

Indigenous pest management practices followed in major horticultural crops of Assam, India

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Received 25 March 2025; revised 25 September 2025; accepted 08 October 2025

A study was conducted to explore the indigenous practices of pest and disease management used by the farmers in Assam, India to protect the major horticultural crops and to determine the scientific rationality of these identified practices as judged by the scientists. It was conducted in two districts of Assam viz., Nalbari and Jorhat involving 120 farmers and 25 scientists. Out of 23 indigenous practices identified in management of pests in horticultural crops, 7 are highly effective, 6 are moderately effective and 10 are less effective as perceived by the farmers. Out of the 4 mechanical practices, only 1 was rational, but not highly efficient. Likewise, of the 8 plant-origin practices, 5 were found rational and only 2 have high efficacy. No animal origin practice was found to be rational. More than 50% of scientists rated 7 practices as rational which may provide input for the future research. The effective and rational practices can be validated for other agro-climatic conditions in order to popularize them as component of IPM modules. The efficacy of such rational practices may also be judged against the recently invaded exotic pests in horticultural ecosystem.

Keywords: *Bhimkol*, Fruits, Indigenous, ITK, Plant protection, Rationality, Vegetables

IPC Code: Int Cl.²⁵: A01P 15/00, A01P 17/00

Fruits and vegetables are grown in 4.23 lakh hectares area in Assam with a production of 72.19 lakh MT¹. The insect-pests and diseases are a key constraint in producing quality vegetables in large quantities and vegetable growers are losing 10 to 30% crop yield². Farmers all over the world perform experiments, and have done so since long before the modern experimental science and its recognized forerunners³. Farmers have developed many technologies through the trial-and-error method⁴ in the course of their struggle for livelihood. These forms of knowledge, known as indigenous technical knowledge (ITK), have been recognized as valid and useful in the field of agricultural and the farmers have increasingly been recognized as themselves innovators and experimenters⁵. Thus, ITK is knowledge of a particular community developed over a long period spanning multiple generations and continues to evolve with experience⁶. The ability of farmers to monitor environmental occurrence around them has been ignored^{7,8}. Cultural methods of pest management practices are popular among poor farmers and such

practices form in the core of ITKs. The rural communities depend on ITK for their livelihood and to manage local ecosystem in a sustainable manner⁹. Such knowledge is transferred across the generations and should be documented so as to consolidate this experience into a system¹⁰. The knowledge of farmers in developing countries has not been recorded systematically; hence, they are not easily accessible to agriculture researchers, extension workers and development practitioners¹¹. Thus, there is a need for understanding the scope of identifying, validating and documenting the traditional knowledge in India. Preserving, protecting and harnessing the traditional knowledge systems is timely needed in the areas of agriculture and medicine¹². Documenting such knowledge is necessary to ensure the continuity of these practices for future generations¹³. The problems of sustainability of modern scientific technologies and their impact on the ecosystem and environment have evoked the interest on ITKs in the recent past¹⁴. Such traditional knowledge can be combined with the scientific know-how to increase productivity and improve the living standards of the farmers⁶. Thus, over the years, documenting the traditional farm

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practices are gaining momentum due to pro-community and pro-environment nature¹⁵. The pest and disease management of agricultural and horticultural crops were carried efficiently using locally available inputs¹⁶, because the ITKs are environment-friendly, site specific and cost effective in nature⁴. It is noteworthy that even practices associated with pest management vary among traditional farming communities in different parts of the same country¹⁷. In the above context, the present study was conducted to identify the ITKs adopted by the farmers in the horticultural crops in Assam, to know the perception levels of farmers on the efficacy of the ITKs and to know the rationality of such practices from a group of plant-protection scientists.

Methodology

The study was conducted as per the methodology of Barman *et al.*⁴, as described below.

