain 4.3% N, 0.88% P, and 4.49% K, and afforded the highest production in comparison with chemical fertilizers (Subedi 1993).

20. Ploughing in standing maize for weed control: The interspaces in standing maize field are ploughed when it has attained a height of 15-30 cm for weed control. Ploughing strengthens the root system of the maize crop by loosening the soil which enhances aeration and water filtration (HP) (Verma 1998).



(Photo courtesy - images.mandala.library.virginia.edu)

21. Sorghum: Growing coriander as a mixed crop in sorghum to control the parasitic weed *viz.*, witch weed (*Striga lutea*).



(Photo courtesy – [www.https://www.jaivikkheti.in/DMS/Final.com](https://www.jaivikkheti.in/DMS/Final.com))

Control of Striga in Sorghum: Seeds of suva (*Anthemum graveolens*) are incorporated with sorghum seeds approximately 3-4 kg/ha at the time of sowing to avoid the emergence of striga. Suva is very slow growing and is suppressed at later stages by Sorghum. Farmers divert the harvested rainwater of adjoining fields into the striga infested fields in Saurashtra. Cut branches of Calotropis sp. are kept at the entrance of the rain water channel. This practice minimizes the striga population to a great extent, if repeated for several times during raining days(Bharuch, Gujarat) (Ganchi 1992).



(Photos courtesy – www.iucn.org, www.wageningenur.nl & de.wikipedia.org)

23. Use of finger-millet husk as mulch: Finger-millet husk used as mulch is less affected by termites, checks evaporation and weed growth. Termites fail to get a foot hold and hence their incidence is reduced (Karnataka) (Anonymous 1999).



(Photos courtesy – www.milletts.wordpress.com & www.youtube.com)

24. Cuscuta management in Niger:-Soil drenching with jackfruit leaf extract @ 1-2.5 litres diluted with 1000 litres of water 2-3 days after sowing restricts the germination of Cuscuta. (Koraput, Orissa) (Dixit et al. 2002).



(Photos courtesy – www.pixabay.com & www.en.wikipedia.org)

25. Control of weeds by crop rotation with wild sesamum: For weed control, practices like inter culturing and hand weeding are not so convenient due to the reasons like broadcast sowing, large size of land holding and sloppy as well as undulating land topography. Ramtal (wild species of sesamum) is grown in the field for suppressing the growth of weeds. Growing it once can reduce more than 50% of weed population. Ramtal plant grows faster in the initial stage and suppresses the growth of weeds (Bharuch, Gujarat) (Vasava 1992).



(Photos courtesy – www.namibrand.com, www.prota4u.org & www.golatoski.de)

26. Wooden blade harrow for inter cultivation of castor:- Farmers of Manmarri village frequently do inter cultivation in castor by a blade harrow, which is sown by rectangular planting. This tool is made of wooden beam 45 cm wide, fixed to wooden pegs. Blade made of iron or mild steel is fixed to the wooden pegs. Two wooden beams with 3 m length are fixed to the main wooden frame which is tied to the yoke of one pair of bullocks. The farmers with this tool can cover intercultural operations of 1 ha in a day, costing Rs 120. This tool is useful not only to control the weeds in both directions but also to increase the infiltration capacity in vertisols. Reported by Shri V. Srinivas, Research Associate, TARIVLP, Central Research Institute for Dryland Agriculture, Hyderabad (Andra Pradesh).

27. Cotton shells for control of *Cyperus rotundus*: These cotton shells are broadcast in the field where patches of this weed are found. It is layered up to 3 inch thickness in these patches one month before rainy season begins. The field is then cultivated by plough to incorporate it well into the soil. This kills the root of the weed. By this practice, the field remains weed free for about 2-3 years. (Gujarat). Gami (1996).



(Photos courtesy – www.dreamstime.com & www.flickr.com)

28. Wooden blade harrow for inter cultivation of cotton: Farmers of Manmarri village of district of Ranga Reddy in Andhra Pradesh do inter cultivation in cotton by a blade harrow frequently. This tool is made of wooden beam of 3 m length, fixed to the main wooden frame that is tied to the yoke of one pair of bullocks. The farmers with this tool can cover intercultural operations of 1 ha in a day costing Rs 120. This tool is used not only to control the weeds in both directions but is also useful to increase the water-infiltration capacity in vertisols. Reported by Shri V. Srinivas, Research Associate, TARIVLP, Central Research Institute for Dryland Agriculture, Hyderabad (Andhra Pradesh).

29. Use of paddy stalk to suppress weeds and conserve moisture in sandy loam soil:- During first week of June, paddy stalks are spread in a thick layer on sugarcane field. The layer acts as a cover to decrease the intensity of rain and suppress germination of weed seeds. After decomposition it is converted into organic matter, which is available to the succeeding crop, *i.e.* wheat or green gram. This technology is quite useful for the crop grown on sandy soil, and sugarcane crop can sustain moisture stress up to 20-30 days. About 70-80% weed population is controlled by this practice. Reported by Dr Ranjay K. Singh, Assistant Professor (Agricultural Extension and Rural Sociology), College of Horticulture and Forestry, Central Agricultural University, Pasighat (Arunachal Pradesh).



(Photo courtesy - www.extension.umn.edu)

30. Mini tractor-drawn ridger, weeder and sugarcane leaf mulcher:

The ridger is developed as an attachment to the three-point hydraulic linkage of the mini tractor. The ridger comprises an upper main frame, a central shank and a ridger bottom. The distance between the outer edges of the rear wheels of the mini tractor is 1.2 m and total width of the implement is about 1 m. Hence in crop rows of 1.5 m normal spacing, the implement can be very easily used without damaging the crop. The moisture level of soil should be enough for the tool to penetrate. The cutting tool penetrates and cuts the soil. The soil is cut up to 22.5 cm depth and is lifted on the wing board on each side. The lifted soil is thrown on both sides. The tractor is moved in 'alternating field machine pattern' in the field by going from one end of the field in one direction between first and second rows and coming back in opposite direction after skipping the next two rows through fifth and sixth rows and alternating in a similar manner. The ridger-weeder is unique as it does both weeding and earthing-up in a single operation in sugarcane crop. There is a saving in cost and time by more than 60%. Since it helps in



(Photo courtesy -nif.org.in/innovation)

trash mulching and obviates the need for its burning, the ridgerweeds also contributes towards conserving moisture and improves organic matter content in the soil. Reported by Shri P. K. Jeyakrishnan Facilitator: National Innovation Foundation, Ahmedabad (Gujarat).

31. Pingalidhanti for intercultural operation in tomato: The ITK Meerkhanpet village, Kandukur mandal, Ranga Reddy dist. (Andhra Pradesh) the ITK Bullock-drawn pingalidhanti can be effectively used for weed control in tomato both during *kharif* and *rabi* instead of hand-weeding. It can cover an area of 0.4 ha/day with a cost of operation of Rs. 150/ha. By adopting this, clean weeding is achieved. It costs about Rs. 100. Name and address of the discloser Shri B. Narsimha Rao, Meerkhanpet, Kandukur, Ranga Reddy (Andhra Pradesh). Experimenters Dr. B. Sanjeeva Reddy, Scientist, Senior Scale (FMP), Dr. G. Nirmala, Scientist, Senior Scale (Agricultural Extension) and Dr.G.Subba Reddy, Head, Division of Crop Sciences, Central Research Institute for Dryland Agriculture, Hyderabad (Andhra Pradesh). The use of pingalidhanti for inter-culture operation enhanced the productivity (21.74 q/ha) and net income (Rs 583/ ha) compared with the inter-culture with traditional blade harrow. Inter-culture with pingalidhanti along with hand-weeding gave 47% increase in net income over the blade harrow with hand-weeding (Rs 2,303/ha). Also, there was no significant difference with regard to field capacity and draft between the indigenous pingalidhanti, blade harrow and its combination with hand-weeding. The results also revealed that, operation of pingalidhanti along with hand weeding showed higher weeding efficiency (89.53%) over inter-culture with pingalidhanti alone (65%). There was variation between two inter-culture implements in respect of weeding efficiency and energy expenditure for inter-culture operations. When farmers perception was judged, it was found that, pingalidhanti has an edge over traditional blade harrow in terms of coverage, extended period of operation during the crop-growth period and efficacy in controlling weeds, ease in handling, cost effectiveness, durability and

replicability of the implement. However, blade harrow has edge over indigenous tool in terms of cost, availability and ease in fabrication. Conclusion Use of pingaldhantialongwith hand weeding enhanced profitability (47.1%), weeding efficiency (24.53%) in rainfed tomato compared to the traditional blade harrow. It facilitated to control weeds effectively beyond 45 days after transplanting. Farmers perceived that pingalidhanti has an edge over traditional blade harrow in terms of coverage, extended period of operation during crop growth period efficiency in controlling weeds and ease in handling.



(Photo courtesy –www.zpd7icar.nic.in)

32. Use of dry leaves for mulching in cardamom:-Mulching with dry leaves in cardamom helps in retaining moisture in soil by reducing evaporation and to check weeds (Karnataka) Anonymous (1999).



(Photos courtesy – www.thehindu.com & extension.oregonstate.edu)

33. Control of *Parthenium hysterophorus* weed: To control carrot-weed grass (*Parthenium hysterophorus*) in the agricultural fields, construction of pit is in practice. Digging a pit with 2 m length, 2 m

breadth, and 4 m depth is recommended. Weeds collected from the fields are deposited in this pit. Since spores remain at the bottom of the pit, its spread is controlled resulting in check of *Parthenium*. Reported by Shri D. Kuppusamy, Gangavaram, Gingee, Villupuram (Tamil Nadu).



(Photos courtesy - <https://vikaspedia.in/>)

34. Control of *Cynodon dactylon*: Dry stalks of cumin plant are spread over the field in summer. In the monsoon, the rain water gets absorbed in the stalks before filtering down the soil. It is believed that water filtering through the cumin stalks prevents the germination and growth of this weed. It takes one year for the stalks to decompose. (Gujarat) (Thakor 1996).



(Photos courtesy – www.gardeningknowhow.com)

35. Control of weeds through mango leaf mulching: Farmers use mango leaves for mulching to control motha weed (Gonda, U.P.) (Anonymous 2000).



(Photos courtesy – www.mykitchengarden.info, agropedia.iitk.ac.in & www.en.wikipedia.org)

36. Control of weeds through mango leaf mulching: *C. dactylon* and *C. rotundus* in sugarcane, grapes and pomegranates is managed by growing *Amaranthus* (Sholapur).



(Photos courtesy – kanseki-vortex.blogspot.com, www.toyogreen.com & www.teline.fr)

37. Grazing Animals to control weed

1. Goats & Sheep - eat weeds and root or graze
2. Pigs - root out tubers of nut sedge and quack grass
3. Geese - young shoots of grasses and sedges over broadleaved vegetables



(Photos courtesy – www.trentwallis.com & www.domestic-executive.com)

38. Soil management through cultural practices:-In West Himalayan region in March/April when snow melts and weather condition improves the bunds and corners of the fields are dug out and weeds and grasses are removed with the help of spade and clods are beaten to separate the soil which is collected in lower fields and thereby, improving the fertility of soil. This practice enables not only better weed control but also does not waste the area under cultivated crops (West Himalayan region) (Verma 1998).

39. Shangma stone for weed control: A bluish local stone called 'Shangma' is used for weed control because it seems to possess toxic properties. Pieces of stones are spread over a small heap of soil in the middle of the field in the month of December. This soluble stone when mildly irrigated percolates into the field (Changthan area of Ladakh in Himachal Pradesh) (Verma 1998).

40. Control of *Cynodon dactylon*:- Dharo (*Cynodon dactylon*) is a noxious, perennial, grassy weed that grows on fertile patches and bunds in the fields. Even running a harrow for interculturing is very difficult in spots where the weed grows. The weeds are difficult to remove even manually. Dry stalks of the cumin plant are spread over the field in summer. In the monsoons, the rain water gets absorbed in the stalks before filtering down to the soil. It is believed that the water filtering through the cumin stalks prevents the germination and growth of the Dharo. It takes almost 1 year for the stalks to decompose (Mehasana, Gujarat) (Thakor 1996).

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Low-Cost Plant Protection Technologies in Indian Agriculture

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Abstract

Indigenous plant protection technologies emerged from grass-root level innovators are considered as low-cost technologies which are less expensive, durable, practically feasible and safe to human and animal health and wealth, natural resources, non-target organisms and their associated environment. Various cultural practices for managing key insect pests of major field and horticultural crops including cereals, millets, pulses, oilseeds, cash crops, fruits and vegetables, considering their ecology have been enlisted. Out of farm gate, post-harvest losses to stored agricultural commodities due to insects, rodent, diseases etc., are estimated up to 9-10% annually in India. Low-cost and non-toxic technologies are highly helpful to protect the agricultural produces, meant for seed and consumption purposes with minimum contaminations and chemical residues. Few gadgets mentioned in this chapter for monitoring and mass-trapping of storage pests under small and large scale storage conditions are non-toxic and durable green technologies to protect stored commodities scientifically.

Keywords: Indigenous technologies, key insect pests, post-harvest losses, mitigation

Introduction

Biotic stress is stress that occurs as a result of damage done to plants

by living organisms such as bacteria, viruses, fungi, parasites, harmful insects, weeds and cultivated or native plants. Biotic stresses in crops can cause direct losses as well as indirect losses with larger implications towards the society and environment. Direct losses include yield loss, quality of produce, possible contamination of toxins during or after harvesting, cost of controlling stresses and replanting, extra cost for harvesting, contamination of planting material etc., whereas indirect losses may affect farm, rural community, consumers, trade, nation and the environment. Crop pests continue to pose threat to crop production and productivity globally. Losses caused by pests and diseases in different crops are well documented. The crop losses due to pests and diseases may vary from low to high depending upon various existing factors. Approximately 10% of the global crop output is lost due to attacks by pests, weeds and diseases which doesn't predict well for farming given the critical challenges ahead and thus agrochemicals have an increasing role to play. In India, yield loss to crops is estimated as 33% by weeds, followed by insects (26%), diseases (20%), rodents (6%) and others (6 to 8%). The Indian farmers mostly rely on chemical pesticides like insecticide, fungicide, nematicide, herbicide etc. to manage biotic stresses of crops. Additional pest and disease losses occur after harvest. Globally the post-harvest losses in agriculture food production is estimated to 9 to 10% which equals to 13 % of the total calories produced. India is losing 12 to 16 Mt of food commodities under storage annually due to insects, diseases, rodents, birds etc., costing approximately Rs. 50,000 crores which is sufficient to feed 1/3 of India's poor. Out of which, 1300 crore worth materials are damaged by insects and 2.5% by rodents. Though several modern green technologies are in vogue in plant protection of the Indian

agriculture, several indigenous knowledge know-how, emanated from the grass-root innovators are being used severally. Many of them are in use by the stake-holders in plant protection in India which are ecologically viable ITKs and are documented hereunder.

Cereals

Rice

- ❖ Yellow stem borer: Clip the rice seedling tips before transplanting to eliminate yellow stem borer egg masses and collect and destroy the egg masses in main field
- ❖ Bag worm: Dislodge the bag worm cases by passing a rope and drain water. Collect the cases and destroy. Mix kerosene to the standing water
- ❖ Swarming caterpillar: Flood the nursery to expose the hiding rice swarming caterpillar to the surface for birds to pick them up
- ❖ Leaf hopper: Nursery should not be located near the street lamps to minimize rice leafhopper damage
- ❖ Gall midge: Early ploughing, early planting and removal of alternate host
- ❖ Leaf folder: Avoid excessive nitrogenous fertilizers
- ❖ Brown planthopper: Optimum spacing and intermittent wetting and thawing of rice fields
- ❖ Mealybug: Remove the grasses and trim the bunds during the main rice field preparation before transplanting for containing mealybug incidences
- ❖ Ear head bug: Grow *Acorus calamus* to deter
- ❖ Raise eco-feast crop like cowpea in rice field bunds to attract natural enemies

- ❖ Rat: Erect owl perch @ 20 nos./ha for management of rat in rice fields

Maize

- ❖ Shoot fly: Avoid staggered sowing and use excess seed rate of maize to reduce the shoot fly damage

Millets

Sorghum

- ❖ Shoot fly: Take up early sowing of sorghum immediately after the receipt of South West or North East monsoon to minimise the shoot fly incidence. use increased seed rate up to 12.5 kg/per hectare and remove the shoot fly damaged seedlings at the time of thinning or raise nursery and transplant only healthy seedlings. Plough soon after harvest, remove and destroy the stubbles
- ❖ Stem borer: Intercrop cowpea in sorghum to minimize stem borer damage
- ❖ Midge and ear head caterpillar: can be managed by early sowing in a short period

Bajra

- ❖ Shoot fly: Use low cost fish meal trap 12/ha
- ❖ Stem borer: Collect the stubbles after harvest and burn to destroy diapausing borers

Finger millet

- ❖ Cut worm: Avoid green manure and apply FYM to prevent cutworm egg laying

- ❖ **Leaffolder:** Damage can be avoided by crop rotation with non-cereal crops

Pulses

Red gram

- ❖ **Gram pod borer:** Raise one row of sunflower as intercrop for every 9 rows of pigeon pea and plant maize as border crop. Bird perches 50/ha, Mechanical collection of grown up larva and blister beetle
- ❖ **Blue butterfly:** Avoid dense and close planting; avoid early or late sowing; regular soil digging cause death of larvae and pupae
- ❖ **Spiny pod borer:** Deep summer ploughing in 2-3 years to eliminate quiescent pupa; Early sowing, short duration varieties; Avoid closer plant spacing; Grow tall sorghum as companion crop to serve as biological bird perches; Collect and destroy larvae and adults to the extent possible

Chickpea

- ❖ **Cutworm:** Deep summer ploughing; Use well decomposed organic manure; Adapt crop rotation; Early sowing in the last week of October; Intercropping with wheat or Linseed or Mustard reduces infestation; In the early stages pick the insects and destroy; Do not grow Tomato or Lady Finger in nearby field; Grow marigold on bunds

Soybean

- ❖ **Bihar hairy caterpillar:** Deep summer ploughing; Avoid pre monsoon sowing; Use optimum seed rate; Adequate plant spacing should be provided; Intercrop soybean either with (early

maturing) pigeon pea variety or maize or sorghum in the sequence of 4:2 should be practiced; Collect & destroy infested plant parts, egg masses and young larvae.