A descriptive research design, following an *ex post facto* approach was used. We selected two types of respondents *i.e.*, (i) 120 farmers of Nalbari district, Assam and (ii) 25 plant-protection scientists of the Assam Agricultural University, Jorhat. The Indigenous Pest Management Practices (IPMPs) collected from the farmers were validated by the scientists. The IPMPs were collected using semi-structured schedule following 4 Focus Group Discussions conducted in the 4 agricultural extension circles (30 farmers sampled from each circle). The efficacy levels of the identified IPMPs as perceived by the farmers were recorded using pre-tested semi-structured schedule by personal interview. To measure the efficacy level of the identified IPMPs, the efficacy level was sought from the farmers in a 3-point scale *viz.*, highly effective (3), moderate effective (2) and less effective (1). Later on, the efficacy score of the practices was calculated by the following formula.

$$x = \frac{\sum x_i}{n}$$

Where,

$\sum x_i$ = Summation of individual respondent wise score on 'x' IPMP.

n = Number of respondents furnished score on 'x' IPMP

x = Efficacy score of 'x' IPMP

Based on the efficacy score the explored IPMPs were grouped into 3 categories *viz.*, Less effective

(with a score range of 1.00 - 1.66), moderately effective (with a score range of 1.67 - 2.33), and highly effective (with a score range of 2.34 - 3.00). The rationality level of each of the identified practice was sought from the respondent scientists in a 3-point continuum *viz.*, rational, undecided and irrational assigning a score of 2, 1, and 0 respectively. The frequency and percentage distribution of responses were calculated according to their perceived level of rationality. The scientific reasons as furnished by scientists were also noted and discussed in the following sections.

Results & Discussion

We identified 23 indigenous plant protection practices of horticultural crops; of these, 7 are highly effective, 6 are moderately effective and 10 are less effective as perceived by the farmers. These practice along with their target pests and diseases, stages of crop in which they are followed and the nature of the effect are mentioned in Table 1. The number of identified indigenous practices in horticultural crops are relatively less than that in rice ecosystem as reported from the same district by Barman *et al.*⁴.

Indigenous pest management practices of vegetable & fruit crops

We identified 14 practices in vegetables crops (Table 1). In case of potato, 1 practice is followed during land preparation and 3 practices in seedling stage. Red ants being a notorious pest in potato, 3 ITKs are in practice for controlling the red ant. Among 3 identified practices of brinjal, 2 practices are used against shoot and fruit borer in active vegetative growing and flowering stage. In case of cucurbits, all practices are followed against the fruit fly and blight disease.

Nine practices have been identified in fruit plants (Table 1), 4 in citrus, 3 in coconut, and 2 in mango. In citrus, 2 practices are followed in active vegetative growing stage and other two are in flowering stage. In citrus, 3 practices are used for controlling trunk borer. In coconut, all the practices are followed against the rhinoceros beetle at flowering stage.

Effectiveness of indigenous practices as perceived by the farmers

As shown in Table 1, out of 23 identified practices, 3 are highly effective, 4 are moderately effective and 16 are less effective as perceived by the farmers.

Table 1 — Indigenous pest management practices of horticultural crops and their parameters as explored in Assam