- ❖ Cutworm: Deep summer ploughing; Avoid pre-monsoon sowing; Optimum seed rate (70-100 kg/ha) should be used; Collect and destroy infested plant parts, egg masses and larva.
- ❖ Sucking pests: Dusting of cow dung ash and spraying of clay suspension as asphyxiants for soybean sucking pests (in small area and low incidence of sucking insects)

Oilseeds

Sunflower

- ❖ Head borer: Grow inter crops like, green gram, black gram, groundnut, soybean; Sow 3-4 lines of maize (or) jowar around the sunflower crop to monitor the moth; Sow trap crops like marigold at 50 plants/acre
- ❖ Bihar hairy caterpillar: Deep summer ploughing; Use of well rotten manures; Intercropping with pigeon pea at a row ratio of 2:1 is effective in reducing the insect attack; Collection and destruction of larvae

Groundnut

- ❖ Red hairy caterpillar: Dig out and destroy the pupae from the field bunds and shady spots prior to summer rains; Collect and destroy gregarious, early instar larvae on lace-like leaves of intercrops such as redgram and cowpea; Collect and destroy egg masses in the cropped area. Avoid migration of larvae by digging a trench 30 cm deep and 25 cm wide with perpendicular sides around the

infested fields

- ❖ Leaf miner: Intercropping of groundnut with bajra at 4:1 ratio
- ❖ Defoliators: Deep summer ploughing; Intercrop one rows of red gram for every 5 or 6 rows; Grow castor as border or intercrop in groundnut fields to serve as indicator or trap crop; Monitor the emergence of adult moths by setting up light and pheromone traps; Collect egg masses and destroy

Castor

- ❖ Slug: The pest should be kept in check by picking the gregarious caterpillars and the cocoons that are found on tree trunks and destroying them

Mustard

- ❖ Diamond back moth: Collection and careful destruction of the larvae at gregarious stage at least twice a week
- ❖ Sawfly: Summer ploughing to destroy the pupa; Early sowing should be done; Maintain clean cultivation; Apply irrigation in seedling stage is very crucial for sawfly management because most of the larvae die due to drowning effect. Severe cold reduces pest load; Collection and destruction of grubs of saw fly in morning and evening
- ❖ Aphid: Use tolerant varieties like JM-1 and RK-9501; Destroy the affected parts along with aphid population in the initial stage; Crop sown before 20th October escapes the damage
- ❖ Painted bug: Deep ploughing so that the eggs of painted bugs are destroyed; Early sowing is needed to avoid pest attack; Irrigate the crop during four week after sowing to reduce pest attack; Quick threshing of the harvested crop should be done; Burn the remains

of mustard crop so that the stages of insect do not reach the next year crop; The bugs usually congregate on the leaves and stem, which can be jerked to dislodge them and killed in keratinized water

Minor Oilseeds

- ❖ Sphinx moth: Deep ploughing exposes the pupae for predation to insectivorous birds; Hand picking collection and destruction of caterpillars
- ❖ Linseed gall fly: The infested buds should be removed and destroyed to reduce further incidence of the pest
- ❖ Safflower borer: Intercropping with non host crop like wheat or barley; Avoid chickpea as intercrop; Excessive application of nitrogen should be avoided

Cash Crops

Cotton

- ❖ Bollworm: Synchronised sowing of cotton preferably with short duration varieties in each cotton ecosystem; Avoid continuous cropping of cotton both during winter and summer seasons in the same area as well as rationing; Avoid monocropping. Growing of less preferred crops like greengram, blackgram, soyabean, castor, sorghum etc., along with the cotton as intercrop or border crop or alternate crop to reduce the pest infestation; Removal and destruction of crop residues to avoid carryover of the pest to the next season, and avoiding extended period of crop growth by continuous irrigation; Optimising the use of nitrogenous fertilizers that will not favour moth multiplication of the pest;

Judicious water management for the crop to prevent excessive vegetative growth and larval harbourage

- ❖ Leaf folder: Collection and destruction of damaged plant parts; Hand picking and destruction of grown up caterpillars
- ❖ Tobacco cut worm: Growing castor along border and irrigation bunds; Removal and destruction of egg masses in castor and cotton crops; Removal and destruction of early stage larvae found in clusters that can be located easily even from a distance; Collection and destruction of shed materials; Hand picking and destruction of grown up caterpillars
- ❖ Whitefly: Avoid the alternate, cultivated host crops of the white fly in the vicinity of cotton crop; Growing cotton only once a year either in winter or summer season in any cotton tract; Adopting crop rotation with non-preferred hosts such as sorghum, ragi, maize etc., for the white fly to check the buildup of the pest; Removal and destruction of alternate weed hosts like *Abutilon indicum*, *Chrozophore rottlari*, *Solanum nigrum* and *Hibiscus ficulensus* from the fields and neighbouring areas and maintaining field sanitation; Timely sowing with recommended spacing, preferably wider spacing and judicious application of recommended dose of fertilizers, particularly nitrogenous and irrigation management is essential to arrest the excessive vegetative growth and pest build up; Late sowing may be avoided and the crop growth should not be extended beyond its normal duration; Field sanitation may be given proper attention. Cultivation of most preferred alternate host crops like brinjal, bhendi, tomato, tobacco and sunflower may be avoided. In case their cultivation is unavoidable, plant protection measures should be extended to these crops also.

Sugarcane

- ❖ Early shoot borer: Use resistant varieties like CO 312, CO 421, CO 661, CO 917 and CO 853; Early planting during December-January escapes the early shoot borer incidence; Sugarcane intercropped with Daincha recorded the lowest early shoot borer incidence; Trash mulching along the ridges to a thickness of 10-15 cm 3 days after planting; Ensure adequate moisture to bring down the soil temperature and increase humidity (unfavourable condition for the multiplication of early shoot borer); Partial earthing up on 45 days after planting reduces the incidence.
- ❖ Internode borer: Use resistant varieties like CO 975, COJ 46 and CO 7304; Select pest free setts for planting.
- ❖ Top shoot borer: Use resistant variety CO 419, CO 745 and CO 6516 and tolerant varieties Co 859, Co 1158 and Co 7224; Small earthing up followed by trash mulching; Do not undertake maize, sorghum as intercrops; Prefer paired row system for planting; Remove the dead heart plants and destroy them
- ❖ Whitefly: Avoid water stagnation and provide proper drainage facilities; Detrashing of cane at the 5th and 7th month; Avoid the excess application of fertilizers.
- ❖ Woolly aphid: Paired row system of planting; Avoid excessive use of nitrogenous fertilizers; Use of organic fertilizers; Rapping of canes all along the rows; Infested tops should not be transported; Infested canes should not be used as seed material for planting.
- ❖ Mealybug: Use resistant varieties like CO 439, CO 443, CO 720, CO 730 and CO 7704; Drain excess water from the field.
- ❖ White grub: Provide adequate irrigation; Deep ploughing immediately after harvesting; Avoid ratoon cropping; Stagnating water for 24hrs in the field then the grub will come out from the soil.
- ❖ Scale insect: Use resistant varieties like CO 439, CO 443, CO 453,

CO 671, CO 691 and CO 692; Select and plant the scale insect free setts; Keep the fields and bunds free from weeds; Avoid water stagnation in the field for a longer period; Avoid repeated ratoons.

- ❖ Termite: Flood irrigation at the time of planting because it stops termite attack due to excess moisture and the optimum moisture level will revive; Fill the gaps in the field to compensate the population

Fruit Crops

Mango

- ❖ Stem borer and Bark borer: Remove and destroy dead and severely affected branches of the tree; Remove alternate host, silk cotton and other hosts; Grow tolerant mango varieties viz., Neelam, Humayudin.
- ❖ Hoppers: Avoid close planting, as the incidence very severe in overcrowded orchards; Orchards must be kept clean by ploughing and removal of weeds.
- ❖ Fruit fly: Collect fallen infested fruits and dispose them by dumping in a pit; Provide summer ploughing to expose the pupa; Monitor the activity of flies with methyl eugenol sex lure traps.
- ❖ Scale insect: Pruning of infested branches and burning

Sapota

- ❖ Fruit fly: Collect fallen infested fruits and dispose them by dumping in a pit and covering with soil; Provide summer ploughing to expose the pupa; Monitor the activity of flies with methyl eugenol sex lure traps.
- ❖ Leaf webber: Remove and destruct the infested fruits from the orchard; Collect and remove the dried clusters of leaf web

- ❖ Hairy caterpillar: Field sanitation; Free from weeds and debris; Collect and destroy the egg mass; Burning the groups of larvae found on tree trunks with torches.
- ❖ Striped mealybug: Collect and destroy egg masses and caterpillars; Use burning torch to kill the congregating larvae

Guava

- ❖ Fruit borer: Collect and destroy damaged fruits; Clean cultivation as weed plants serve as alternate hosts; Fruit fly: Collect and destroy fallen and infested fruits; Summer ploughing to expose pupa
- ❖ Bark caterpillar: Remove and destroy dead and severely affected branches of the tree; Remove alternate host, silk cotton and other hosts

Banana

- ❖ Rhizome weevil: Select healthy sucker and plant; Do not take regular crop in the same field to avoid initial infestation; Ensure clean cultivation; Removal of pseudo stems below ground level; Trimming the rhizome; Avoid growing Robusta, Karpooruvally, Malbhog, Champa and Adukkar; Grow less susceptible varieties like Poovan, Kadali, Kunnan, Poomkalli
- ❖ Pseudostem borer: Remove dried leaves periodically and keep the field clean; Prune the side suckers every month; Use healthy and pest free suckers to check the pest incidence; Do not dump infested materials into manure pit; Uproot infested trees, chop into pieces and burn; Use longitudinally split pseudostem trap at 65/ha
- ❖ Aphid: Ensure clean cultivation; Use healthy and pest free suckers to check the pest incidence; Destroy diseased plants with rhizome
- ❖ Cutworm: Hand pick and destroy the caterpillar; Collect and

destroy the damaged plant parts; Summer ploughing to expose to the pupae

Citrus

- ❖ Fruit sucking moth: Destroy the weed host *Tinospora cardifolia* and *coccules pendules*

Grapevine

- ❖ Stem girdler: Remove loose bark at the time of pruning to prevent egg laying; Collect and destroy damaged plant parts
- ❖ Flea beetle: Remove the loose bark at the time of pruning to prevent egg laying; Shake vines to dislodge adult beetles; Collect into trays containing kerosenated water and destroy them

Pomegranate

- ❖ Anar butterfly: Collect and destroy damaged fruits; Clean cultivation as weed plants serve as alternate hosts; Endemic areas - grow less susceptible varieties; Cover fruits with polythene bags

Vegetable crops

Tomato

- ❖ Fruit borer: Collect and destroy the infected fruits and grown up larvae; Grow simultaneously 40 days old American tall marigold and 25 days old tomato seedling at 1:16 rows; Collection and destruction of damaged fruits and grown up caterpillars.
- ❖ Whitefly: Uproot and destroy the diseased leaf curl plants; Use nitrogen and irrigation judiciously; Remove alternate weed host *Abutilon indicum*
- ❖ Stripped mealybug: Spray fish oil rosin soap @ 25g/lit or neem oil

0.5% along with teepol 1 ml/lit

- ❖ Pinworm: Collect and destroy the pinworm affected plants and fruits; Avoid solanaceous crops after tomato; Use healthy seedlings for transplanting

Brinjal

- ❖ Shoot and fruit borer: Remove the affected terminal shoot showing boreholes; Remove the affected fruits and destroy; Avoid continuous cropping of brinjal crop; Grow the varieties with long and narrow fruits in endemic areas
- ❖ Hadda beetle: Collect damaged leaves with grubs and egg masses and destroy them; Shake plants to dislodge grubs, pupae and adults and destroy.

Chilli

- ❖ Thrips: Intercrop with agathi (*Sesbania grandiflora*) to provide shade which regulate the thrips population; Do not grow chilli after sorghum; Do not follow chilli and onion mixed crop

Cucurbits

- ❖ Fruit fly: Collect infested and fallen fruits and burn in deep pits; In endemic areas, change the sowing date as the fly population is low in hot dry conditions and at its peak during rainy season; Expose the pupae by ploughing and turning over soil after harvest; Use ribbed gourd as trap crop and apply carbaryl 0.15% or malathion 0.1% on congregating adult flies on the undersurface of leaves; Use attractants like citronella oil, eucalyptus oil, vinegar (acetic acid), and lactic acid to trap flies.
- ❖ Pumpkin beetle: Plough the fields just after harvesting destroy the hibernating adults; Collect and destroy adult beetles

Cole Crops

- ❖ Diamond backmoth: Remove and destroy all debris and stubbles after harvest of crop; Grow mustard as trap crop at 2:1 ratio (cabbage: mustard) to attract DBM for oviposition at least 10 days ahead of planting of main crop; Crop rotation with cucurbits, beans, peas, tomato and melon

Low cost Durable Technologies for Minimizing Post harvest Losses

Low-cost non-toxic protectants are useful to avoid post harvest losses with minimum toxic residues.

Storage Insect Pests

Insect Probe Trap

It consists of three parts including a main tube with 2 mm dia perforations, a detachable cone at the bottom and a cap at top. The total length of the trap is 39 cm. The trap is inserted vertically in bags containing rice, wheat grains etc., keeping the white cone downside. The top red cap should be at the level of the grain surface. The trap is unscrewed once in a week and the insects trapped can be identified and killed. Two to three traps are recommended per 25 kg bag/bin. Insects present in the top six inches of the grains can be monitored, collected and killed. More than 80% of the insects can be controlled within 10-20 days. It is used to monitor and control various storage insects including *Rhyzopertha dominica*, *Sitophilus oryzae*, *Tribolium castaneum* etc.

Pit Fall Trap

It is used for capturing insects active on grain surface and in other

layers of grains. It consists of a perforated lid (2-3 mm dia), a cone shaped bottom portion and a sticky material on inner side of cone. This trap is modified by attaching a cone shaped bottom with perforated lid which tapers into a funnel shaped trapping tube. It can be used to trap insects present in the grain surface and within the grains.

Two-In-One Model Trap

It is made by combining probe traps and pit fall trap. It is more efficient to trap insects in top and deep layer of the grain bags. It can trap live insects. It attracts more number of insects when used along with pheromones.

Indicator Device

It consists of cone shaped perforated cup (3 mm dia) and a lid at the top. A cup is fixed at the bottom with a container and circular dish, smeared with vaseline. Insects stuck on the vaseline can be monitored. The field carryover infestation can be monitored before storing. It is useful to monitor pulse beetle in pulses. The cup with 2 mm dia perforations is recommended for monitoring cereals.

Automatic Insect Removal Bin

TNAU insect removal bin can remove insects automatically. The structure has 4 major parts namely outer container, inner perforated container, collection vessel and the lid. The model exploits wandering behaviour of stored product insects as well as the movement of these insects towards well aerated regions. The grains are held in the specially designed inner perforated container. The space between inner and outer container provides good aeration for the insects.

Insects, while wandering, enter the perforation to reach the aerated part and while doing so, get slipped off and fall into the collection vessel through a pitfall mechanism provided in the collection vessel. In order to quickly collect the insects, as and when they emerge from grains, perforated (2 mm) rods are fixed in the inner container.

The container will be useful for storing rice, wheat, broken pulses, coriander etc. The insects such as rice weevil, lesser grain borer, red flour beetle, saw toothed beetle, which are commonly found attacking stored grains can be removed automatically by storing grains in this container. Within a very short period of 10 days a majority of the insects (more than 90 per cent) can be removed from the grains. The containers are available in 2 kg, 5 kg, 25 kg, 100 kg and 500 kg capacities. Grains (paddy and sorghum) stored in Automatic insect removal bin (100 kg and 500 kg) recorded only 1-4% damage by insects compared to 33 to 65% damage in ordinary bin after 10 months of storage. The population of insects (*R. dominica*, *S. oryzae*) ranged from 0-2/kg in grain stored in 100 kg Automatic insect removal bin compared to 5-191/kg in ordinary bin after 10 months of storage (<https://vikaspedia.in/agriculture/post-harvest-technologies/technologies-for-agri-horti-crops/storage-insect-pests-management>).

Stack Trap or Warehouse trap

The invention disclosed in this application relates to a device for detecting stored grain insects in bagstacks which comprises a main hollow tube having a diameter in the range of 1.8 to 2.0 cm with equi-spaced perforation in the range of 1.8 to 2 mm on its upper portion with a bend at one end which ends in a transparent collection unit to collect the insects falling down from the bend, the other end of main tube being closed (<https://vikaspedia.in/agriculture/post-harvest->

technologies/technologies-for-agri-horti-crops/storage-insect-pests-management).

Advantage

- ❖ The device is useful in detecting stored grain insects in bag stacks of the food grain warehouses without any damage to sacks.
- ❖ The device does not require any bait materials to trap insects.
- ❖ The device is useful in studying the distribution pattern of stored product insects in various layers of bag stacks.
- ❖ The device will be useful to validate the effect of fumigation by using it immediately after fumigation, in different layers of the fumigated stacks.
- ❖ The device will also be useful at farm level when farmers store their produce in bags.

4 W UV Trap

The UV light trap mainly consists of an ultra-violet source (4 W germicidal lamp). The lamp produces ultra-violet rays of peak emission around 250 nanometer. The light is fitted at the centre of a funnel of 310 mm diameter at the top and 35 mm diameter at the bottom. The bottom end of the funnel is attached with a transparent plastic container for collecting the trapped insects. To hang the unit at desired points, three hooks have been provided at the periphery of the funnel. The unit is also provided with a tripod stand.

The UV light trap can be placed in food grain storage godowns at 1.5 m above ground level, preferably in places around warehouse corners, as it has been observed that the insect tends to move towards these places during the evening hours. The trap can be operated during the night hours. The light trap attracts stored product insects of paddy like lesser grain borer, *Rhyzopertha dominica*, red flour beetle,

Tribolium castaneum and saw toothed beetle, *Oryzaephilus surinamensis* in large numbers. Psocids which are of great nuisance in godowns are also attracted in large numbers. Normally 2 numbers of UV light trap per 60 x 20 m (L x B) godown with 5 m height is suggested.

The trap is ideal for use in godowns meant for long term storage of grains, whenever infested stocks arrive in godowns and during post fumigation periods to trap the resistant strains and left over insects to prevent build up of the pest populations. In godowns of frequent transactions the trap can be used for monitoring. It has been found that two traps kept at the corners of the warehouse (60m × 20m × 5m) can catch around 200 insects/day even from a godown where normal sampling did not show any insect presence, thus indicating its effectiveness as a monitoring and mass trapping device. It has been recorded around 3000 *Rhyzopertha dominica* on a single day from single trap kept in a paddy godown (<https://vikaspedia.in/agriculture/post-harvest-technologies/technologies-for-agri-horti-crops/storage-insect-pests-management>).

Smart Trap

This box-shaped device with dimensions of 21 cm × 11 cm × 7.5 cm, including the plastic box and the attached electronic kit (Figure 1) attracts insect pests, senses the entering insect and takes automatically a picture of the internal space of the box. The picture is communicated through the Wi-Fi commonly found in such establishments to an authorized person/stakeholder receiving the picture to take proper action. In this way, continuous, accurate and verifiable, real-time detection is achieved, without the need for human intervention. It is a monitoring device for urban pests in the context of smart homes and smart cities (<https://www.mdpi.com/2079-9292/7/9/161>).

Non-chemical Methods of Rodent Control

Rodents are gnawing mammals of an order, Rodentia that includes rat, squirrel, guinea pig, porcupine, voles, lemmings and their relatives, distinguished by strong constantly growing incisors and no canine teeth. They constitute the largest order of mammals. Four species of rats such as Black rat, Norway rat, House mouse, and Bandicoot rat are common in India. Out of them, rat is a predominant rodent which could cause 2.5% losses to the stored commodities. Rat is active during night with poor vision, but it has excellent senses of hearing, feeling, smell and taste. It can cause damages directly to the stored food materials and indirectly by contaminating with urine, fecal droppings and body hairs and acting as vector for around 50 human disease including typhoid, paratyphoid, trichinosis, scabies, plague etc. Some of the indigenous and non-toxic management strategies of rat is given below.

1. Formation of narrow bunds of 45 cm breadth in rice fields can avoid the construction of burrows by rats
2. Before the initiation of *kharif* crops, dig the burrows, catch and kill the rats, using professionals
3. Erection of poison bait with Zinc phosphide, using coconut wastes in rice fields
4. Send smokes generated from burning of waste cloth, gunny bags, papers etc., into the burrows to scare away rats from burrows
5. Construction of agricultural produces drying yards 80 cm above the soil surfaces can avoid the rats to claim into the drying floor
6. Keep the surroundings of the crop fields free from weeds to avoid hiding of rats
7. Crop residues should be stored away from the fields to avoid the nesting places of rats

8. Electrocution of rats, using electric fences around the warehouse, storehouse etc.
9. Fix the GI sheets at the bottom wooden door to minimize mechanical damage by rats
10. Avoid growing trees near storage godowns, store houses, warehouses etc., to avoid entry of rats
11. All rat entry point of the houses should be closed
12. Windows of store houses, warehouses etc., are to be closed with wire mesh
13. Soil surfaces surrounding the store houses, warehouse etc., are to be cemented to avoid the construction of rat burrows
14. Provide ¼” GI wire meshes in the joints of foundation of buildings and soil surfaces
15. Different storage bins made out of wood, GI sheets etc., can be used to store grains against storage insect, rat etc.
16. Patch up the holes of store houses, ware houses etc., with the mixture of cement and pieces of glasses
17. Cris-cross staking of grain bags over the wooden dunnage can minimize the post harvest losses
18. Extension of floor in the loading docks, keeping the steps away from entrance and leaving a gap of two feet between steps and the entrance and providing an obstacle at the entrance of store houses, warehouses etc., can avoid the entry of rodent
19. Extra holes surrounds of insertion of water pipes in home are to be sealed
20. Use the machines producing 40 to 50 M Kz ultrasonic waves can scare away the rats temporarily under domestic conditions
21. Biocontrol agents like owl, snake, birds, cat etc., can be employed to catch and kill rats

Non-toxic Durable Traps

Various kinds of indigenous traps such as snap traps (bow trap, wonder trap), sticky traps etc., can be used for trapping rats live or dead. Wonder trap is used to catch several individuals which works without affecting the behavior of rats. These traps are non-toxic and durable and can be used safely under domestic conditions.

Conclusions

Though the indigenous technologies developed at the grass-root level unscientifically, considering the feasibility in adaptation of those technologies or know-how work satisfactorily and provide 'Seeing is believing' impression to the stakeholders. Many of the ITKs invented and being followed by the farmers are mostly organic in nature or with locally available materials which could be comparatively more safe to the environment in which health and wealth of the human and animals are considered. It is the dire need of the plant protection scientists to find out the scientific proof of the ITKs by conducting suitable experiments under lab and field conditions so that some of the ITKs can be fine tuned and promoted to the technology level.

References

- <https://vikaspedia.in/agriculture/post-harvest-technologies/technologies-for-agri-horti-crops/storage-insect-pests-management>
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- TNAU agriportal: Plant protection



Automatic insect removal tool



Biocontrol agents of rat



Modern rat proof thrashing floor



Scientific method of storage



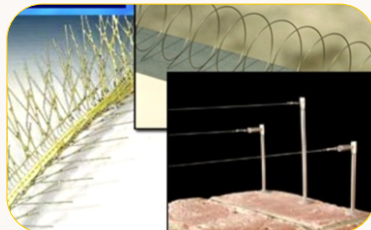
Removal of crop residues



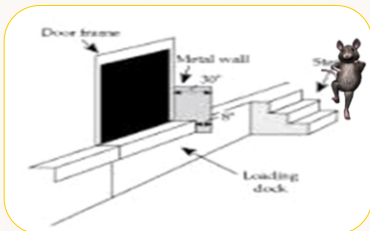
Mechanical catching of rate



Door protected from Rat



Electrical fence for rat



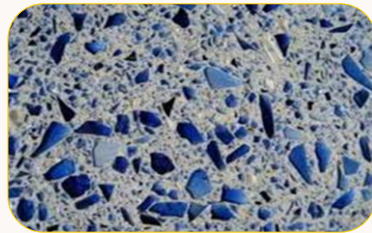
Warehouse entrance for rat



Foundation with wire mesh



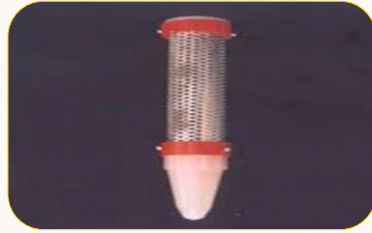
Field premises free from weed



Wholes plugged with galss pieces



Insect indicator device



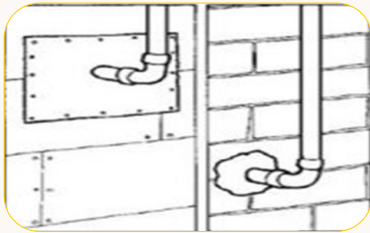
Insect probe trap



Narrow field bund for rat



Owl for rat control



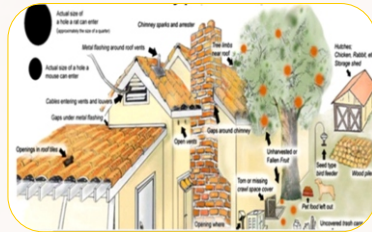
Sealing of pipe hole



Pit fall trap



Poison bait for rat



Rat entry points



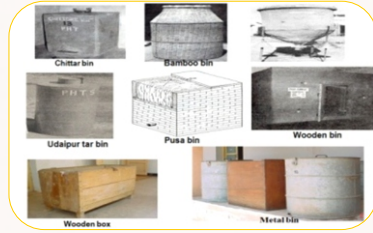
Rat traps



Smart trap for storage insects



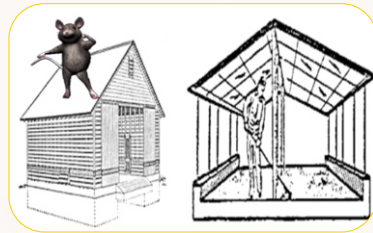
Smoking for rat



Storage bins for storage insects



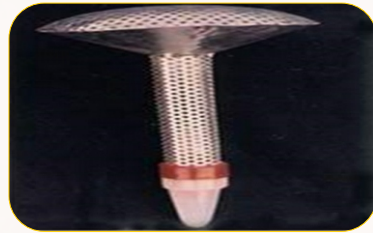
Stack trap for storage insects



Thrashing floor for rat



Avoid trees near storage



Two-in-trap for storage insects



Ultrasonic sonic sound for rat



Wire mesh for rat

Indigenous Technical Knowledge (ITK) for Plant Disease Management in India

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Abstract

Indigenous technical knowledge (ITK) refers to the unique local knowledge acquired and preserved since ages by the communities or society in particular geographical location. The ITK covers a wide range of subjects, viz. crop production, livestock rearing, natural resource management, food preparation, healthcare, insect pest and disease management in agriculture. However, a number of practices disappear because of intrusion of advanced science-based technologies that promise short-term solution to problems without being capable of sustaining agriculture. Nevertheless, due to gaining natural and organic agriculture momentum in recent years, different ITK play crucial role in sustaining agriculture in India. In India, some of the prominent ITK used for plant disease management are (1) mixing of kerosene oil with cow dung and straw for disease management in rice (2) use of bichhu buti and cow urine decoction for fungal disease management of vegetables (3) fermented cow urine along with neem leaves and piece of copper to protect rice from blast diseases, (4) control of blast and brown spot diseases in rice by leaves decoction of *Cedrelatoona* and *Xanthium strumarium* and milky liquid of *Euphorbia antiquorum* (5) Panchagavya for control of fungal disease control in chillies, cotton and lemon fruits, (6) *Kunapajala* along with mustard, honey, milk, neem bark etc are useful for plant protection. This mini chapter synthesizes a number of

ITK dealing with plant disease management in India.

Keywords: Indigenous technical knowledge, fungal and bacterial diseases, Panchagavya, Kunapajla

Introduction

The inception of the concept of sustainable agriculture in late 1980 in Indian agriculture has stimulated interest on indigenous technical knowledge (ITK) that has the element of use of natural products/local practices to solve the problems pertaining to agriculture and in allied fields. Rich tradition of ITK has been interwoven with the agricultural practices practiced by the Indian farmers. India's ancient scriptures consisting of Vedas, Upanishads, Bhagwad Gita, Brahmasutras, Purana, Manu Sniriti, Kautilya Shastra and Smritis as well as the sayings, proverbs and sages contain profound information of ideas, concepts and practices which are designed to address the process of building harmonious relationship among man, animal and nature. The enhancement of the quality of life of the Indians who in great majority live in and depend on agricultural production systems would be impossible by keeping this rich tradition of ITK away.

Indigenous technology knowledge (ITK) can be defined as any information originated out of farmers experience which has practical utility in solving farmers problems, feasible, profitable and socially acceptable and adopted farmers own conditions which moves from one generation to another by word of mouth (Grenier 1998; Sabarathnam 1996). The community of indigenous people of particular society or culture have developed ITK which is based on human experiences and test the cases over centuries, endowed with

highest possible adaptability to local culture and environment and put greater weightage on minimizing risks rather than maximizing profit. Today, many ITK systems are at risk of becoming extinct because of the rapid change in environmental conditions, economics, politics, and cultures. Many practices have vanished as they became inappropriate for new challenges. For example, most of the rice farmers from Assam, on the day of first transplanting, used to plant a banana (*Musa* sp.) sucker, a black colocasia (*Colocasia esculentum*) plant, wild turmeric (*Curcuma angustifolia*) and a bamboo perch in the north east corner of the field that is ready for transplanting. It is believed that these may help in pest control. But with times this practice has been lost in many regions of the state (Hazarika et al.2009). Under this circumstance, due to adverse effects of fast changing world by using chemicals non-judiciously in agriculture and human under changing climatic situations, today adoption of natural- and organic-farming under climate resilient conditions involving ITK has become mandatory for ensuring sustainability in agriculture.

ITK in Plant Disease Management

The “*Vrikshayurveda*” has been in use since ancient times dealing with science of plant life. In general, *Vrikshayurveda* deals with the following aspects: detection of underground water; spacing between trees; methods of propagation; preparation of pits for planting; seed treatments; nourishment; protection; and some other relevant information (Nene 2012).Specifically, the *Vrukshayurvedic* texts provide information on various traditional pest management practices using locally available resources. A plethora of literature is available

on the role of cow urine against various insect pests (Kumari and Chandla 2010). It has been demonstrated that botanicals fermented in cow products like cow dung and cow urine could enrich microbial cultures which help in providing plant nutrients in addition to acting as pest repellents (Prasad and Rao 2007). Nene (2007) also indicated that utilization of organic wastes based on the methods recommended in Vrikshayurveda offers tremendous opportunity to develop novel, eco-friendly methods of manuring and plant protection through research. To rejuvenate natural and Parampragat Krishi practices, conservation and use of ITK pertaining to plant disease management is necessary (Boruah et al. 2020). The accounts of some of the ITK pertain to plant disease management are given hereunder.

1. Farmers of Chhattisgarh state prepare solution by mixing Bicchubooti (*Utrica dioca*) in 8-10 litre cow urine for 24 hrs. The prepared solution is then dispersed in the vegetable crops such as tomato, capsicum, onion, raddish, cucurbits etc. for controlling fungal diseases (Sharma et al. 2022).
2. In Chhattisgarh, to save the paddy crop from the attack of insect/pests in the field, farmers prepare pellets of kerosene oil with cow dung and straw mix and spread them in the field. Another ITK, pellets *mahua* leaves with kerosene oil mix are being placed in the paddy field to prevent the crop from pests (Joshi and Singh 2006; Rizwan and Lyaqet 2011).
3. The South Indian farmers cut green *Aloe vera* plant and then applied in mandarin orange tree during flowering phase for controlling powdery mildew disease (Sharma et al. 2022).
4. The Jharkhand farmer formulates cow urine mixed with tobacco soaked powder for managing leaves and fruits diseases of cucurbits; cowpea and lady finger (Devendra et al. 2020).

5. Fungal disease control in chillies, cotton and lemon fruits is managed by spraying a mixture, locally prepared called '*Panchagavya*'. The mixture is prepared by mixing 5 parts milk, 2 parts curd, ½ part ghee, 2 parts cow urine, ½ part cowdung and 10 parts water. The mixture is then kept for 7 days before it is sprayed in field where fungal disease is predominant (Kanan et al. 2015). *Panchagavya* contains many groups of beneficial microorganisms such as fungi, actinomycetes, and bacteria, comprises almost all of the macro- and micronutrients and growth hormones that are required for plant growth.
6. *Kunapajala*, a fermented liquid obtained from animal wastes containing flesh, dung, urine, marrow, and skin, contains basic constituents such as amino acids, sugars, fatty acids, keratins, and macro- and micronutrients in available form. Plants naturally respond very well to the nourishment provided by *Kunapajala* and flourish with excellent growth, flowering, and fruiting (Nene 2012). *Kunapajala* along with mustard, honey, milk, neem bark, vidanga, and hair/nails/horns are suggested for plant disease. The mustard has insecticidal activity, whereas honey has antimicrobial, antibacterial, and contains plant growth hormone as well as for promoting wound healing and drought resistance.
7. Aloe vitex extract: Boil 5 Kg vitex leaves in 10 litres water for 30 minutes and cool the extract. Remove the outer part of the aloe leaves (2 kg) and grind in water to get the extract. Mix the two extracts and dilute in 50-60 litres of water to cover 0.4 ha area. Add 50-60 ml soap in the mixture and spray early in the morning or late in the afternoon. This Aloe vitex extract is reported to control bacterial and fungal plant diseases (Bissdorf 2008).

8. Tribal farmers of Chhindwara district of Madhya Pradesh use fermented solution of 5 kg of cow dung, 5 litre of cow urine, 150 gm lime + 100 litre of water to control bacterial and viral diseases in paddy and vegetable crops (Shakrawar et al. 2018).
9. Some farmers of tribal areas of Madhya Pradesh used to apply fresh cow dung near the collar region of chilli plant to control fungal disease, viz. damping off and dieback (Roy et al. 2015; Shakrawar et al. 2018).
10. For management of brown spot disease of rice, farmers used to prepare solution from 2 kg fresh leaves of papaya by dipping in 3-4 liters of water for 24 hours. After that solution is filtered by using a cloth and subsequently further diluted in 50-60 liters of water along with 250 ml of soap solution as a sticker or surfactant (Roy et al. 2015; Shakrawar et al. 2018).
11. Brown spot of rice can be controlled by spraying ash prepared by mixing ash with water. The spraying should be done at panicle initiation stage of rice. The reason behind this ITK is that ash alkaline in nature and contains hydrocarbon, sulphur etc which may prevent the spreading of infection (Saha and Dutta 2013).
12. Cultivation of marigold followed by solanaceous vegetable crops is effective to control bacterial diseases (Roy et al. 2015).
13. In Manipur, farmers are raising seedlings of tomato, chilli etc. in artificial tray made up of half split bamboo at 3-4 ft height for control of damping off of seedlings. This practice helps in production of disease free seedlings (Gogoi 2010).
14. The Meghalaya, Jaipur, Punjab and Himachal Pradesh farmer utilizes decomposed mulch for inhibiting the pathogen in the soil (Rana 2016).
15. Farmers of Karnataka and North-Eastern dissolve chilli seedlings

- in 1:3 solution of cow urine water. The cow urine water assists in protecting seedlings against damping off (Rakesh et al. 2013).
16. The Tamil Nadu and North-Eastern farmer is mixing cotton seed with ash and cow dung slurry. The ash and cow dung slurry containing cotton seed are dried in the shade before sowing. The cow dung slurry removes the fibre from the seed, protects against damping off (Manickam et al. 2013).
 17. The farmers of betelvine growing area, apply sesame, mustard and neem cake for the control of Sclerotia wilt and root rot in betelvine (Sahu and Satapathy 2021)
 18. Farmers of Tikamgarh district are using Neem and Karanj cake for the control of soil-borne disease in vegetables (Singh et al. 2010).
 19. Farmers of Chhatarpur district, Madhya Pradesh, treats ginger and turmeric rhizome by the solution of fresh cow dung (1 kg cow dung in 5 litres water) for the management of soil- and seed-borne diseases and better germination. Cow dung have emulsifying properties on seeds when applied as a thin dry layer which acts as blotting paper and readily absorbs moisture from the surrounding soil to facilitate seed germination in presence of moisture. The presence of bacteria in the cow dung residues including cellulose; hemicellulose and pectin fermenters may have antagonistic potential towards pathogens ready to attack the seed (Nene 2006) as the fungicidal property of cow urine is well documented (Khanuja et al 2003).
 20. In Sagar district of Madhya Pradesh, farmers are treating 30 kg seed of chickpea with 05 gm Heeng (asafoetida) + 200 gm salt mixed in one litre of butter milk (whey) for the management of wilt disease of chickpea. The asafetida contains about 40–64%

resin, 25 % endogenous gum, 10–17% volatile oil, and 1.5-10 % ash and is well known for antimicrobial properties since ancient time. Butter milk is also having number of beneficial bacteria that help in reducing harmful pathogens/ microbes in the soil. Application of salt slightly maintains the soil pH which may reduce the harmful microbial population. Butter milk having antifungal properties (Nene 2006) and asafoetida worked as biopesticide (Sridevi and Sridhar, 2006; Tripathi et al. 2020).

21. Titeypati (*Artemisia vulgaris*) and Chilounney (*Schima wallichii*) are being used as mulching material to manage soft rot, bacterial wilt, Fusarium dry rot of Ginger (*Zingiber officinale*) in the Sikkim state (Rajan 1999; Kumar et al. 2012).
22. Farmers are boiling 20 kg *Casuarina equisetifolia* leaves for 20 minutes in water followed by filtering and cooling. The resultant extract after proper dilution is being used for treating bacterial and fungal infections in plants (Sahu and Satapathy 2021).
23. Pre-soaking of paddy seeds in diluted cow's urine before sowing, considerably reduces the incidence of leaf spot and rice blast whereas pre-soaking of paddy seeds in milk increases its resistance against 'Tungro and Stunt' viruses in rice (Celsia and Janarthanan 2019).
24. For control of red leaf spot disease in paddy, the seeds are soaked in 'Pudina' leaf extract for 24 hour (Celsia and Janarthanan 2019).
25. A mixture of 5 kg of common salt and 15 kg of sand is applied for 1 acre to control brown spot disease in rice (Celsia and Janarthanan 2019).
26. Soaking of the paddy seeds in 20% mint leaves solution before sowing will control the brown leaf spot of rice (Celsia and Janarthanan 2019).

27. To control blight disease in paddy, *mahua* (*Madhukaindica*) cake (100 g) is mixed with 1 litre of water. The extract is mixed with washing powder and spraying is done (Shakrawaret al.2018).
28. In Manipur, farmers broadcast ash on the vegetable crops to protect from the powdery mildew. They observed that broadcasting of ash in the morning while the plants are still damp with dew effectively reduces the disease incidence and prevents yield losses. The ash becomes wet after sticking to the dew covered plant and slightly alters the pH of the plant surface, altering the microclimate and making the environment uninhabitable for the pathogens (Ansari et al. 2011).
29. The liquid extract of the *Cedrela toona* leaves fermented with cow urine for ½ a month is used for spray the rice crops to control blast of rice crops (Santosh and Chhetry 2012).
30. Milky liquid of the plant of *Euphorbia antiquorum* is extracted by grinding and further diluted with water @ 1:10 and sprayed over the rice crops for control of blast and brown spot diseases in rice (Santosh and Chhetry 2012).
31. In arid regions of Rajasthan, use of raw cow milk (RCM) along with *Trichoderma* and or *Gliocladium* has been found effective in controlling downy mildew in pearl millet, anthracnose and leaf curl disease of chilli, and Fusarium wilt disease in Jeera (Cumin) (Kumar, 2014). Raw cow milk is known to have amino acids and potassium phosphate which help in boosting the immune systems of plants through induced resistance. Preservation and use of RCM in agriculture is crucial in Indian perspective because of patenting of a milk-based product for controlling fungal diseases in general and mildews in particular by the Horticulture and Food Research Institute of New Zealand Limited (Hfrinzl 2005).

32. Growing of trees such as *Azadirachta indica*, *Lanneacoro mandalica*, *Leucaena leucocephala*, and *Thespesia populnea* on field bunds is a regular practice in North east coastal region of Tamil Nadu. This practice helps to optimize the supply of green leaf manure and thereby improves the nutrient availability, provides stress resistance against soil moisture, and reduces the intensity of soil-borne diseases especially wilt caused by *Fusarium oxysporum* in vegetables and root rot caused by *Marophomina phaseolina* (Kanan et al. 2015).