Practice (Type)	Pest / Disease	Crop Stage	Nature of effect	Efficacy Score*	Rationality**		
					R	U	IR
Crop: Potato							
1) Application of salt in soil (Chemical)	Red ant	Seedling	Irritation to insect body due to salty nature	2.44 (H)	8 (32)	12 (48)	5 (20)
2) Dusting of ash in leaf foliage (Plant origin)	Late blight	Seedling & vegetative	Alkaline nature of the ash	1.28 (L)	10 (40)	8 (32)	7 (28)
3) Hiding or keeping Banana fruit (var. <i>Bhimkal</i>) under the soil surface. (Plant origin)	Red ant	Seedling	Banana attracts red ants in large number which can be destroyed easily manually	2.09 (M)	9 (36)	10 (40)	6 (24)
4) Incorporation of mustard oil-cake into the furrows. (Plant origin)	Red ant	Land preparation	Pungency of oil-cake repels the red ant	1.42 (L)	15 (60)	8 (32)	2 (8)
Crop: Brinjal							
1. Dusting of ash on foliage and around plants (Plant origin)	Brinjal Soot and Fruit borer (BSFB)	Vegetative & flowering stage	Alkaline nature of ash. It also causes physical abrasion to larvae.	1.52 (L)	13 (52)	10 (40)	2 (8)
2. Using solution of <i>hing</i> (asafoetida) & raw turmeric (Mixture)	Wilt; Aphid	Active vegetative stage	Pungency of turmeric & bitter taste of asafoetida	2.55 (H)	13 (52)	12 (48)	0 (0)
3. Spraying of tobacco leaves solution (Plant origin)	Aphid, fruit and shoot-borer	Flowering	Insecticidal activity of tobacco leaves due to nicotine content	1.61 (L)	12 (48)	11 (44)	2 (8)
Crop: Cucurbits							
1. Rope made with rice-straw where dry chilli packets are attached and burnt at one end to produce smoke in the crop field (Plant origin)	Fruit fly	Fruiting	Smoke carries unbearable odour to the fruit fly	1.84 (M)	14 (56)	11 (44)	0 (0)
2. Fruits lying on the ground are covered rice-straw or thatch (Mechanical)	Fruit fly	Fruiting	The fly get difficulty in attacking the covered fruit	1.94 (M)	12 (48)	8 (32)	5 (20)
3. Throwing of rotten fruits on the roads (Mechanical)	Fruit fly	Fruiting	The larvae of fruit fly are exposed biotic and abiotic stresses	1.84 (M)	14 (56)	11 (44)	0 (0)
Crop: Tomato							
1. Spreading the rice straw in the ground around the tomato plants (Mechanical)	Blight and fruit rot disease	Fruiting	Due to presence of straw, the branches of plants and fruit do not come in contact with soil and so fruit rot and blight disease is controlled.	1.30 (L)	10 (40)	14 (56)	1 (4)
2. Dusting of ash in the plant (Plant origin)	Blight	Vegetative stage	Alkalinity of ash reduces the disease incidence	1.30 (L)	9 (36)	14 (56)	2 (8)
Crop: Cauliflower and cabbage							
1. Ant nests are kept near pest infested pockets of cauliflower, cabbage field (Biological)	Competitive pests of aphid	Seedling	Ants take the honeydew produced by aphids and in turn, provide protection to them from its natural enemies and other competitive pests	1.0 (L)	7 (28)	13 (52)	5 (20)
Crop: Chili							
1. Dried chillies are burnt and put in holes of cricket pests (Plant origin)	Field cricket	Seedling	The crickets come out from the hole due to the irritation caused by smoke and they are killed by beating	2.57 (H)	13 (52)	9 (36)	3 (12)

(Contd.)

Table 1 — Indigenous pest management practices of horticultural crops and their parameters as explored in Assam (Contd.)