Conclusions

Indigenous knowledge including plant protection is gradually disappearing from the society due to fast development of advanced technologies in agriculture. Nevertheless, many proven and productive indigenous knowledge existing in the society can still relevant to be applied in practicing areas and also in similar agro-ecosystems in rest of the country. Hence, documentation of indigenous knowledge is necessary in order to blend with modern technologies for effective management of plant pathogens in eco-friendly manner. In present era, such documentation will help farmers and researchers to conserve plant protection based ITK for rejuvenating and promoting natural and organic farming in India.

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Indigenous Traditional Knowledge for Stored Grain Insect Pests Management

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Introduction

Indigenous Knowledge (IK) is unique to a particular culture and society. It is the basis for local decision making in agriculture, health, natural resource management and other activities. Learning from ITK, by investigating first, what local communities know and have can improve the understanding of local conditions and provide a productive context for activities designed to help the communities (Dunkel and Sears 1998). Throughout history, many cultures have used natural products from plants to protect themselves, their crops and their livestock against insects (Dunkel and Sears 1998). Traditional storage methods adopted by farmers are well anchored in the culture of local people. However, they seem to be ineffective in containing the heavy losses caused by pest infestations. Effective storage plays an important role in stabilizing food supply at the household level by smoothing seasonal food production. However, despite significant advances in food storage methods, many communities still rely on traditional storage methods for food, fodder and seed. Although these traditional storage methods are being relatively simple and inexpensive to construct and maintain, lead to substantial post-harvest losses. Indigenous practices are passed on from generations and are an outcome of elder's wisdom and experience as a result of their close contact and deep knowledge of their environment. These reasons imply that indigenous knowledge is

eco- friendly and safe both to man and his environment. Indigenous Knowledge is the knowledge which has unfolded within the group and is transferred from one generation to another. Proper storage of food grains is necessary to prevent spoilage, increase keeping quality and to avoid wastage of precious resources and money. Food security till the forthcoming harvest is also ensured by good storage practices. Along with this, the farmer is not compelled to sell the harvest or commodities during the period when market is already flooded with the produce. By doing so they help to reduce the storage losses which are greatest when compared to the ones in the field before and during storage.

The use of non-chemical methods for pest control is already gaining importance in several countries including India. The integrated pest management strategies developed and promoted by the Governments is now based on the use of plants extracts. If an effort is made towards production of Indigenous Traditional Knowledge (ITK) based products on cottage scale, it can be an economically viable option for sustainable development of eco-friendly pesticides/insecticides. The ITK practices followed by farmers/tribal peoples are enumerated below:

Drying and Packing

The sun drying is carried out and the dried pulse grains are packed in gunny bags. This is helpful in removing extra moisture and elimination of field infestation. The activity is repeated more frequently in a season. This is usually done on a full moon day, as this is thought to reduce the risk of damage by pests and diseases. The method is very convenient to follow for any quantity of grain. This method controls the internal insect and infestation growth due to periodic drying.



Sun drying

Mixing with other Crop Grains and Packing

In this practice, pulses are packed tightly in double gunny bags or hard knit gunny bags to reduce the insect movement through weave clearance. Smaller cereal grains are mixed with pulses to fill intergranular space to limit the movement of the insects and also air circulation in the stored grain, which would prevent development and spread of pulse insects and pests. It is easy to follow this practice, if the grains are small in quantity, as no additional cost is involved. If the method is to be adopted for huge quantity of grain, considerable efforts are needed to separate cereals and pulse grain as there are no suitable cleaners and graders are available in rural areas.



Mixing of grains

Storage in Earthen Pot/Structure

This practice involves pouring of pulse grain into the structure and placing a layer of dry sand or cow dung and clay mix at the top to a

thickness of 20 cm. The grains to be stored in this practice need to be dried before storage to reduce the moisture content to safe storage level. Even little excess moisture will spoil the grain in this storage practice. The enclosed storage structure provides complete protection to the stored grain from external pests and insects infestation.



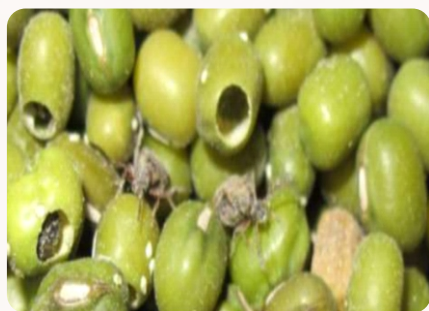
Dry sand



Metal bin

Mixing of Plant Materials with Pulse Grains

In this traditional practice of protecting the pulse grains from the storage pests and insects, any one of wood ash, cow dung ash, soap nut leaves, neem leaves or *Pongamia* leaves are mixed and then stored in bins or bags. The farmers believe that these substances act as insect repellents, antifeedant and oviposition deterrents. This practice protects the grains up to few months from pests and insects. As the effectiveness of plant materials is lost, the infestation starts again.



Infested grains



Neem leaf

Storage of Grains with Natural Products/Botanicals

The practice of admixing of natural products or botanicals for the storage of food grains dates back to the very earliest periods of known history, well before the advent of synthetic insecticides/fumigants. The practice is common in Africa and Asia, with the increasing development of resistance and the negative impact of these synthetic insecticides on human health and environments (Isman 2008). There is renewed interest in the utilization of these products for the management and preservation of stored grains from insect infestation. Being cheap and readily available, resources-poor farmers perceive that natural product possessed repellence, anti-feeding and ovipositional deterrence, fumigant or contact activity, growth inhibition etc., and uses them against storage insect pest than relying on the expensive, adulterated and not readily available synthetic insecticides to prevent storage pest from attacking their produce (Rajashekar et al. 2012). In this practice farmers mix pulverized plant parts with the grains in the storage container(s), the irritating odour emanating from these products repelled insect from infesting the produce. At times, famers place the leaves of the plants believed to possess insecticidal properties as layers in between the gunny bags arranged one above other in the store room. Using the natural products/botanicals grains could be stored up to a year. There are empirical reports or findings on the utilization of *Acorus calamus*, *A. indica*, *Pongamia glabra*, *Artemisia* species, *Citrus aurantium*, *Curcuma longa*, *Khya senegalensis*, *Caspicum* spp. etc. for the management of stored grains insect pest.

Oil coating to Pulse Grains

In this indigenous storage practice, the pulses are coated with a thin layer of edible oils, neem (*Azadirachta indica* A. Juss.) or karanja

(*Pongamia pinnata* Pierre) oils to protect them against insect infestation. There is a complete protection from infestation for a longer period of storage in this method. Coating of edible or non-edible oils to the pulses drastically reduces adult insect emergence and thereby controls the storage loss. The insect not lays eggs on oil coated pulse grains and there is no emergence from already laid eggs.



Infested pulses

Heating and Packing

The dried pulse grains are heated by mixing wood ash/cow dung ash/sand and stored in a new earthen pot to suppress the pest infestation growth during storage. The crystalline property of the ash/sand causes mechanical wound to the insect body, as a result, the dehydration takes place and the insect dies. Due to elimination of insects and pests before storage, the practice provides protection to grains up to one year.



Packaging of grains

Use of Chilli Fumes for Storage

The storage structures and rooms are major source for the stored grain pests. To get rid of the initial inoculum load, farmers use partially burnt cow dung cakes and put chili powder to make fumes in the room before storage of grains. Then the room is kept air tight for two days and then used for the store the grains.



Mixing of grains

Sand Layer to Pulse Grains

In this indigenous storage practice the well dried pulses and filled in a container and 3.0 cm sand (without soil particles) layer is placed over the pulse grains and the sand layer keeps the grains free from pulse beetles up to six months. The sand layer does not allow the beetles to come up on grain surface for copulation and if insect movement takes places in sand layer the wax layer is damaged by sand and insect pests kills due to water desiccation.



Sand layer to pulse grains

Storage with Cow Dung

Seeds meant for next season sowing are stored with cow dung after

the seeds must have been ascertained to be properly dried. Rural farmers believe that cow dung possess pesticidal properties to protect such seeds from insect infestation, they equally believe that cow dung immunostimulant properties increased seed viability (Karthikeyan et al., 2009). For seeds to be stored in cow dung, farmer collect fresh cow dung and made it to a plate-like round shape and the seeds are embedded into the cow dung and then sun dried for 2–3 days depending on the intensity of the sunlight. In the process of sun drying, the seeds get stuck onto the cow dung and then stored in open or inside a wooden box. Seeds treated this way can be stored for up to a year.



Cow dung

Storage by Common Salt

Common table salt was used to store pulses for a period of 6-8 months. In this practice about 20 g of salt is mixed manually in one kilogram of pulse. Due to this practice, insects were kept away from the stored grains. As salt had abrasive action on skin of insects thereby preventing their movement inside the storage containers and as a result their growth in the storage box was inhibited. This practice was perceived to be moderately effective and affordable in cost. Karthikeyan (2008) also reported that farmers used common ingredient, table salt, in red gram grains for storage in their house. Salt has hygroscopic and insecticidal property which helps in keeping the grain dry by absorbing the moisture thus avoiding spoilage and hence aid in safe storage (Gupta et al. 2010).

Storage of Rice

Majority of the respondents mixed turmeric powder with the rice grains before storing them in containers or jute bags. Some of the farmers applied mixture of mustard oil and turmeric powder on rice grains. Other methods used were putting cloves of garlic in layers of rice as garlic.



Infested rice and Rice weevil



Garlic cloves

Use of camphor

Use of camphor for both the cereals as well as pulses repels a wide range of storage pests. Hence majority of respondents placed 1.0 gram of camphor piece per 5 kg. of grain in the jute gunny bag. This practice of keeping camphor inside the storage bag repelled the pests due to the strong odour emanated from camphor. Short term storage of grains up to 3 months was possible with this traditional storage method. For subsequent storage, the grains were sun dried and fresh camphor was kept in the bag.



Camphor

Storage of Wheat

As neem oil was used for pulses, dry neem leaves were put in cloth bags, by most of the respondents, which were placed at the top, middle and bottom of the container. Anti-parasitic, sterilant, insect and pest repellent, anti-fungal and non-toxic qualities of neem prevent the wheat grains from spoilage. Match boxes were also used by farmers in the similar fashion because of phosphorus in them which is anti-repellent in nature. Another method adopted by farmers was mixing of cow dung ash in wheat as it is desiccative and insecticidal in nature. A few farmers used turmeric powder at the bottom of container, in the middle and top of container. Turmeric has pesticidal, insecticidal and antifungal properties. The use of neem leaves, husk, salt, camphor was practised either singly or in combination to prevent food grains from insect infestation (Dhaliwal 2010).



Lesser grain borer & Rice weevil

Finger millet Husk for Grain Storage

Finger millet is a common hill millet in the tribal area. Farm women use husk of finger millet as it is fine and smooth in texture. It is used in storage of all type of grains as well as pulse seed, preferably in the

earthen pots, locally called Madka. This prevents the grains from the storage grain pests.

Various common ITKs are presented below according to their applications.

- ❖ Storage of harvested jowar is done by digging a pit underground and keeping the produce with dry neem leaves. The pit is then made air tight with mud and left for drying in Sun. This storage can be safely done for two years and the produce remains free from pests.
- ❖ Spray of castor seed oil and then making it air-tight help safe storage of wheat in a small go-down/room.
- ❖ Leaf powder of *Vitex negundo* is mixed with paddy to control common storage pests. This is practiced in Tamil Nadu.
- ❖ Ash is commonly obtained by burning the wood. It is mixed with Cowpea. The ash has crystalline property and may cause wounds in insects' body, which leads to dehydration and ultimately insects die after some time.
- ❖ Turmeric and chilli powder are added to stored rice to repel the different stored grain pests. These substances act as insect repellent, antifeedant and oviposition deterrents.
- ❖ Ginger powder is mixed with pulses. The pungent taste of ginger gives protection to the stored seeds of Pulses. Ginger causes adult mortality in *Callosobruchus chinensis* and repels *Tribolium castaneum*.
- ❖ Seed mixed with *Acorus calamus* (baje) powder in the ratio of 10 kg: 1 kg, would help in preserving the seed free from stored pests for long time.

- ❖ Sorghum seeds were treated with dried cow dung powder and cow urine before sowing. For one kg of seed approximately 100 g cow dung powder and 250 ml cow urine were used for better germination. Cow dung powder was also used for storage of seeds.
- ❖ Lime powder (Calcium carbonate) is mixed uniformly with grains and stored them in gunny bags at dry place. The lime is generally used @ 10-15 g/kg of grains. The rice grains are protected from the pest attack. The lime has a repellent and antifeedant property and lime also prevents insects to get multiplied

Conclusion

Food grains are the main source of human calorific requirements and animal feed worldwide and more so in developing countries. The spoilage of grains at the time of storage has resulted in the starvation of million people worldwide, including people who suffer from undernourishment. Indigenous technical knowledge provides valuable inputs to make efficient use of natural resources and extends relevant support for sustainable development. Indigenous techniques used are mostly organic, eco-friendly, sustainable, viable and cost effective. But there is a need to explore, verify, modify and scientifically validate these practices for their wider use and application. All these traditional techniques are cheap, technically feasible, compatible with components of the existing farming system and internal resources of household, eco -friendly, avoiding spoilage of stored grain, check insect pests, simple and easy to apply.

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Ethnoveterinary Medicinal Practices among Tribal Community of Chhattisgarh

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Introduction

The use of plants as medicine is widespread throughout the world. It is estimated that more than 35,000 plant species are being used around the world for medicinal purposes. India is endowed with rich wealth of medicinal plants which are widely used by all sections of people either directly as folk remedies or in different indigenous systems of medicine or indirectly in the pharmaceutical preparations of modern medicines. More than 8, 000 plants are used in our country especially for their medicinal values by the rural people (Dandotiya et al. 2013). The knowledge of botanical medicine has been accumulated in the course of many centuries based on different Indian systems of medicines such as Ayurveda, Unani and Siddha. These systems of medicine play a very important role in healthcare system of rural people covering all types of ailments and developed over years of observation, trial and error, inference and inheritance has largely remained with the aboriginal people. Traditional medicinal practices and ethnobotanical information play an important role in the scientific research, particularly when the literature and field work data have been properly evaluated. The documentation of indigenous knowledge on the utilization of local plant resources by different ethnic groups or communities is one of the main objectives of ethnobotanical research.

Ethnoveterinary Medicine (EVM) refers to holistic study of traditional knowledge, skills, methods, practices and folk beliefs of the people about the health care, healthful husbandry and production

of livestock (McCorkle 1986). It encompasses information on diseases and their control; remedies and clinical practices for treatment and prevention; management, feeding and breeding strategies; spiritual elements; and the human resources that hold the information and experience (Mathias 2004). The use of plant based veterinary medicine is increasing in the recent times. Several workers have documented ethnoveterinary practices in various districts and states of India with different lines of researches in Ethnoveterinary plant species used in curing the various ailments of livestock.

The Chhattisgarh state of India is one of the best representatives of the Deccan Peninsular bio-geographic zone that obtains biodiversity rich deciduous forests. About 44% geographical area of Chhattisgarh state is under various types of forests with rich plant diversity, of these about 17 species of plants used as ethnoveterinary drugs are reported by Shukla et al. (2006). The various tribal communities comprise about 34% population of Chhattisgarh states. About 44 tribal communities live in Chhattisgarh state. The predominant tribes are Abujhmaria, Baiga, Bhil, Gond, Kol, Korku, Korwa, Oraon, Sahariya etc. They inhabit in and around the forest areas and mainly dependant on forest resources for fulfilment of their routine requirements such as food, medicine, fodder, fibre, hunting and fishing, household and agricultural equipments etc. Although they mainly depend upon forest resources for their livelihood but they also raise domestic animals for milk, agriculture and commercial purposes. As the modern medicine is either not available or not affordable for the poor tribes therefore, they use traditional veterinary practices to prevent and treat common animal ailments and diseases with the help of locally available plants. The ethnoveterinary medicine is easily available, cheap and effective, cures many diseases and causes no side effects. Besides, no

complicated technology is required for its preparation. The tribal people have been using this traditional system for a very long time. They have acquired this valuable knowledge from experience and trial and error methods. This knowledge has passed down from one generation to next generation by word of mouth. But it has been observed that the younger generation of the tribal communities neither had the knowledge nor the experience to practices of ethno veterinary medicine effectively. Therefore, it is necessary that before this valuable traditional knowledge is lost forever it must be properly documented from old and experienced tribal medicine men.

In order to conserve and maintain the natural populations of these ethnobotanical species as well as to meet their requirements, the Chhattisgarh State Minor Forest Produce Co-operative Federation has been established, which deals with various conservation, development and livelihood issues at state level. A large number of hunter-gatherer societies live in the forests of Chhattisgarh from historical times, and these tribal and non-tribal groups meet their daily requirements from the surrounding forest resources. Over the years of trial and errors, they have accumulated a great deal of knowledge on the utility of surrounding biodiversity. This traditionally occupied knowledge is transmitted by oral means and is mostly acquired through learning-by-doing approaches.

Summary of Ethnoveterinary Medicinal uses in Chhattisgarh

The livelihood of tribes of Chhattisgarh is primarily depends on the forest resources, and they use to collect many ethnobotanical species for their day-to-day activities. They use traditional veterinary practices to prevent and treat common animal ailments and diseases with the help of locally available plants (Table 1).