Practice (Type)	Pest / Disease	Crop Stage	Nature of effect	Efficacy Score*	Rationality**		
					R	U	IR
Crop: Citrus							
1. Painting of citrus trunk with lime solution up to 1-1.5 m (Chemical)	Trunk borer and/or stem borer	Active vegetative stage	Since lime is alkaline in nature, it reduces the attack of the borer pest	2.60 (H)	16 (64)	9 (36)	0 (0)
2. Sealing of trunk holes made by trunk borer with bamboo plugs after clearing the holes and /or otherwise plastering of those with mud (Mechanical)	Trunk borer and/or stem borer	Active vegetative stage	Pest cannot come out from the hole and die inside	1.57 (L)	12 (48)	9 (36)	4 (16)
3. Spraying of lime solution in pest infested parts of the plants (Chemical)	Trunk borer and/or stem borer	Flowering	Alkaline nature of lime retards the pests	1.94 (M)	11 (44)	13 (52)	1 (4)
4. Dusting of ash on foliage (Plant origin)	Lemon butterfly	Flowering	Ash is alkaline and physical irritant to the butterfly	1.35 (L)	11 (44)	13 (52)	1 (4)
Crop: Coconut							
1. Placing a basket of raw cowdung and a few dry fish at the base of the coconut plant in the evening. (Mixture)	<i>Rhinoceros</i> beetle	Flowering	The pest come out at night and gather to this cowdung-fish mixture and farmers can kill them easily	2.50 (H)	12 (48)	9 (36)	4 (16)
2. Pouring fresh cow milk on the shoot portion (Animal origin)	<i>Rhinoceros</i> beetle	Flowering	Fresh milk attracts the ants which disturb the activities of the pest	1.67 (L)	2 (8)	12 (48)	11 (44)
3. Application of mixture of sand and ash on shoot portion (Mixture)	<i>Rhinoceros</i> beetle	Flowering	The mixture irritates the beetle and restricts their movement and feeding in the crown & flower	2.60 (H)	13 (52)	12 (48)	0 (0)
Crop: Mango							
1. Smokes are produced beneath the tree by burning dried leaves, twigs, etc. (Plant origin)	Most of the pests of mango	Flowering	Smoke exerts the fumigation effect on the pests and ward off them from the flowers	2.35 (H)	17 (68)	8 (32)	0 (0)
2. Banding around tree trunk with a rope, made of rice- straw and cowdung (Animal origin)	Mealy bug	Flowering	Banding prevents the upward movement of the mealy bug	2.27 (M)	12 (48)	11 (44)	2 (8)

*Efficacy score: L: Low; M: Moderate; H: High.

**Figures in the parenthesis indicate percentage in rationality where R: Rational; U: Undecided; IR: Irrational.

Scientific rationality of the identified indigenous plant protection practices as judged by the scientists

The rationality of the practices was judged by the scientists as obtained through a questionnaire. The frequency and percentage distribution of scientists as respondents have been shown according to their perception level of rationality (Table 2).

Rationality of indigenous pest and disease management practices of vegetable and fruit crops

It can be seen from the Table 1 that out of 14 explored indigenous practices in vegetable crop, 6 practices are judged as rational by more than 50% of scientists. The scientists have also put the reason behind the rational practices e.g. oil cake and smoke act as repellent, wood ash acts as physical irritant, tobacco leaves extract acts as poison, fruit covering acts as physical barrier to oviposition process of gravid female etc. Likewise, out of 9 explored

Table 2 — Type based summary of rational indigenous practices in horticultural crops

Type of IPMP & No. of practices identified (within parentheses)	Rational practices	
	No. & % of rational practices	No. of rational practices with high efficacy
1. Mechanical/Physical (04)	1 (25%)	Nil
2. Plant-origin (10)	5 (50%)	2 (40%)
3. Animal-origin (02)	Nil	Nil
4. Chemical (03)	1 (33.3%)	1 (100%)
5. Biological (01)	Nil	Nil
6. Mixture (03)	2 (66.7%)	2 (100%)

*Based on table 1; H: High efficacy; M: Medium efficacy;

practices, 3 practices are rated as rational in fruit crops. Scientists also stated the reasoning of such efficiency of a practice e.g. painting citrus trunk act as physical barrier for egg laying, tightly sealing the trunk holes leads to suffocation of pest, ash may act as

feeding deterrent, smoke act as repellent and bonding act as physical barrier.

All the 23 IPMPs identified (Table 1) are categorized into 6 kinds based on the material used in the practices (Table 2). Such rational practices (*i.e.*, the practices which are rationalized by more than 50% of the scientists) are correlated to the efficacy as perceived by the farmers. Of the 4 mechanical IPMPs, only 1 (25%) were rational which is not highly efficient (Table 2). Likewise, out of the 8 plant-origin IPMPs, 5 were rational and only 2 (40%) had high efficacy. No animal origin practice is found to be rational. The remaining IPMPs are summarized in Table 2. The different kinds of IMPMs had different level of rationality and efficacy as compared to those in the identified in the same district in rice ecosystem⁴.

The scientific justifications of the efficacy of a few rational practices are highlighted below:

Common salt (NaCl) against red ant has been reported by farmers as highly effective. It is presumed that the entry of salt into the insect body may affect osmoregulation process that regulates the balance of ion and water in insect. Red ant being a terrestrial insect such regulation is vital owing to the evaporation of water and thus, common salt becomes effective on it. Use of table salt against white grub in Uttarakhand state has been reported¹⁸. Likewise, a high mortality of the larvae and pupae of *Aedes aegypti* has been reported¹⁹.

Wood ash may cause physical irritation and injury to labile stage of the insects, more particularly in early larval stages. Such injured larvae may get exposed to the intense solar heat and temperature which may lead to desiccation of larva. Consequently, they may be washed away by intense rainfall. Use of wood ash has also been reported from Manipur against powdery mildew and sucking pests²⁰. Likewise, the sand traps have been reported against Rhinoceros beetle from Southern Peninsular India²¹.

Hiding or keeping the banana fruit (var. *Bhimkal*) under the soil surface has been reported as effective lure for red ant due to its sweetness. The fruit size of *Bhimkal* (*Musa balbisiana* Colla) is big and has lots of seeds and a good mass of pulp over it. The pulp and fibre also remain interwoven in the spaces among the seeds and keep the seeds as a tight mass as compared to other seeded banana varieties. The pulp over the seed is easily taken away by the red ants but remain engaged for a longer time while exploring the pulp from this tight mass inside. They keep

themselves busy on exploring the banana for days together which in turn reduce their population and time for attacking the potatoes. Farmers also get enough time to kill them mechanically *in situ*.

Asafoetida has insecticidal property. Eighteen compounds have been identified in Asafoetida oil and few of them have been found effective against two species of *Culex* mosquitoes through its ovicidal and larvicidal action²². Tobacco is a widely applied insecticide due to the nicotine content which acts as neurotoxin in insect's body. Chilli has been traditionally effective against fruit fly; Chilli pepper has also been reported as an effective homemade insecticide against termites²³. Mustard oil cake has insecticidal property as well as soil enriching capacity. Antifeedant & insecticidal activity potential of mustard seed extract against *Spilosoma obliqua* have been assessed and reported that GC-MS of mustard oils shows compounds responsible for insect-detering potential²⁴. The pests of tomato by using leaf extract of *Cynodon dactylon* in Tamil Nadu, brinjal fruit and shoot borer by kochila (*Strychnos nux-vomica*) mixed with cowdung compost in Odisha, pests of cucurbits/cowpea/lady's finger by spraying the cow urine mixed in tobacco-soaked water in Jharkhand, vegetable pests by spraying animal urine and dusting of cow dung ash in Jharkhand, pests of *Solanum melongena* by tobacco soaked water in Bihar, pests of cabbage by ash and cow urine in Himachal Pradesh, rhinoceros beetle in coconut by cow dung slurry in Tamil Nadu, and diseases of yam by cow dung slurry in Odisha have been reported¹¹. Holes are made to fill it with cow-dung cakes and burnt before transplanting chilli seedlings to protect it from white grub⁶. Neem seed extract mixed with cow urine; erection of bamboo perches has been evaluated as effective tool against the pests of potato in Cachar district of Assam²⁵. A few ITKs of pest management in vegetables and fruits have also recorded from 4 districts of Assam²⁶.

Throwing of rotten fruits of pumpkin, bottle gourd etc. on the roads is a unique mechanical way controlling the larvae of fruit fly. The larvae get exposed to sunlight and mechanical injuries caused by the vehicles running over it. The larvae are devoured by the insectivorous birds in the early morning. Such fruits are also eaten by stray-animals (cattle, goat etc.) and birds.