Table 1. List of medicinal plants used for animal diseases treatment

Botanical name	Local name	Family	Indication	Parts used
1. <i>Abrus precatorius</i>	Kainch, Indian Liquorice, Crab's eyes	Fabaceae	Cataract of cattle	Root
Method of application: It is believed that cataract of cattle is cured when the roots of this plant are tied to the neck of the cattle particularly on Saturday after a process of purification of the animal with Dhupa.				
2. <i>Achyranthes aspera</i>	Apamaranga	Amaranthaceae	Bloat, diarrhoea, corneal Opacity, Anorexia in ruminants and Ranikhet Disease in poultry	Leaves, root
Method of application: ❖ 20 gms of roots are collected, washed and fed to the cattle along with green grass once only in case of bloat. The animal gets relief within 3-4 hours. ❖ Seven leaves of this plant are given orally once only to cure nonspecific diarrhoea. ❖ Seven leaves along with a piece of stem are massaged on thigh opposite of the eye affected. Opacity is cleared at least after 3-4 such applications. ❖ At least 20 gms of the root of plant is given orally with grass. Non-specific anorexia is cured with one such administration. ❖ Take about 50 gms of root, 50 gms garlic, 100 gms green turmeric and 25 gms red chilli. Grind all the ingredients of make a paste. Then mix this paste with 2.250 kg of broken rice and dry under shade. Feed this mixture @ 10gms/bird daily for at least 5 days. Provide sufficient water during the period of medication. This can be repeated thrice in year to prevent Ranikhet Disease in poultry.				
3. <i>Aegle marmelos</i>	Bael	Rutaceae	Wound and Black Quarter	Green leaves

Method of application: ❖ About 200 grams of leaves boiled in 1 litre of gruel for half an hour. The decoction applied over the wound twice a day for seven days, heals up the wound. ❖ The leaves of this plant along with leaves of <i>Datura</i> are boiled and a decoction is prepared and applied to the foreleg joint arch of the cattle suffering from black-quarter disease. At the same time the decoction is also administered orally to the diseased animal.				
4. <i>Alangium salviifolium</i>	Ankul	Alangiaceae	Conjunctivitis in cattle	Tender leaves
Method of application: The tender leaves of this plant are crushed and the juice is collected for use as eye drop in traumatic conjunctivitis @ 2 to 3 drops daily for 3 days.				
5. <i>Ananas comosus</i>	Pineapple	Burmaniaceae	Worm infestation	Leaves
Method of application: 20ml juice extracted from the leaves mixed with 20 gms of turmeric paste and one spoon of honey is administered orally to calves with gastro-intestinal parasitism.				
6. <i>Andrographis paniculata</i>	Bhuinnimba	Acanthaceae	Worm infestations and dermatitis in cattle	Whole plant
Method of application: Juice (10-15 ml) is administered along with honey (One spoon) orally for all types of worm infestations. The plant extract is applied over skin for dermatitis				
7. <i>Azadirachta indica</i>	Limba, Neem	Meliaceae	Black Quarter, Glossitis, Ascariasis	Leaves, stem
Method of application: ❖ Neem leaves with marking nut oil are boiled and applied on the fore-leg joint arch of the cattle suffering from black-quarter disease. ❖ A piece of neem stick is to be inserted to the palatal foramen of the cattle suffering from glossities. ❖ Green leaves are fed to the calves, kids and lambs to get rid of ascariasis				

8. <i>Bacopa monnieri</i>	Brahmi	Scrophulariaceae	Worm infestation of cattle and buffaloes	Leaves
Method of application: About 2 g of green leaves is ground to make paste and given orally in case of worm infestation.				
9. <i>Bambus aarundinacea</i>	Bamboo, Kanta Baunsa	Poaceae		Leaves
Method of application: Bamboo leaves are fed along with green fodder after delivery of the cow and goat for the early removal of the placenta				
10. <i>Bombax ceiba</i>	Simuli, Buru	Bombacaceae	Bone fracture	Bark
Method of application: The bark of the plant is made into paste and applied on the joints and wounds of animals in case of bone fracture.				
11. <i>Butea monosperma</i>	Palasha	Fabaceae	Worm infestation, Diarrhoea	Seeds
Method of application: ❖ Five gram seeds with 10-15 gm of jaggery is given orally once only to cure worm infestation in cattle. ❖ The same can be given for three days for treatment of diarrhoea in cattle.				
12. <i>Capparis zeylanica</i>	Hadabhanga	Capparaceae	Fracture	Whole plant
Method of application: The whole of plant (about 50 grams) is crushed with milk and made a paste. The paste is smeared over the site of fracture of animal and bandaged once in every two days for five applications. It facilitates the healing and union of the fractured bone.				
13. <i>Carica papaya</i>	Amritbhanda	Caricaceae	Agalactia in cows	Fruit
Method of application: One fruit is crushed with 100 grams of black gram and mixed with gruel given twice daily for 4 to 5 days in case of agalactia.				
14. <i>Cassia fistula</i>	Sunari, Swanajhari	Caesalpinaceae	Black-quarter, Swellings in cattle	Leaves, Root

Method of application: ❖ Leaves of this plant along with banana (<i>Musa paradisiaca</i>) and bel (<i>Aegle marmelos</i>) leaves are mixed with cattle dung, boiled and made into a paste. The paste is applied on the foreleg joint of cattle suffering from black-quarter disease. It is applied continuously for 4 days. ❖ The roots of the plant along with black pepper (<i>Piper nigrum</i>) and small amount of red mud are mixed and the mixture is applied on the throat of the cattle to relief the swelling				
15. <i>Cassia occidentalis</i>	Chakunda	Caesalpinia- ceae	Wound	Leaves
Method of application: Juice extracted from the leaves of this plant is applied on the fresh bleeding wounds of animals to stop bleeding.				
16. <i>Celosia argentia</i>	Mayurtopa	Amarantha- ceae	FMD and hip- dislocation	Root
Method of application: ❖ One gram of its root is ground and given orally once daily for 3-4 days in case of FMD. The preparation can be applied externally over FMD lesions for early healing. ❖ Ten grams roots are ground and applied topically in case of hip dislocation after setting right the dislocation.				
17. <i>Chloroxylon swietenia</i>	Sitaveru	Meliaceae	Wound	Tender leaves
Method of application: The paste made out of tender leaves of this plant is applied over the wound after washing and cleaning it with warm water. The wound is healed up after 4 to 5 days of application once daily. It also kills the maggots if present.				
18. <i>Cissampelos pareira</i>	Akanabindhra	Menisperma- ceae	Non-specific Diarrhoea	Root
Method of application: 25 gms of roots is crushed and mixed with one glass of curd and then drenched 2 times daily. Diarrhea is ceased after 2-3 days.				
19. <i>Cissus quadrangular</i>	Hadasangat	Vitaceae	Fracture	Stem
Method of application: The quadrangular stem of this plant is fried in sesamum or groundnut oil and bandaged on the bone fractured point of the cattle. Then karanja (<i>Pongamia pinnata</i>) oil is applied on the bandage.				

20. <i>Coccinia indica</i>	Kunduri	Cucurbitaceae	Glossopharyngitis and Fever	Leaves
Method of application: ❖ Five gram of leaves and 5 gm of common salt ground with 10 g of human urine. In case of glossopharyngitis (Benga), the vase of the tongue of cattle is to be cauterized with a hot wire on 2-3 points and the above suspension is given orally once to reduce the associated symptoms. ❖ In case of fever, 5 gm leaves is ground with 5 g common salt and then mixed with 100 ml mustard oil and the preparation is massaged from head to tail on the back. This will reduce the fever within half an hour.				
21. <i>Eclipta prostrate</i>	Kesandura	Asteraceae	Tympany	Whole plant
Method of application: The whole of plant (about 50 grams) is crushed finely and mixed with salt and 1 liter of water and administered orally 2 to 3 times a day for 2-3 days relieves tympany in cattle.				
22. <i>Emblicaofficinalis</i>	Amla	Euphorbiaceae	General debility, indigestion	Fruit
Method of application: About 30-50 gms of powder made from dried fruits is given daily for 15 days to cattle in case of general debility and off-feed.				
23. <i>Hygrophila auriculata</i>	Koilikhia	Acanthaceae	Glossopharyngitis	Root
Method of application: All the roots of one plant along with grass in fed to the cattle suffering from glossopharyngitis. It cures the disease when given once daily for 2-3 days.				
24. <i>Jatropha curcas</i>	Jahajigaba/Baigaba	Euphorbiaceae	FMD	Stem juice
Method of application: Milk of this plant mixed with charcoal powder is applied on the FMD lesions on foot. This prevents maggot formation and helps in speedy healing of the wound.				
25. <i>Lasia spinosa</i>	Kantasaru	Araceae	Haemorrhage septicaemia	Root

Method of application: Fifty grams of root is crushed with 2 gms of pepper and 2 gms of sunthi and administered orally 2 times a day in case of haemorrhage septicaemia.				
26. <i>Leea indica</i>	Raktakhai	Leeaceae	Fracture	Root
Method of application: Ten grams of root of <i>Leea indica</i> , a small piece of creeper Hadjoda (<i>Cissus quadrangulare</i>) weighing about 50 gms and 50 gms of barks of <i>Careya arborea</i> (Kumbhi) are ground and made paste. It is applied over the fracture after setting the bones in apposition and then bandaged with bamboo sticks and bandage cloth to keep it immobile. The bandage should be opened after seven days.				
27. <i>Mangifera indica</i>	Mango	Anacardiaceae	Diarrhoea	Bark
Method of application: Barks (20 grams) of this plant with 20 gram of bark of <i>Psidium guajava</i> (Guava) crushed together, mixed in gruel, kept overnight and drenched early in the morning in empty stomach @ 50 ml daily for 3 to 4 days gives good result against bloody diarrhoea.				
28. <i>Momordica charantia</i>	Karela	Cucurbitaceae	Early removal of placenta (Ecboic)	Leaves
Method of application: The leaves of this plant along with salt are given to cattle after delivery for the early removal of placenta.				
29. <i>Mucuna pruriens</i>	Baidanka	Fabaceae	Gastro-intestinal parasitism	Seed, root
Method of application: ❖ The skin of the seeds mixed with milk is drenched to the calves to get rid of Ascariasis. ❖ The root of the plant is administered orally along with green straw to kill and remove the intestinal worms in case of cattle.				
30. <i>Nicotiana tabacum</i>	Dhuanpatra	Solanaceae	FMD	Leaves
Method of application: Processed tobacco leaves are crushed and make into a paste with sawdust (wood). The paste is applied on the hoot of the cattle affected with foot and mouth disease.				
31. <i>Nymphaea pubescens</i>	Saluka mandi/ Lal Kain	Nymphaeaceae	Diarrhoea	Tuber

Method of application: About 200 g of the tuber of this is ground with 200 ml water and it is given as drench once only to cure diarrhoea. It also acts as tonic.				
32. <i>Phyllanthus niruri</i>	Bhuin amla/ Badi amla	Euphorbiaceae	Jaundice, indigestion	Whole plant
Method of application: Whole plants are collected and ground to paste along with seven leaves of Bael. About 50 gms of this paste is drenched by mixing with gruel once daily for 7 days.				
33. <i>Polygonum hydropiper</i>	Dhadisula	Polygonaceae	Haemoglo- bunuria	Leaves
Method of application: At least 5 gms of tender leaves is crushed with salt and 200ml of curd and the mixture is drenched 2-3 times a day for 3 days.				
34. <i>Pongamia pinnata</i>	Karanja	Fabaceae	Cold, wound	Seed kernels, oil
Method of application: In case of common cold and serous discharge from nose; karanja seed oil is applied on and around horns and ears of the animals. The karaja oil alone or in combination with neem oil is used treat the open wounds.				
35. <i>Psidium guajava</i>	Guava	Myrtaceae	Diarrhoea	Bark
Method of application: Barks (20 grams) of this plant with 20 gram bark of mango tree (<i>Mangifera indica</i>) are crushed together, mixed in gruel, kept overnight and drenched early in the morning in empty stomach @ 50 ml daily for 3 to 4 days. It gives good result against bloody diarrhoea.				
36. <i>Ricinus communis</i>	Jada/Arandi	Euphorbiaceae	Removal of placenta (Ecboic), bloat	Leaves, oil
Method of application: ❖ Leaves along with common salt made into a paste and administered orally to cattle twice after delivery for the removal of placenta. ❖ Castor oil drench is given to ruminants in case of bloat.				

37. <i>Semecarpus anacardium</i>	Kalabhalia/ Dangorbhalia/ Bhalia	Anacardiaceae	Abscess of cattle, FMD, Enterotoxae- mia	Fruits, Seeds, Leaves
Method of application: ❖ Warmed marking nut oil (the tar-like oil is extracted from the pericarp of the fruit) is applied on the abscess of the cattle for a rapid cure. ❖ Warmed oil is also applied on the hoof of the cattle suffering from foot and mouth disease. ❖ The punctured fruit is rubbed on the mount of the goat suffering from enterotoxaemia. ❖ At least five fruits are cut into small pieces and then ground with 10 g of rice to make a paste. It is given orally for general anorexia and dullness. ❖ Paste made of leaves is efficacious in healing up the FMD wounds in five days.				
38. <i>Tephrosia purpurea</i>	Kolathia- pahanra/ Bana koltha	Fabaceae	Retention of placenta.	Whole plant
Method of application: In case of retention of placenta, three plants are crushed and mixed with 10 grams of asafetida is given orally. The placenta is expelled out after 30 minutes of administration.				
39. <i>Terminalia chebula</i>	Harida	Combretaceae	FMD, Ulcer	Fruit
Method of application: ❖ The decoction of the fruit is applied on the hoofs of the cattle suffering from foot and mouth disease. ❖ Also applied for washing the ulcer (wound) of the animal				

Conclusions

The livelihood of tribes of Chhattisgarh is primarily depends on the forest resources, and they use to collect many ethnobotanical species for their day-to-day activities. The wild medicinal and food plant species provide credibility of folk claims and clues for pharmacological screening may be screened and standardized as per scientific norms for medicinal potency and nutritive values for their wider acceptability. The need of hour is to identify and disseminate the valuable information about the important ethnobotanical species and knowledge for the benefit of society and science. To mitigate the ongoing pressures on ethnobotanical species beyond their sustainable capacity, the local people may be educated on the future consequences of nature resource over-exploitation process and environmental degradation. The forest dwellers may also be provided the sufficient resources for their basic requirements. Many ethnobotanical species provide food and medicine to the rural people therefore, such species may be protected through non-destructive way of harvesting. Rather than exporting important ethnobotanical species in raw forms, attempts should be made at the village level to promote their processing and value addition. Agro-techniques of demand driven ethnobotanical species need to be developed and the useful tree species may be planted as agro-forestry species. Besides, the state Government may encourage agro-forestry, farm forestry and on-farm cultivation of ethnobotanically useful species. There is need to record such ethnomedicinal uses of plants before they are lost. However, the information available with the tribes about medicinal uses of plants, need to be scientifically validated. Such information is likely to help in the conservation of biodiversity and providing important lead for drug development.

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Abrus precatorius



Achyranthes aspera



Aegle marmelos



Alangium salviifolium



Ananas comosus



Andrographis paniculate



Azadirachta indica



Bacopa monnieri



Bambusa arundinacea



Bombax ceiba



Butea monosperma



Capparis zeylanica



Carica papaya



Cassia fistula



Cassia occidentalis



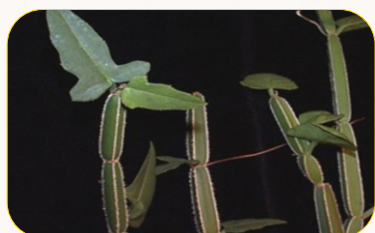
Celosia argentea



Chloroxylon swieteniana



Cissampelos pareira



Cissus quadrangular



Coccinia indica



Eclipta prostrata



Emblica officinalis



Hygrophila auriculata



Jatropha curcas



Lasia spinosa



Leea indica



Mangifera indica



Momordica charantia



Mucuna pruriens



Nicotiana glauca



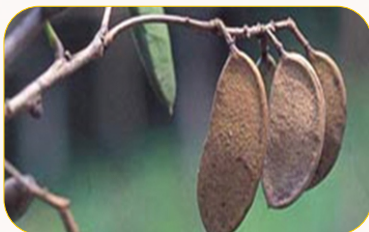
Nymphaea pubescens



Phyllanthus niruri



Polygonum hydropiper



Pongamia pinnata



Psidium guajava



Ricinus communis



Semecarpus anacardium



Tephrosia purpurea



Terminalia chebula

Indigenous Technical Knowledge (ITK) for promotion of Sustainable Fisheries and Aquaculture

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Introduction

Fisheries and Aquaculture remains as the fastest-growing food production sector in the last century. South east Asian countries has been the centre of aquaculture production for decades and currently, more than 90 percent of the total aquaculture production of the world comes from Asian countries. Interestingly, more than 70 percent of the total aquaculture production comes from small-scale farmers, who are also the major contributors of small-scale innovations and adaptations of aquaculture technologies. India is the second largest fish producing country in the world and accounts for 7.58 per cent of the global production. The fish production in India has reached an all-time high of 14.16 million metric tons during 2019-20. The fisheries sector contributes 1.24 per cent to the GVA and 7.28 per cent to the agricultural GVA. The export of marine products stood at 12.9 lakh metric tons with a value of ` 46,662 crores during 2019-20. The livelihood opportunities provided by this sector have been instrumental in sustaining incomes of over 28 million people in India, especially the marginalized and vulnerable communities, and has promoted meaningful socio-economic development. India is the 3rd largest fish producing and 2nd largest aquaculture nation in the world after China. The Blue Revolution in India demonstrated importance of Fisheries and Aquaculture sector. The sector is considered as a sunrise sector and is poised to play a significant role in the Indian economy in near future. In the recent past, Indian fisheries has witnessed a paradigm shift from marine dominated fisheries to inland

fisheries, with the latter emerging as a major contributor of fish production from 36% in the mid-1980 to 70% in the recent past. Within inland fisheries, a shift from capture to culture-based fisheries has paved the way for sustained blue economy.

Although inland fisheries and aquaculture have grown in absolute terms, the development in terms of its potential is yet to be realized. The unutilized and underutilized vast and varied resources, in the form of 191,024 km of rivers and canals, 1.2 million Ha of floodplain lakes, 2.36 million Ha of ponds and tanks, 3.54 million Ha of reservoirs and 1.24 million Ha of brackish water resources offer great opportunities for enhanced production along with livelihood development and ushering economic prosperity. In many countries of the world, the adaptation of indigenous technologies has resulted in the development of sustainable and environmentally friendly aquaculture practices and hence helped the farmers to increase aquaculture production during the past decade.

The traditional farmers are continuing the use of ITKs as a part of their culture, generation after generation. In most of the cases, the ITKs have a good scientific basis with an eco-friendly approach which is an urgent need of current era. The scientific background of such ITKs can be integrated with modern technologies for better efficiency and as well as this authentic knowledge base has to be documented for the future upliftment of hidden scientific rationales of different ITKs. The Indigenous technological (ITK) in aquaculture predominantly related to farm inputs has been developed by the farmers themselves, based on their experiences. Farmer's innovation is based on their indigenous knowledge. The indigenous knowledge is the accumulated knowledge, skills, and technology of the local farmer derived from the interaction of the ecosystem. The knowledge has been inherited from generation to generation. This radically

changes the use of fertilizers and devised some unique right-hand thumb rule for disease diagnosis and treatment without the costly antibiotics and chemotherapeutic agents, which is mostly useful for middle fish farmers Indigenous Technical Knowledge (ITK) is characterized as the sum of experience and knowledge for a given ethnic group, which forms the basis for decision making in regard to familiar and unfamiliar problems and challenges. It can play key role in designing of sustainable farming systems including fishery practices thereby increasing the livelihood that rural populations would accept, develop and maintain innovations and interventions. For ages, human beings, in particular, the resource poor farmers and marginal societies around the world, have been utilizing locally available plant resources for formulating a wide range of plant-based medicines for treating fishery diseases as an economical, accessible, efficacious and ecologically sustainable means to fish health care practices. Since the evolution of mankind man has been entrusted with resources and location specific avenues like agriculture, fishery, dairy, animal husbandry, ayurvedic, medicine and weather study etc. In rural areas, indigenous technical knowledge of fish farmers associated traditionally. Farmers' wisdom is supposed to be thumb rule in the rural setting, which followed from generations to generations to come up with different situational constraints (Gupta 1990). The tested and proven innovation of ancestors needs to be valued and blended with new technological support (Das et al 2002). Traditional wisdom is time tested and understanding the dimension of technologies of the fish farming helps in asserting the degree and directional change through formal research. Thus, recording of indigenous innovation becomes important which would otherwise be obsolete soon without recognition to future. Currently the modern

information system seriously addresses the issue of sustainability of productive system of the world. Persistent poverty, air and water pollution, soil degradation, global warming etc have raised doubts about the wisdom of pattern of development currently being pursued. With the implementation of multifaceted knowledge and skills, substantial contribution to our productive efforts ensuring high yield, can be achieved through modern techniques of enhanced fish production in an economically sound manner. In short indigenous knowledge is traditional type of innovation by the farmers that is stored in peoples' memories and activities and it is expressed in the form of stories, song, folklore, proverbs, dances, myths, cultural values, beliefs, rituals, community laws, local language and taxonomy, agricultural practices, equipment materials, plant species and animal breeds (Jha and Shiyani 1992). The major advantages of farmers' innovation over other technological innovations is that it has little or no cost and is readily available. These innovations are socially acceptable, economically viable, and sustainable and involve minimum risk to rural farmers and producers, and above all, they are widely believed to conserve resources. The farmers' innovations encourage transparency and accountability (Goswami et al. 2006). The use of farmers' innovation, skills and wisdom promotes active community involvement because people depend more on each other (Ratnakar and Reddy 1991). People are less dependent on outside supplies; that may be costly, scarce and irregularly available.

Keeping these facts in view, the present article is compiled with the following objectives:

- ❖ To identify and compile the various types of existing indigenous technical knowledge (ITK) in fisheries.

- ❖ To explore the use of indigenous technical knowledge (ITK) in fish farming in rural communities.
- ❖ To find out the purpose and rationale of indigenous technical knowledge (ITK) to control fish disease management in fisheries.

In this article, we have attempted to compile some of the prominent indigenous knowledge practiced by fish farmers. Aquaculture is the controlled production, propagation and rearing of aquatic organisms of highly economic value in a controlled environment such as ponds, channels and enclosures, using a higher density of cultured aquatic organisms than normally found in nature. Many rural farmers have applied indigenous knowledge in various stages of aquaculture in order to meet their livelihood necessities. In the coming years, small scale aquaculture (sometime referred to as 'rural aquaculture') is poised to play significant role in increasing freshwater fish production in the country. This low-input aquaculture system is closely associated with Indigenous Technical Knowledge (ITKs). Though efforts are made to identify, validate and recommend ITK by some Governments, much indigenous knowledge remains undocumented. There is a need to recognize ITK, compile, value and appreciate their interaction with local communities. The enhancement of the quality of life of the people who depend on aquaculture production would be almost impossible if this rich tradition of ITK is kept to a few people.

Therefore, ITK needs to be incorporated into the zonal research and development agenda. However, before reliable recommendations can be made, there is an urgent need to understand, critically validate and document the different ITKs so as to integrate the best ones into the farming system.

I. Pond construction and maintenance

1. Site selection

The fish farmers of many parts of our country are reported to have selected low-lying areas near the home for fish pond. These ponds can be used as multipurpose ponds for bathing, cloth and utensil washing in addition to fish culture. They preferred to construct embankment ponds to the dugout ponds.

2. Soil quality

In order to test the suitability of soil in terms of water retention, a mud ball is prepared from the soil where the pond is to be constructed. If the ball does not break, the soil is considered to have enough water holding capacity, hence suitable for pond construction.

3. Outlet

Farmers of used hollow bamboo fitted at a certain height from the bottom as outlet pipes. The end of the bamboo facing the ponds is blocked with stone and clay soil.

4. Protection of pond dyke

During pond construction, the bottom of the pond is made wider than the top as it can better withstand the force of water. In places experiencing heavy rainfall, most dykes are prone to erosion and damage. Farmers plant plantation crops like coconut, papaya or vegetable crops with creeping vine like cucumber, gherkin etc. or turf with fodder grass. In Manipur, farmers use pond dykes for Colocasia plantation at 3000 nos. ha⁻¹, which is used as a vegetable in many parts of India

II. Fish breeding and seed transportation

1. Breeding

Knowledge on dry and wet bundh systems of fish breeding and spawn production has been recorded from farmers. Breeding in bundh including Bangla bundh with hormonal injection is a very cheap and effective method practiced by the farmers in many parts of West Bengal. These bundhs are most economical and very much tuned to the environment. Farmers in West Bengal were reported to use proper doses of the extract of water-immersed catechu (*Acacia catechu*) and myrobalan (*Myrobalus indica*) nut in hatching pool, to make the eggshell hard. This is known to help in shell hardening and prevent immature release of hatchlings, enabling higher hatching rates. In Tamil Nadu, the practice of covering the rostrum of brood stock of freshwater prawn with plastic tube has been reported (TNAU). This is done to avoid damage of packing material during transport. TNAU also recorded that some fish breeders use banana leaves for deposition of eggs and teak leaves to maintain acidic pH in the ornamental fish tanks during breeding egg layers and place carrot/ potato slices and banana peels in ornamental fish larval rearing tanks to enhance the formation of live feed Infusorians.

2. Seed collection

Collection of spawn of murrells like *Channa punctatus*, which moves in shoals and periodically comes to the surface for breathing in natural waters using bamboo sieve/mosquito net/ cloths is reported to be a practice during monsoon in Assam

3. Seed transportation

Saha and Chowdhary have described the traditional method of

transporting fry and fingerlings in hundis, practiced in Bengal. A traditional hundi is an earthen vessel, but later aluminum hundis were introduced. Though the hundis are of variable sizes, they are generally of two types, the smaller one has 22 cm mouth diameter and 23 l capacity carried as a head load and the other larger one has 23 cm diameter and 32 l capacity used for transport by rail or bicycle or as slings. The hundis are filled with water from the same source as the fry and are stocked at 50 000 in the smaller and 75 000 in the larger ones. About 58 g of fine silt is sprinkled over the water surface in the hundi. During transport, the hundis are shaken periodically. Basu had reported that addition of silt coagulates the suspended organic pollutants. Saha and Chowdhury have observed that management practices like addition of silt, removal of sediments by mopping them up with a rough cloth rope and partial exchange of water permitted transport up to a duration of 30 hrs. Saha et al. demonstrated that pulverized earth and activated charcoal tend to absorb carbon dioxide and ammonia from the medium, consequently increasing the survival of fry. Use of around 50 ml of rice beer for every 10 l of water in aluminum hundis, which probably acts as an anesthetizer has been reported in Assam during seed transport. However, traditional methods of transporting fish seed in hundies (earthen or aluminum pots) resulted in heavy mortality of fish seed.

III. Seed stocking

1. Weed fish eradication

Mahua oil cake is used for killing unwanted fish. This later gets converted into organic manure enhancing pond fertility, reducing the quantity of cow dung to be applied subsequently.

2. Bird scaring

Some farmers have recorded the use of audio/video tapes/coloured plastics for bird scaring in several fish farms of Karnataka.

3. Testing the seed quality and species identification

To test the quality of seeds, farmers keep a few of them in the water taken in a plate and rotate the water with finger. Those seeds which swim in the opposite direction are considered as healthy seeds .Kalitha et al. have recorded that farmers distinguishing fry of catla from rohu and mrigal by its bigger head and their preference of fingerlings to fry since they grow quickly.

4. Stunted seeds

Andhra Pradesh farmers have developed the technique of using stunted seed that are aged but have not attained a weight proportionate to their age, and stimulating their rapid growth in a limited period of time by compensatory growth effect.

IV. Fish feeding

1. Fish feeding using gunny bags

2. Supplementing common salt with feed:

Another indigenous practice followed by Andhra farmers is the use of common salt in feed. Studies conducted at College of Fisheries, Mangalore with carps have revealed the growth promoting potential of Na Cl.

3. Use of agriculture by-products as fish feed: Some farmers are reported to feed partially fermented maize, poultry offal and chopped dead poultry birds to the African catfish for high growth. Many

farmers in Bangladesh were found to use kura, the red powdery coating of rice under the husk as feed. Other food sources include cow dung, poultry waste, choker (the remains of wheat grains) obtained after the extraction of aata and oil cake., some where it is termites are a frequently cited problem by farmers. It is reported that the local women and children collect up the mounds which are then thrown into fish ponds. Feeding fish with other on-farm resources like grass, azolla have been observed in some parts of Karnataka. The addition of banana leaves to ponds stocked with grass carp was recorded. Grass-fed fishponds are reported. In a polyculture pond, the poorly-digested excreta from grass carp serve as fertilization for the pond ecosystem and also as direct feed for other fish species. The inclusion of grass carp as 'grass bio-processor' enables the use of near-pond grass sources and leads to marked increases in overall fish production.

V. Fish health management

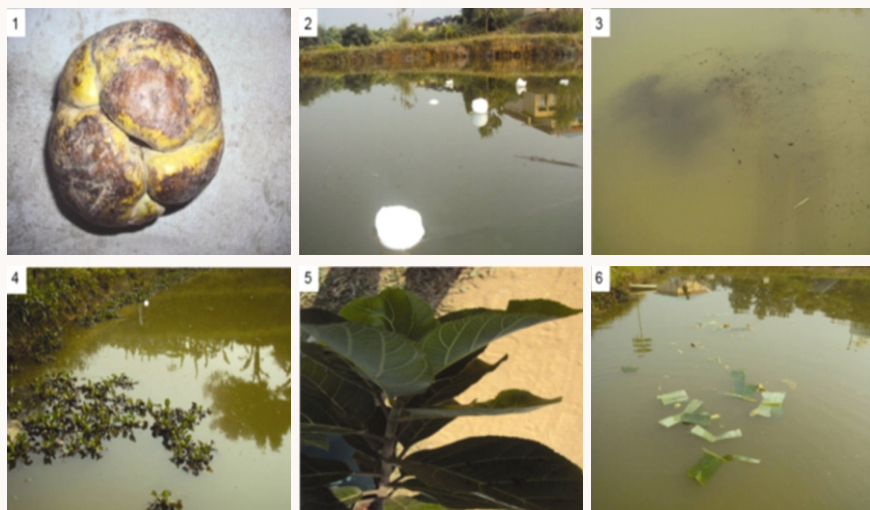
1. Dissolved oxygen deficiency

Depletion of dissolved oxygen especially during morning hours is managed by farmers through indigenous methods like channelizing fresh spring water, beating the water with bamboo pole/banana pseudo stem (TNAU), spraying water with open containers, making children swim in ponds and reported the use of ducks which swim in pond and aerate the water.

2. Turbidity management

For controlling persistent clay turbidity farmers apply paddy straw/pieces of banana stem. The application of lime to ponds to clear unclean water and addition of pieces of banana stem was also recorded by Chowdhury et al. in WB (as Picture given below 1 to 6).

When these substances rot, they will be removed periodically. To control algal bloom, practices like spraying cattle urine in considerable quantities or mixture of red soil and sand on pond surface have been reported to be effective. It was also observed the use of bamboo poles with toothed prongs or coir rope to remove aquatic weed (*Jahanesbaptistia* sp.) from water bodies where *Penaeus monodon* (Bagda) is cultivated.



3. Argulus (fish lice) control

In cases of infection with the crustacean ecto-parasite *Argulus* sp., farmers plant bamboo pieces in ponds. Farmers believe that the fishes can get rid of *Argulus* by rubbing their bodies against the bamboo pieces. In fact, Bamboo poles are good substrates for *Argulus* to breed. They colonize on bamboo poles and lay eggs on them (Hemaprashanth, Pers. Comm.). Some farmers also keep old gunny bags submerged in pond water. Bamboo poles or gunny bags will be removed periodically and dried to kill eggs of the *Argulus* deposited over them.

4. Leach control

Farmers in Assam are reported to throw peels of cucumber or leaves of bitter gourd made into paste form. It is believed that these bitter plant materials help in eradicating leaches.

5. Control of epizootic ulcerative syndrome (EUS)

Epizootic ulcerative syndrome (EUS) is one of the deadliest fish diseases occur during winter due to an oomycete fungus, *Aphanomyces invadans*. Large hemorrhagic cutaneous ulcers, epidermal degeneration, necrosis and sloughing of scales are the principal symptoms of the EUS (Kar et al. 2000). Tripura was the first State to report the losses due to the EUS in India during September, 1988 (ICSF 1992) and currently, North East India has become a hub for EUS (Kar et al. 2006). After almost three decades since its first occurrence, farmers of North-East and North India still today consider EUS as the most devastating in fish farming. CIFAX (1-liter/ha-m) is an effective preventive medicine against the EUS but its curative application is ineffective. Furthermore, timely availability of the CIFAX is a matter of serious concern in the remote places of Tripura and other NE states where livelihood heavily relies on Fisheries. Therefore, there is a search for cost-effective alternative medicines against the disease. During EUS, there is an overgrowth of *A. invadans* and secondary microbes in the infected sites; as a result, fish became immunologically depressed. Kerosene eliminates the microbes and parasites from the blood, bowel and infected organs (Last 2012) and up-regulated the host defence mechanism by facilitating the function of phagocytes, natural killer cells, complement system, bactericidal and lysozyme activities, and antibody responses. Thus, the disease intensity is reduced and wounds

healed. There is no report of using kerosene against the fish pathogenic fungi but it has been reported against the human pathogenic fungus, *Candida* sp. without altering the activity of normal gut bacteria (Awodele et al. 2007).



Application of a paste of turmeric powder and ash of hay or bamboo to control EUS has been practiced by fish farmers in Assam. Some farmers even apply branches of Neem plant into fish ponds. Goswami et al. have reported the use of a paste made from garlic (2 kg), salt (2 kg), CuSO_4 (20 g), KMnO_4 (20 g) mixed in 30-50 liter of water and sprayed over pond water of 0.133 ha pond by hatchery owners in West Bengal to control EUS. Saha and De reported the application of a solution of rotten jaggery on fish for controlling ulcers as given in picture 7 and 8 above.

6. pH control

Toddy (palm sap) is used by shrimp farmers for pH control. Goswami et al. have reported that banana pseudo stem can be used to increase pH through their alkaline secretion by cutting them into pieces and immersing in pond water. This practice of West Bengal farmers is reported to minimize protozoan diseases and Argulus.

7. Removal of poisonous gas

Raking of the pond bottom by dragging tree-branches or brick suspended from a rope is practiced by some farmers for the release of obnoxious gases trapped inside the soils.

8. Hiding places

Farmers cultivating exotic fishes like Australian freshwater crayfish *Cherax quadricarinatus* use tyres and bricks as hiding places. They also use onion bag bundles to protect and harvest small juveniles from ponds. Use of bricks/tiles/ tyres as hide outs is also seen in India in prawn culture ponds.

Some More interesting ITK practised in India are documented below

1. Garlic and Fenugreek-As a fish attractant: Some farmers are used garlic and fenugreek seed for easier harvesting and fish attractant. For that 1kg of semi-dried garlic mixture with 250g of roasted and grind fenugreek seed. After mixing, both compounds applied in a pond. After one hour, a group of fish gets attracted to it because of aroma release through this compound, and fisher catches the fish easily. This mixture is enough to a water body for the one hectare area. This combination is also used as bait or attractant for angling. 2. Application of cattle urine Some fish farmers in India collected cow urine and sprinkled on the surface of the fish pond to get control of algal bloom, but this method has been a band in other countries.

2. Broadcasting ash in fish pond In this system,: first of all, burns the paddy straw or hay and after that complete burning gets ash, this ash is broadcasting in the fish pond, Farmers believe that it prophylactic measures to keep out the fish disease.

3. Asafoetida (Hing) are used for attracting Magur and Singhi Most of the fish farmers in India culture Magur and singhi because

there is a lot of demand in the fish market, but there is a lot of difficulty in harvesting it because it burrows inside the mud. For eliminating this problem twigs, leaf or branch of tree are placed in the pond before harvesting. Then the hing is tied in a cloth and is kept in around the leaf or twigs so that the fish becomes attract After 5 to 10 minutes put the net around the twigs and harvest the fish.

4. Control of Argulus by gunny bag and bamboo pole: Some farmers are old gunny bag is kept in bottom of pond, So that the larvae sticks to the bag and the farmer dry and killed eggs of Argulus deposited over them, and some of the farmers used bamboo pole for buried in the pond in several places, the fish rubs own body with this pole and the argulus is leaves the body surface of fishes.

5. Using Turmeric in fish ponds as an antibacterial agent: Turmeric having antibacterial and anticancer properties curcumin is the active compound in turmeric which has been shown to have a wide range of therapeutic value, fish farmers broadcast the paste over the water to treat the *Aeromonas hydrophilla* infection. Sometimes also used in an external insecticidal and antifungal agent.

6. Uses of Mahua: Mahua (*Madhuca longifolia*) belongs to family Sapotaceae, which is known for its sweet flowers which possess a lot of ethnic values among the tribal people for the development of various fermented and non-fermented food products. In the fisheries sector, it is used for control the weed and predatory fishes, the dose is @250 ppm, because of saponin and mourinactive compound present in Mahua and it is Hematotoxin (toxins that destroy red blood cells, disrupt blood clotting), which breakage the RBC and causes the death of fishes.

7. Use of pieces of banana trunk to control of alkalinity: In villager fish farmers, pieces of the banana trunk place afloat to maintain the alkalinity and to serve as a food supplement, banana trunk having pores containing oxygen which ultimately helps to increase the level of oxygen. Before the rotten of banana trunks its remove from the pond.

8. Use of pieces of rachis of jackfruit for Tadpole infestation: is a serious problem, primarily due to competition between tadpoles and fish for food and also caused harvest problems and impaired post-harvest sorting and grading. For control this problem Jackfruit is used. Jackfruit rachis is a stick in nature because it's containing gummy shell, farmers utilize the rachis of jackfruit in the pond for relief from tadpole, the tadpole is attached with the rachis, and later tadpole is removed from the water.

9. The ripe palm fruit for crab reduction: Some areas of fish farmers are used ripe palm fruit for the reduction of crab from a pond. The smell of the ripe fruit attracts the crab and they aggregate on the fruit to eat and farmers remove them easily by hand or by scooping. In some cases empty earthen pots are also used for removal of crab from shrimp farm because this crab is competition to shrimp for feeding, empty pots are placed at the bottom of the shrimp pond at a different place where feed is usually placed. After 4-5 days the pots are removed from the pond which gets filled with crabs.

10. Usage of Haritaki and khayer for hatching of fish eggs: Many medicinal plants such as Acacia catechu and Terminalia chebula are used for the hatching of fish eggs because early hatching of spawn dies due to

immature condition, for solving the problem local farmers adopt a solution of 2 kg Haritaki and 250 g khayer for 100 liter of eggs.

Procedure: Mixing the above material in 2 lit of water and keep for one night and heat the mixture for one hour later filtering the mixture through fine cloth and mixture is applied to the eggs in hatchery, after 6-8 hrs of fertilization this fertilized eggs kept in the mixture for 5 minutes, due to the application of this mixture the outer membrane of the fertilized eggs become hard which increase the hatching time.

11. Use of paddy straw to control turbidity: As we know turbidity is common problem during rainy session. For control, the turbidity of pond farmers is used paddy straw, when the straw rots the farmers periodically remove them from the pond the method especially controlling clay particles is found to be effective.

12. Akashi fruit for fish tranquilizer: For harvest the fish from pond tranquilized or anesthetized is the best method. The indigenous communities of Jharkhand use the fruit of Akash plant as a fish tranquilizer. This fruit is semi grained and mixed with water @1 kg per 100 liters and sprinkled over the water surface. After half an hour fish start to float on the water surface and they are collected by netting or hand picking.

13. Control pH of water Some places such as Mathurapur and south 24 Parganas use the branches of tamarind and moringa trees for reducing the water pH. : The dose is 3-5 pieces of 30-35 cm and keeps it for 3-4 days when they yellowish color of water turn off then they remove those branches.

B. ITKS practiced in Chhattisgarh



Chhattisgarh, Bastar tribes use traditional fishing techniques

Bisar: Bisar is made from bamboo splits like a normal mate and weaves with nylon threads across the bamboo splits. Bisar is attached with Sodiya they help to collect the fish in flowering water. The uppermost part is open and the lower part is less open when to take out fishes from sodiya. For trapping the small and medium size of the fish used as evidenced in given picture below.

Pelna: It is a triangular shape made of bamboo weave with a nylon net and tied with a triangular frame. One arm had for holding the pelna upright. Under deep water, they move forward keeping pelna upright from the bottom of pond or rivers. **Dhuta:** Dhuta used for storage of fish it's made up from bamboo splits weaving it as bottle shaped container. The capacity of dhuta is 2-5 kg and 1-3 kg dry fishes and fresh fishes respectively. ITK is such knowledge that is presumably

eco-friendly; economic and highly credible with a practical point of view, without any side effect. There is also a possibility for combining the indigenous technical knowledge and knowledge of management based on modern science to create effective hybrid management systems. It is imperative to analyze such technologies so that the scientific principle behind them could be properly understood. Once this is done, it will be easier to further refine and upgrade them by blending them with modern scientific knowledge.

Some Indigenous techniques used by the farmers in Aquaculture practices

- ❖ **To reduce the water pH:** use of Moringa (*Moringa oleifera*) and Tamarind (*Tamarindus indica*) stem and branches. 8-10 numbers of 1.5-3 m branches are immersed per bigha (33 decimal) of pond depending on water pH.
- ❖ **To control some protozoan diseases and increase the water pH:** Use of Banana stem, Banana stems are cut into small pieces and immersed in the water.
- ❖ **To control White Feces Syndrome in shrimp:** use of Thankuni (*Centella asiatica*) leaf. Fresh thankuni leaf is mixed with the shrimp feed @30-40 leaves per kg feed.
- ❖ **To make the fishes hardy (disease resistant) and reduce the mortality rate:** Use of Mahua (*Madhuca longifolia*) oil cake. Mahua oil cake is packed in gunny bags @ 10-15kg and immersed in two corners of a stocking pond (per bigha/ 33 decimal).
- ❖ **To attract fish during angling:** Use of Ekangi (*Kaempferia galanga L.*) rhizome and Jayatri (*Myristica fragrans*) flower.