The bamboo-perches erected in crop fields facilitate the insectivorous birds in roosting and thereby enhance their predation on insects. By sitting

Table 3 — Comparative analysis of effectiveness & rationality of indigenous practices

Parameters	High	Moderate	Less
i) No. of indigenous practices with different efficacy level as perceived by farmers	7	6	10
ii) Average rationality judged by scientists (%)	52.57%	48.0%	40.4%

on a perch within the field itself, a bird can visualize the presence of pests on and around the foliage more vividly. It saves their energy, otherwise needed, for flying to and fro the trees outside the crop-field. Birds can utilize this saved energy for predation of more preys⁴. However, the use of bamboo-perches is common in rice ecosystem in Assam^{4,14,16,27} than in vegetable crops. The bamboo fencing and trees around the vegetable crop ecosystem in Assam assures the perching of birds and their foraging.

Comparative analysis of effectiveness & rationality of the practices

It is hypothesized that highly effective practices for farmers should be rational for scientists. However, we found variations in it. For instance, even though, 7 highly effective practices had an average rationality of 52.57% (Table 3), two practices viz., (i) application of salt in soil against red ant in potato & (ii) placing a basket of raw cow dung and a few dry fish at the base of the coconut plant in the evening against Rhinoceros beetle were rationalized by less than 50% scientists. Likewise, two moderately effective and two less effective practices were judged as rational by more than 50% scientists (Table 1 & Table 3). Such a variations may be attributed to different factors such as weather parameters affecting the efficacy of the method applied (e.g. rain after dusting of ash on foliage and around plants against brinjal shoot and fruit borer). In a similar study conducted in Bageshwar district in Uttarakhand, 27 indigenous practices were found to be rational by the scientists out of 32 documented practices⁶.

Need of validation of the rational practices against newly invaded exotic pests of horticultural crops

The relationship between traditional knowledge and horticulture dates back to centuries, wherein the communities have developed newer crops and varieties of horticulture produce by employing methods of traditional domestication and selection²⁸. This is very true in NER India where the tribal people of different ethnic origin have been living for centuries and developing their unique traditional knowledge in farming. It can be noted that this region has experienced the invasions of a few exotic pests in recent time in horticultural ecosystem viz., Papaya

mealybug²⁹, Rugose Spiralling Whitefly^{30,31} and Fall Armyworm⁸ in maize crop. The rational practices can be also validated further to judge its efficacy against these invaded exotic crop-pests.

Conclusions

The North Eastern Region of India has rich diversity of indigenous practices in proportion its rich biodiversity, but these are remained unexplored owing to the poor accessibility to many remote villages. These crop protection practices can be identified in the horticultural ecosystem of NER and other states as well in order to test them for future study on their efficacy and validate it in different agro-climatic conditions (cross-sectional validation) so that these can further be refined for regional and national recommendation. The efficient practices can also be used to develop of combo products, e.g. combination of botanical and animal origin substances in order to generate cost-effective, eco-friendly, location specific module with durability, stability and social acceptance. There is tremendous scope of identifying the molecule of the insecticidal plants and develop commercial formulation out of it. By conducting the extensive demonstrations of suitable indigenous practices as part of Integrated Pest Management module, the extension machinery can take the organic and natural farming to the farmers. It is a need of the hour to work more rigorously on the effective traditional practices so a as to manage the changing pest complex due to changing climate.

Acknowledgements

The authors are grateful to the farmers of Nalbari district and the Plant-protection Scientists/Teachers of the Assam agricultural University, Jorhat involved in the study for their valuable inputs. The authors extend their gratitude to Dr. P K Neog, AAU for his valuable suggestions received during the course of study.

Conflict of Interest

The work is a part of the PG Research of the 1st author. The authors of the present work declare that no conflict of interest is associated with this manuscript. The co-author has gone through the manuscript and they have given their consent to the

corresponding author to handle the manuscript and to publish.

Author Contributions

IB: Conceptualization, Literary review, Methodology, Investigation, Resources, Formal analysis, Writing, Reviewing, Editing. AKS: Literary review, Formal analysis, Resources, Writing, Reviewing, Editing.

Ethics Approval

Not applicable

Prior Informed Consent

Prior informed consent was taken from all knowledge holders.

Data Availability

The work is a part of PG research of the 1st author. The data generated during the study have been included in this article.

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