Ekangi rhizomes and Jayatri flowers are sundried followed by moderate heating in the hot plate and ground into powders for incorporation through the feed.

- ❖ **To manage fish lice by providing a rough surface for rubbing of the fish body:** It also helps in minimising the poaching problems. Use of Bamboo (*Bambusa vulgaris*) branches. Different size of bamboo branches are placed in the separate location of a pond.
- ❖ **To attract fish due to its aroma and to make the fishing effective:** Use of Garlic (*Allium sativum*) and Fenugreek (*Trigonella foenumgraecum*) seeds. 1kg of semi-dried garlic is mixed with 250 g of roasted and ground fenugreek seeds. This mixture is then applied before one hour of fishing.

Conclusions

The above-mentioned indigenous technology is very much viable in combating the problems of the fish health management. Farmers knowingly or unknowingly employed such techniques in effective disease management of such systems. The basic difference of ITK from other scientific method or technologies is ITKs are adopted first depending on their positive response to the local people followed by sophisticated research work in the laboratories of the research institutions. The indigenous technical knowledge on pond construction and maintenance, fish seed transportation and fish health management were perceived high on cost effectiveness and easy to follow, moderate on scientific value/logic, efficacy, availability of material, cultural, appropriateness and environmental soundness. Therefore, it is imperative to analyze these technologies so that the

scientific principles/basis behind them could be properly understood. Once this is done, it will be easier for extension of ITK, further refine and upgrade them by blending them with the modern scientific knowledge. The same knowledge and technologies may be further fine-tuned in the days to come. It is imperative to analyse such technologies so that the scientific basis behind them could be properly understood. When this is completed, it will be possible to further refine and upgrade them by blending with modern scientific knowledge. Admitting the scientific approach of the above discussed technology one should protect this for betterment in fish culture for the near future.

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ITK for Insect Pest Management in Cereal Crops

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Abstract

Traditional knowledge is the classic form of information and practices developed by our forefathers over time. In Agriculture, farmers from different regions and ethnic groups have developed their own systems for the cultivation of various crops. The farmers use a diverse array of natural resources for crop husbandry and farm-linked activities. They preserve and transmit information in the next generation for creating mobilization in the rural community. Traditional agriculture information transforms agriculture resources, maintains biodiversity ethics, and enlightens historical and practical approaches to the present generations. In current-day agriculture, monoculture and excessive use of organic pesticides have caused serious imbalance and heavy depletion of natural enemies in agroecosystems. To overcome these problems, there is an urgent need to develop ecologically sustainable and pesticide residue free pest management practices. In this context, Indigenous technological knowledge (ITK) can be an option and may play a vital role in organic agriculture, particularly in insect pest management. Moreover, most of the ITK's are non-pesticide based, eco-friendly, and compatible with already existing pest management practices. ITK's can strongly contribute toward organic farming and pesticide residue-free agricultural production. Owing to the great potential of ITK's in insect pest management, here we discuss the most practiced and important ITK's in important cereal crops.

Keywords:-ITK, eco-friendly, sustainable, cereal crops, ecological, pest management

Keywords: Indigenous technology, crops, management

Introduction

Indigenous technical knowledge (ITK) is the knowledge that people in a given community have developed over time. It is the accumulation of awareness, information, and understanding of various facts which people have developed over many generations and continue to expand it. Thurston (1992) described it as a systematic body of knowledge acquired by local people through the accretion of experiences, informal experiences, and intimate understanding of the environments in a given culture. It is always based on experiments and experience; tested and practiced over a long period; generally adapted to local culture and climate, changing over the generations, and emphasizes the conservation strategy rather than maximizing profit. Indigenous knowledge of the rural people is dynamic and unique to a given society, culture, ethnic group or race, and local environment. It changes through indigenous creativity and innovativeness as well as through contact with the knowledge system. However, It is an unwritten body of knowledge, there is no systematic record to describe what it is and what it does. Local people, including farmers, landless farm laborers, farm women, and rural craftsmen are the real upholders and conservators of the indigenous knowledge systems (Singh and Sureja 2008).

In Agriculture, farmers from diverse regions have developed their own systems for the cultivation of their food crops. It is a product of the long-term adaptation of farming practices to the local

environment, creating unique indigenous farming practices. The highest degree of biodiversity contributing in the prevention of erosion of genetic resources is one of the most important features of traditional farming systems (Altieri 2003). Knowledge, skills, and survival strategy of farmers using minimal external inputs have often been ignored to promote modern agriculture (Rizwana and Lyajet 2011). Indigenous agricultural traditional knowledge has a scientific rationale and a great deal of relevance for agricultural productivity and ecological sustainability. The scientific community accepted that the assessment of ITKs is an indispensable part of the introduction of new agricultural technology.

There are overwhelming pieces of evidence that, current day pesticides pose a serious risk to human and other life forms and also affects the environment. These harmful effects of pesticides have raised awareness to grow pesticide-free food products and organic agriculture. Now it has become a necessity to develop holistic methods of insect pest management to make it eco-friendlier, economically viable, and socially acceptable for the farmers (Dutta et al. 2015) Indigenous traditional methods and pest management practices make an excellent base to develop such a holistic pest management approach. In this preview, the traditional knowledge developed by farmers across the country and actively practiced for insect pest management in various cereal crops is discussed in the following sections crop-wise.

Rice

Rice, *Oryza sativa* L. is one of the most important staple food crops in India. Rice cultivation is considered as one of the oldest forms of

agriculture and its cultivation has been traced at the ancient age of human civilization. Over time, rice-growing farmers have developed their own pest management practices. Some of the popular local pest management methods are discussed here.

Farmers in the Raipur district of Chhattisgarh use kerosene oil with cow dung and straw to protect the paddy crop from insect and pest attacks in the field. This mixture is prepared as small pellets, which are then applied to the field. Mahua leaves mixed with kerosene oil and cow dung is another ITK used to protect the crop from pests in the field. This mixture is then used to create pellets, which are then spread out across the paddy field (Rizwana and Lyaqet 2011). At southern parts of Chhattisgarh, farmers use Bhelwa (*Semecarpus anacardium*), Neem (*Azadirachta indica*), Karra (*Cheistanthus collinus*), Bantulsi (*Ocimum basilicum*), Sulfi (*Caryota urens*) and Karanj (*Pongamia pinnalai*) leaf extracts to control rice leaf folder (Netam et al. 2017). Farmers use karra (*Cheistanthus collinus*) sticks with leaves, which are 2 to 3 metres long and prepared with one sharp end to be placed in paddy fields. The sharp end is inserted under the soil and it is used to control all insects in rice fields (Sahu and Kumar 2018). The farmer apply 50-200 kg fresh Karada leaves for controlling Gundhi bug from the paddy field. The leaf contains high phenol content which repels the gundhi bug (Richa et al. 2017).

In Seoni, Madhya Pradesh tribal people use Garadi leaves for control of rice leaf folder and grasshopper. To make the extract from Garadi leaves (*Cleistanthus collinus*), 10 kg of the leaves are soaked in 10 litres of water for 8 days. By decanting, the supernatant is separated and used in a 10% solution. The alcohol and chloroform present in the leaves of the garadi plant may act as the agent responsible for inactivating or killing the leaf folder and grasshopper

in rice (Das et al. 1999).

In Tamil Nadu, farmers grind neem seed kernels, soak them in an equal amount of water overnight, and then spray the solution on rice crops after filtration to prevent brown plant hoppers and green leaf hoppers. To stop stem borer larvae from moving and boring holes in rice fields, Tamil Nadu farmers cut branches from cashew trees and planted in the field. For control of the leaf folder, they combine neem oil, pongamia oil, and soap nut powder in a 1:1:1/2 ratio and apply in field. For control of ear head bugs, queen sago (*Cycas circinalis*) flowers are placed on sticks in rice fields during the panicle formation stage, as they have an offensive odour that deters ear head bugs (Ravi 2017). Leaf folder is successfully controlled by spraying tobacco (*Nicotiana tabacum*) and chilli (*Capsicum annum*) extract in the Karur district of Tamil Nadu (Arya and Babu 2017). The Kerala, Tamil Nadu, and Uttar Bengal farmers spread dried peel of citrus in the transplanted rice fields for managing stem borer (Patnaik 2011). The North-East and Tamil Nadu farmers peg branches of *Cymbopogon khasianum* and *Sacharrum spontaneum* to inhibit stem borer in paddy (Gopal and Lassaad 2015).

In Karnataka, mukudda (*Lasiosiphon eriocephalus*) leaf extract is used to control brown planthoppers in paddy. One kilogramme of leaves boiled in 10 litres water, filtered and diluted in a 1:10 ratio. Sprayed twice, once during the nursery stage and one after transplantation (Dinesh 1998). In Karnataka, Pondichery, Andhra Pradesh, Jharkhand (East Singbhum), Uttar Pradesh, Arunachal Pradesh farmers use broadcasting of leaves and fruits of Ashan (*Terminalia elliptica*) in Paddy fields infested with termite and other soil borne insects and these prove to be toxic, bitter and acrid to insect pests, which helps in controlling their population (Mahapatro et al. 2017).

The Meithei (Manipuri) Farmers in Barak Valley of Assam use the twigs of Nishinda plant (*Vitex negundo* L.) to control rice hispa (*Dicladispa armigera*), which were repelled by the plant's foul smell. *Leptocorisa* sp. is attracted by “Utongthangmei”, which is the practice of burning clothes on bamboo sticks in the four corners of a rice field at night, the fire is used as a trap. Another approach that was used for Gundhi bug was to place a rotten crab on a stick, smell of crabs was used as a trap for the control of insect. Gundhi bug is also managed in the paddy fields by using kuthap (*Clerodendrum viscosum* Vent.) twigs (Bhattacharjee and Ray 2010). For control of stem borer (*Scirpophaga incertulas*), farmers of Assam use slices of pumalo (*Citrus grandis* Osbeck) in the paddy field @1 trap/6m² and placing chopped Indian rhododendron or phutuka (*Melastoma malabathricum* Linn.) leaves in a rice field, the chopped leaves emit pungent smell which repel the insect away from the field and farmers also uses neem (*Azadirachta indica* A. Juss.) seeds and leaves which are steam-decocted, and the extract is applied to rice crops. To make the extract, combine 1 to 3 g of ground neem seed or leaf in 1 lit of water (0.1-0.3% concentration) for 12 hours. Neem seeds and leaves contain azadirachtin, act as insect growth inhibitor and antifeedant for insect.

Puthi or barb fish (*Puntius* sp.) is buried in the ground for 15 to 20 days while water extract is sprayed over rice fields, the fermented fish extract repels stem borer. Placing grounded bark of drumstick in rice field is also done because the bark of drumstick has insecticidal properties. For gundhi bug, farmers burn bicycle tyres near the rice field before panicle initiation, the foul smell of burned tyres repel the insect (Deka et al. 2006). In north eastern states, the farmers use Pomace (wine residue) made up of millets for pest and disease control in rice fields.

The wine residue is dispersed with irrigation channel for controlling leaf folder and rice blast. The farmer apply oak tree bark, placed through irrigation for controlling insect-pests in rice. The farmer uses 5 months old paddy husk, applies in the field for controlling blast disease and improving soil fertility (Firake et al. 2012).

In Jharkhand, Sindwar leaves are boiled in water and the resulting solution is cooled. In order to control caseworm (*Nymphula depunctalis*), it is sprayed on the crop (1 kg leaves per 5 litres of water per 0.06 acres). 60 per cent case worm is controlled by using this practice. Tribal farmers also use Parsa/ Karla, *Cleistanthus collinus* leaves to control case worm as well as stem borer and gundhi bug. The majority of farmers in Jharkhand's Ranchi region uses the branches of the bhelwa tree to protect their rice crop from gundhi bug insect. They collect bhelwa tree branches and plant them in rice fields, this approach prevents insects from damaging rice crops because of repellent character of bhelwa (Ratan et al. 2016). In Jharkhand, tender bamboo (*Bambusa arundinacea*) shoot rhizomes locally referred to as Karilare submerged in water For 2-3 days @ 1 kg per 4 lit. of water. The extracted solution sprayed in the paddy fields is reportedly controlled the caseworm. For one acre of crop, around 50 litres of the extract are needed. For control of rice hispa in field, farmers broadcast branches of Germany ban (*Eupatorium odoratum*), Bihalongoni (*Arthyrium spp.*) and Posotia (*Vitex negundo*) on standing water at early tillering stage. Fresh leaves of parasi (*Cleistanthus collinus*) tree are broadcasted in paddy fields with standing water for the control of rice hispa. Parasi leaf has strong bitter taste, which is toxic to the insects, thus it works as repelling agent (Arya and Babu 2017).

In Orissa cut pieces of bamboo shoots, kolathia (a local weed) and suan (minor millet) are utilise to manage the paddy leaf-roller and caseworm (Parasar and Bibudha 1994). Chopped pieces of *Colocasia* (*Colocasia esculenta*) and chopped peels of citrus (*Citrus grandis*) are spread in the rice fields. This makes water bitter some and acts as repellent to the caseworm larvae when they fall on the water. This is a common practice in Orisa to control caseworm infestation in rice (Arya and Babu 2017).

In Andhra Pradesh for the control of leaf folder and stem borer in paddy, people use plant materials like fish tail palm leaves (*Caryo taurens*) and Jeelugu. They spread 25–30 leaves per acre in rice field. Alkaloids released by these fish tail leaves deter pests. If rice crop is attacked by termites, musidi leaves (*Nux vomica*) are dispersed in the field. In Joynagar, Teliamura (West Tripura), aphid infestations on paddy during flowering time is common. The dried fish is submerged in water by local farmers for one to two days. This fish-soaked water is then filtered, some water is added, and it is sprayed on the ground to keep aphids away from paddy fields. In Gujrat to manage aphids, green twigs of *Calotropis gigantean* plants are placed in the paddy fields and changed every ten days (Ravi 2017).

In Nasik district of Maharashtra some farmers are applying kitchen ash on paddy seedlings to control sucking pests like hoppers (Patil 2016). In Himachal Pradesh and West Singhbhum of Jharkhand farmers spread fresh salai (*Boswellia serrata*) leaves @ 5 kg per 100 m² in the affected paddy field helps to control gall midges (Arya and Babu 2017). Some of the rice pest management practices used by farmers in different parts of India are also listed in the following table (Table1.)

Table 1. Some ITKs used in different parts of India for rice pest management

S. No.	ITK	Pest control	State	Reference
1.	Use of Bhelama (<i>Anacardium</i> spp.) plant twigs in transplanted rice.	To reduce the risk of rice gundhi bug and hoppers.	The North eastern states	Shakrawar et al. (2018)
2.	Ash is sprayed on the newly germinated rice nurseries before the arrival of heavy rain.	Against rice insect pest and diseases. Hygroscopic ash particles absorb moisture from insect eggs and spores, restrict insect eating, and interact with surface lipids due to their potassium content. Potassium interacts with surface lipids, helping to protect plants.	Farmers of Panna district in Madhya Pradesh	Nene (2006)
3.	Farmers uses a mixture of cow urine (15-20 litres), cow dung (1.5-2 kg), and NSKE (10 kg) in 200 litres of water for spray.	Against sucking insect pest in rice.	In Nashik district of Maharashtra	Patil (2016)
4.	Farmers spray solution of lime, ash and green chilli extract.	To control rice leaf folder.	In Orissa Koraput district.	Narayanasamy (2002)
5.	Use of mixture of cow dung, cycas cones and brick kiln ash	Against the rice yellow stem borer. The odour of the cycas flower inhibit the adult moth from ovipositing on the plants.	In Orissa Koraput district.	

6.	Use of <i>Vitex negundo</i> (Nirgundi) plants.	To control rice insect pests. <i>Vitex negundo</i> , which is known to act as an insecticide, is used by farmers to make brooms used to sweep rice fields.	In the hilly areas of Himachal Pradesh	Kumar et al. (2021)
7.	Rice seedlings grown from neem extract-treated seeds.	To control leaf hopper.	Himachal Pradesh	
8.	Use of solution made from neem leaf paste and water (10 kg: 2 litres).	To control rice leaf folder. Neem seeds and leaves contain <i>Azadirachtin</i> , which act as insect growth inhibitor and antifeedant for insect pests.	Himachal Pradesh	
9.	Farmers utilise <i>Agave americana</i> (Ramban) in their rice fields, the Ramban (<i>Agave americana</i>) is crushed and placed into the water channel entry for irrigation of rice fields.	To control the rice against insects like leaf folders and rice hispa. Saponins present in Ramban plants have insecticidal properties.	In North-Western Himalaya	Deka (2006)
10.	Farmers uses leaves of the ankharein plant (<i>Euphorbia antiquorum</i>) to protect their rice from insect pest. In this procedure, the plant's leaves are placed near the opening of the canals leading to the fields before the attack of the rice hispa (chitri).	To control rice hispa.	Palam valley of the Kangra district Himachal Pradesh	Vimal and Das (2015)

11	Raw cow dung is combined with water to create a suspension solution, which is then sprayed on rice fields.	To control thrips.	Assam	Tinto et al. (2005)
12	Neem (<i>Azadirachta indica</i>) seeds, leaves, and extract are decocted and sprinkled on rice, together with citrus peels spread out in fields	To control rice yellow stem borer.	Assam	
13	Kerosene-dipped rope was stirred into rice field water.	To control rice case worms. Kerosene act as toxicant for insect.	Assam	
14	Chopped Indian rhododendron or phutuka (<i>Melastoma malabathricum</i>) leaves, ground drumstick (<i>Moringa olifera</i>) bark, and a few branches of fern (<i>Cybotium</i> spp.) are placed in the field.	To control rice leaf folder and yellow stem borer. It has insecticidal properties.	North-east India	
15	Spreading leaves of <i>Artemisia vulgaris</i> , <i>Croton caudatus</i> , <i>Munromia wallichii</i> , <i>Adhatoda vessica</i> and others, as well as erecting or pegging branches of <i>Cymbopogon Khasianum</i> and <i>Saccharum spantaneum</i>	To control rice stem borer. Chemical compounds present in leaves prevent rice pests from feeding on plant.	North-east India (Manipur, Meghalaya, Sikkim)	Kumar et al. (2009)

16	Cow urine, <i>Vitex negundo</i> (Nirgundi), and <i>Ferula asafoetida</i> (Hing) used by farmers. Nirgundi leaf decoction is prepared until there is just 1 litre left. The above substances are combined with around 5 litres of cow urine, about 10 grams of hing, and are then sprayed over the rice crops that are being affected.	Insects pest of rice. Solution have repellent property against rice insect pests.	Hilly mountain villages of Shimla, Himachal Pradesh.	Kumar et al. (2021)
17	Farmers applying silica or dust mixed with kerosene to control pests.	To control leaf rollers in the nursery and rice Hispa. Insect repel due to the odour of the kerosene oil.	Mursidabad area of West Bengal	Hasan and Chaudhuri (2018)
18	Burning straw, broken tyres, or clothes that have been soaked in kerosene.	To control nocturnal insects, and gundhi bug they fall into it. Burning of tyres act as a repellent to Gundhi bug due to disagreeable odor emitted on burning of tyres.	Mursidabad area of West Bengal	
19	Farmer spread banana sucker, black colocasia, wild turmeric, and bamboo perch at corners of the field during rice transplanting.	To control rice insect pests.	Assam	Sarodee et al. (2020)

20	Tribal farmers use kerosene oil mixed with water that is poured in standing crop fields during the kharif season of rice, and plants are simultaneously stirred by a long rope.	To control bug and hoppers	Madhya Pradesh	Shakrawar et al. (2018)
21	Kerosene rope is pulled over the standing rice crop in field.	To control rice hispa, case worm, and stem borer. The stem borers pests are poisoned by kerosene and case worms are unable to breathe within the case due to the oil film that has formed on the water surface.	Assam	Hazarika et al. (2009)

Sugarcane

Sugarcane is one of the most important cash crops in India. It is grown on almost 5 million hectares across different states of India. Among these, Maharashtra, Uttar Pradesh, Tamilnadu, Karnataka, Gujrat, and Bihar are the major sugarcane growing states. Sugarcane is attacked by many borers and sucking pests. Also, the termite is known for inflicting significant damage in many tropical cane growing states. As the pest is a soil habitant, its management by chemical methods is not efficient. Farmers in sugarcane growing areas have developed some local termite management practices by applying their experience and with limited available resources.

In Gujrat state, farmers use locally available *Calotropis procera* leaf extract to manage termites in the sugarcane fields. Before planting, farmers dip sugarcane setts in 15-20% leaf extract of *C. procera*. Also, the sprinkling of 2% extract in furrows before setts planting is in practice. This practice was found effective for inhibiting the termite attack on freshly planted setts. The alkaloids present in the *C. procera* leaf extract act as a repellent to termites and protects the crop for a long duration (Srivastava et al. 2006).

In tribal areas of Orissa, farmers spread the green leaves of turmeric and Sal (*Shorea robusta*) in the fields during the sugarcane setts planting. These plant leaves act as a repellent to termites and other soil inhabiting pests inhibiting its infestation on freshly planted sugarcane setts. In some parts, farmers mix dried horse dropping @ 100 gm/ha in sugarcane fields during ploughing and are left alone for some days before planting. It is known that; this practice reduces the termite infestation by 70% with a feasible cost: benefit ratio of 1:10. Some framers also apply 2.5 kg lime along with 5 kg salt in sugarcane fields which gives good termite control measures by reducing attack by 60-70% in sugarcane fields. Application of 2.5 liters of kerosene oil per hectare in irrigation water in sugarcane fields is also a local practice to reduce termite attacks. (Mahapatro et al. 2017).

A complex of shoot-borers is another major problem in the sugarcane crop. Farmers apply the chulha ash after 2-3 months of sugarcane planting to control early shoot borer. Neem seed kernels and neem cakes are powdered, overnight soaked in water and the extract is sprayed to check the shoot borer infestation in sugarcane. Dried neem fruits are powdered and applied @ 200 kg/ha to control stem borers and fungal diseases in sugarcane crops.

In Bhavnagar, Gujarat while planting sugarcane, farmers use onion juice to prevent white fly attack. The juice from the onion is

applied to the sugarcane cuttings. In some areas, a gunny bag containing 20 kg of onions per bigha (0.16 ha) are packed and smashed on the ground. The bag of smashed onions is placed at the entry point of the irrigation canal. The onion juice mixes with water and irrigates the crop, thus preventing pest attack (Mavani 1997).

Wheat

Farmers of Karnataka, Pondichery, Andhra Pradesh, Jharkhand (East Singbhum), Uttar Pradesh, and Arunachal Pradesh use *Euphorbia tirucalli* (milk bush, pencil tree, finger tree) plant. The smell of the plant sap keeps termites away. This plant is used for controlling termites in standing crops. Crushed plants are kept in the irrigation channel and the water passing through the plants helps in controlling termites in wheat at the most susceptible stage, ie, at third irrigation (Mahapatro et al. 2017).

In villages of Shimla, Himachal Pradesh farmers uses cow urine + *Vitex negundo* (Nirgundi) + *Ferula asafoetida* (Hing) mixture. These mixtures are highly effective, environmentally safe insecticidal treatment against insect pests of wheat crop. insect pests are repelled by this mixture. Leaf decoction of nirgundi (about 30-40 leaves in 10 litres of water) is prepared till it is left 1 litre. This mixture is filtered properly. About 10 gm hing is mixed in one litre water and then above ingredients are mixed in about 5 litres of cow urine and sprayed over affected crops (Kumar et al. 2021).

Maize

Spraying of diluted onion or garlic juice is used by tribes of the Chhindwara district of Madhya Pradesh to control grasshopper

and other leaf eating insects on the Maize crop (Shakrawar et al. 2018) The North East and Tamil Nadu farmers use citronella grass and lemon grass for controlling weevil and grain attack of Maize crop (Santosh and Chhetry 2012). In Gujrat, tribal people use Simta vine fruits. Simta vine fruits (2–3 kg) are chopped into small pieces and mixed with water (10–12 litres) in a container and stirred well. The suspension is filtered through cotton-cloth after a few minutes. With the use of bamboo leaves or short branches, the filtered solution is sprinkled over maize to suppress insect pest infestation. This fruit is used by tribal people, as it has an extremely pungent taste (Vasava 1992a). Maize is attacked by a Painted grasshopper at an early stage during monsoon in Panchmahal, Gujrat. A juice of 2–3 kg of peeled onions (after dilution) is sprayed on one bigha (0.24 acre) for control of the painted grasshopper (Rathod 1997).

Sorghum and Bajra (Pearl millet)

In Bharuch, Gujarat people use AagFutla fruit extract to control surface grasshopper. During the monsoon, surface grasshoppers, known locally as khapedi, infest sorghum. Fresh AagFutla fruits are collected, crushed in water, and filtered and the crop is sprayed with the liquid (Vitthalbhai 1993). In kagdipura, Madhya Pradesh farmers use country wine or kerosene to reduce the infestation of pearl millet beetle (Vasava 1992). In Bhavnagar, Gujarat jaggery is used for control of larval pest of pearl millet. 500 g of jaggery is dissolved in 10 litres of water and is sprayed on ear head. Perhaps, the jaggery attracts ants and other predators which then attack the larvae (Bhikhabhai 1994).

Conclusions

Traditional plant protection practices and knowledge are the treasure for the present and future which needs to be tapped and conserved for sustainable agriculture. These non-chemical-based pest management methodologies are excellent alternatives to chemical pesticides in conjugation with various Integrated Pest Management (IPM) components like the use of botanicals, bio-pesticides, resistant varieties, pheromones, etc. The ecologically sustainable nature of traditional indigenous practices against organic pesticides should be emphasized and popularized among farmers. Extension agencies should motivate the farmers to adopt the local indigenous pest management practices, which are safer for the environment. As the world is moving towards organic agriculture, it is the need of the hour to encourage and educate the farming community to adopt indigenous, traditional, and eco-friendly pest management strategies.

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Cow Urine: An Indigenous Technical Knowledge as Bio-fertilizer and Bio-pesticide in Agriculture

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Abstract

Local knowledge or indigenous technical knowledge is an awareness that is specific to the culture or society of a particular region. The practise of organic agriculture is currently gaining popularity on a global scale. Cow urine is a special dairy product with enormous properties, which can be applied as bio-fertilizer for improving soil health as well as can be utilized as disinfectants and antimicrobial agents to control a wide range of pests and diseases of plants. It is made up of water, urea, and contains small amount mineral salts, hormones and enzymes. The numerous cow urine-based bio-enhancers viz. Bijamrut, Jivamrut, Panchagavya, Amrutpani, Sanjivak, Amrut Ghol, Neemastra and Agneyastra that have been formulated very easily by the farmers under organic farming systems. These bio-enhancers play significant role not only in plant protection but also act as plant growth promoters. This report gives information regarding significance of cow urine in sustainable organic farming through utilizing the indigenous technical knowledge in preparation of bio-enhancers for increasing the soil fertility, plant growth as well as plant protection.

Key words: Bio-enhancers, Cow urine, Indigenous technical knowledge, Organic farming, Panchagavya

Introduction

Cow is recognized as very sacred animal in India since Vedic and pre-

Vedic period and is worshiped as 'Gomata'. *Panchgavya* is an organic product, produced by using five different products of cow like cow dung, urine, milk, ghee and curd that has played significant role in promoting growth and immunity in plant system as well as it also provides resistance against pest and diseases. The cow urine is a natural and non-toxic product which is easily digestible and several classic Ayurvedic scriptures, including the Charaka Samhita and the Shushruta Samhita, have well described its medicinal application. Traditionally cow urine is being used by mankind for various purposes like rituals as well as bio-fertilizer and bio-pesticide in agriculture (Basak et al. 2002). Several volatile and non-volatile constituents in cow urine could possess a good degree of antimicrobial properties. Cow urine was also discovered to be efficient against some strains of bacteria that were antibiotic-resistant after being photoactivated and purified (Wate et al. 2011). Moreover, cow urine has anti-inflammatory, anti-oxidant properties, anti-microbial, anti-carcinogenic and anti-diabetic effect and hence act as therapeutic agent for human health benefits (Sathashivam et al. 2010). Now-a-days this usefulness of cow urine has been taken in the form of Indigenous Technical Knowledge (ITK) that reflects the use of traditional knowledge for improving plant health as bio-fertilizer and for plant protection as bio-pesticide in agriculture. It can also be called as local knowledge which involves information obtained from local communities possessing long history of it. Traditional agricultural methods are also non-polluting and non-exploitative in nature. In this review, the detailed description of cow urine based on ITK is elucidated. Their role as anti-microbial and bio-pesticide to control several biotic stressors in plants have been explained. Different organic formulations involving cow dung, urine and their

significance in plants have been described. The information in the review will not only help farmers but also would pave a path towards sustainable agriculture.

Composition of Cow Urine

Cow urine contains 95% water, 2.5% urea and the remaining 2.5% mixture of salts, hormones, enzymes and minerals (Ramani et al. 2012). The total nitrogen (N) content of cow urine is very high which ranges from 6.8 to 21.6 g N/l.

Table 1. Effects of various bio-chemical ingredients present in the cow urine and their effects (Singh 2019)

Bio-chemical ingredient	Effects
Urea	Strong antimicrobial agent
Nitrogen	Increases N content in soil
Uric acid	Reduces cardiac inflammation, its antimicrobial activity helps to control cancer and secondary bacterial infection.
Copper	Controls fat deposition and acts as antidote for various poisons in the body
Sulphur	Helps to purify blood and also a good pro-kinetic agent
Iron	Augment the production of RBCs (erythropoiesis) in body
Enzymes	Improves the digestive power and also boost immunity
Creatinine	Antibacterial

Cow Urine as Bio-fertilizer

Bijamrut

Bijamrut is formulated by using the following ingredients.

- Cow dung- 5 kg
- Cow urine- 5 L
- Cow milk- 1 L
- Lime- 250 g
- Water-100 L



A seed treatment called Bijamrut is capable of shielding juvenile roots from fungi as well as soil- and seed-borne infections (Bishnoi and Bhati 2017). This organic formulation based on cow urine is also considered as a potent source to improve soil fertility, crop productivity and additionally control pests and diseases.

Sanjivak

Sanjivak is formulated by using the following ingredients.

- Cow urine- 100 L
- Cow dung- 100-200 kg
- Jaggery- 500 g
- Water- 300 L



The mixture is stored for 10 days

for fermentation and diluted 20 times before use. It is used along with drip irrigation and foliar spray to enrich soil with microorganisms. A biofertilizer called Sanjivak is used to rapidly degrade leftovers and nourish the soil with microbes (Mathukia et al. 2020).

Jivamrut

Jivamrut is formulated by using the following ingredients.

- Cow dung- 10 kg
- Cow urine- 10 L
- Jaggery- 2 Kg
- Flour of gram (Tur, Moong, Cowpea, Urad)- 2 kg
- Live soil (Healthy soil)- 1 kg
- Water- 200 L

This mixture is applied for promoting growth and flowering of the plants and soil fertility enhancer. Jivamrut provides nutrients and also serves as a catalytic agent that encourages earthworm activity and soil microbial activity. Jivamrut aids in the prevention of microbial infections (Ram and Pathak 2019).



Panchagavya

Panchagavya is formulated by using the following ingredients.

- Cow dung slurry- 4 kg
- Fresh cow dung- 1 kg
- Cow urine- 3 L
- Cow milk- 2 L
- Curd- 2 L
- Cow butter oil- 1 Kg



This mixture is applied @ 3 L Panchagavya in 100 L water. This can also be applied as seed and seedling treatment. Panchagavya offers a variety of micronutrients to the soil, promotes plant development, deters insects and aids in developing disease resistance among the plants (Mathukia et al. 2020).

Enriched Amrut Ghol

Enriched Amrut Ghol is formulated by using the following ingredients.

- Cow urine- 5L
- Cow dung- 1 kg
- Decaying fruit juices- 1L

This mixture is prepared and kept for 5 days for fermentation. Then it is applied as a spray of 20L- 30L in 1 acre cropping area.

Growth and flowering enhancer “Enriched Amrut Ghol” is a

traditional agricultural practise that aims to provide high-quality, sustainable yields in plants. It contains a variety of minerals, helpful microorganisms, hormones that act as soil fertility enhancer and also to protect the crop against pests by enhancing the plant's defence mechanisms. A key element of the effectiveness of organic farming in many regions is the stimulation of soil microbial activity using Amritpani formulations (Biswas and Das 2022).



Cow Urine as Biopesticide

Cow urine has a unique place in Ayurveda and has been described in 'Sushrita Samhita' and 'Ashtanga Sangraha' to be the most effective substance or secretion of animal origin with innumerable therapeutic values. The cow urine-based formulations are excellent germicidal. Therefore, in future they are going to reduce the pressure on the existing use of chemicals for controlling pests and diseases on plants. Cow urine has proven as an effective pest controller and larvicide when used alone and also in combination with different plant preparations through enhancing the efficacy of different herbal preparations. Sesame is a major oil seed crop, but the major constraint in sesame production is the insect pest infestation. The natural product preparation containing neem oil, neem seed kernel extract, neem leaf extract and mixed with cow urine are very effective against sucking pests in sesame and also for higher grain yield and net profit (Ahirwar et al. 2010).

Disease control and management

The acidic pH of cow urine is thought to be responsible for its antimicrobial effects. Additionally, it has been established that the presence of urea, aurum hydroxide, creatinine, phenols and calcium in cow urine delineate its germicidal and antibacterial properties (Jain et al., 2010). The urinary polypeptide and amino acids change the hydrophilicity and hydrophobicity of the bacterial surface, increasing the bactericidal potency (Badadani et al. 2007). When tested against the root-knot nematode (*Meloidogyne incognita*), cow dung, urine, and their combination had substantial effects in comparison to the untreated control. The blend of urine and dung had more nematocidal efficacy than any component used alone (Abubakar et al., 2004). The chemical fungicides are very hazardous to both environment and soil. The cow urine in combination with cow dung has potential for controlling Sclerotinia rot caused by *Sclerotinia sclerotiorum* of cucumber (Basak et al., 2002). It has been noted that plant pathogens like *Fusarium solani*, *Bipolaris sorokiniana* and *Xanthomonas oryzae* have been inhibited by cow urine. Kekuda et al. (2014) elucidated the antifungal activity of cow urine-based plant extract and described its inhibitory role against plant pathogen *Colletotrichum capsici* obtained from anthracnose of chilli. As per their observations *Alpinia galanga* leaf extract and *Pimentia dioica* rhizome extract both showed strong inhibitory activity, whereas *P. dioica* leaf extract and *Anacardium occidentale* bark extract had less potent inhibitory effects. Jandaik et al. (2015) also reported antifungal potential of cow urine against damping off and wilting disease of methi and bhindi. They concluded that 15% concentration of cow urine was efficacious for maximum growth inhibition of *Fusarium oxysporum* followed *Rhizoctonia solani* and *Sclerotium rolfsii*. Cow urine also

inhibited the growth of *Aspergillus flavus*, *Aspergillus niger*, *Alternaria* sp., *Mucor* sp., *Fusarium* sp., *Macrophomina* sp. isolated from wheat (Ghosh et al. 2018). Two cups of cattle urine mixed with 5 ml peppermint oil and 10 L water can be used to control fungal diseases on grapes. Various bacterial and viral diseases can be alleviated by using cow urine. A mixture of 5 kg of cow dung, 5 litre of cow urine, 150 gm lime and 100 litre of water is used to control khaira disease, bacterial and viral diseases in paddy (Shakrawar et al. 2018).

Cow urine based formulations for controlling pest and diseases are described below.

Neemastra

Neemastra is formulated by using the following ingredients.

- Crushed Neem leaves- 5 kg
- Cow urine- 5 L
- Cow dung- 2 kg

This mixture is prepared and kept for fermentation for 24 hr with intermittent stirring. It is squeezed and filtered. The extract is diluted



to 100 L. It is use as foliar spray over one acre. Neemastra is very useful against sucking pests, mealy bugs and aphids. All Neem preparations viz. neem leaf extract and neem kernel extract combinations in cow urine significantly reduce aphid population in mustard (Gupta 2005).

Agneyastra

Agneyastra is formulated by using the following ingredients.

- Ipomea leaves- 1 kg
- Hot chili- 500 gm
- Garlic- 500 gm
- Neem leaves- 5 kg
- Cow urine- 10 L



This mixture is reduced into half through boiling. It is squeezed and filtered. It should be stored in glass or plastic bottles. The suspension of 2-3 L extract is diluted to 100 L and then used in one acre cropping area.

Agneyastraas a bio-pesticide, is used against several pests viz. leaf roller, stem/fruit/pod borer. It possesses repellent, chemosterilant, nematocide, rodenticide, anti-viral as well as microbicidal activities (Bishnoi and Bhati 2017).

Organic Earthen Pot Arkh

Agneyastra is formulated by using the following ingredients.

- Collect the fresh leaves of Neem, Pongamia, Calotropis and crush them
- Mix the crushed leaves with cow urine, cow dung and jaggery in the earthen pot
- Cover the mouth of the earthen pot with a clean cloth
- Store it in the shade for 7-10 days

- Collect the extract and further add 5 litre of cow urine

Dilute 20 ml of extract per litre of water and spray the crop or drench the soil in a rose cane for control of disease pests. Cow urine contains high content of urea which is toxic to most of the organisms and pests (Chowdary 2020).



Conclusions

Sustainable agriculture depends on a fundamental shift from present chemical-based agriculture to organic farming in order to safeguard agricultural resources for future generations to come. This conversion is necessary to create high-quality agricultural products as well as to protect the planet from chemical hazards. A variety of organic products are used in farming. Aside from manures, several traditional organic formulations, also referred to as bio-enhancers, play a crucial role for ecologically sustainable agricultural output and quality. Indigenous technical knowledge is crucial for popularization of traditional methods and techniques for benefit of the society. As most of the traditional methods and technologies are not documented, there may be chances of perishing these ITKs. Hence, in today's context, there is an urgent need to evaluate and popularize the indigenous innovations which are very accessible to the rural farmers and also found as less economic. Moreover, there should be appropriate coalition between the ITK and modern technical knowledge which has immense potential to benefit the society.

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ABOUT THE BOOK

The aim of the ITK book is to compile and document various indigenous and low-cost plant protection technologies which are being followed in Indian agriculture by the stakeholders belonging to different states for biotic stress management. Most of the technologies identified and practiced at grass-root level innovators are documented in this book with relevant pictures. This book covers 40 ITKs for weed management in various crops in which few ITKs including Kopar technology, mulching, water management, crop residues, various organic materials are noteworthy. This book highlighted various low-cost technologies and durable and affordable gadgets for management of biotic stress and rodent pest in field and horticultural crops and commodities under storage conditions. The information on ITKs which are being followed for plant disease management are well documented in this book. A separate chapter is included in this book to address various ITKs as protectants exclusively for grains and food commodities under storage. More than 40 Ethnoveterinary medical practices, being used by the tribal community of Chhattisgarh are well explained along with their pictures and method of applications in this book. The ITKs for promotion of sustainable fisheries and aquaculture is one of the chapters in this book. The use of cow urine in the preparation of various bio-fertilizers and bio-pesticides along with method of preparation and application is another noteworthy chapter in this book. This book would be useful to scientists, students, youngsters, stakeholders etc., to understand importance of ITKs in biotic stress management, as eco-friendly and ecologically viable approach.



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