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Indigenous pest management practices in rice ecosystem of Assam, India

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The indigenous pest management practices (IPMPs) adopted in rice farming in Assam were identified along with the farmers' perception levels on their efficacy and the scientific rationality as judged by the agricultural scientists. Data were collected from 120 farmers of Nalbari district and validated by 25 scientists of Assam Agricultural University, Jorhat. The result reveals that out of 33 identified practices, - 6 are highly effective and 10 are moderately effective as perceived by the farmers. A total of 21 practices have been rated to be rational by most of the scientists. Out of the 8 plant-origin IPMPs, all were rational with high and medium efficacy score, whereas out of 16 cultural IPMPs, only 6 (37.5%) were rational with only 2 practices with high and medium efficacy. No botanical practice was judged as irrelevant by any scientist. The effective and rational practices may be validated further in other agro-climatic regions in order to popularize them as a part of Integrated Pest Management module. The rational IPMPs can also be screened to assess its efficacy against the recently invaded crop-pests in Assam.

Keywords: Crop protection practices, Indigenous, IPM, IPMP, ITK, Rationality, Rice

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Rice is the most significant crop in Assam, which accounts for 2.54 million hectares of the overall planted area of 4.16 million ha contributing 96% of the state's entire production of cereal grains[1]. This crop is damaged by nearly 300 species of insect pests, out of which only 23 are serious pests of rice[2] with a yield loss of about 28%[3]. Rural people in their struggle for survival aim to produce enough food for the family and to maintain the productive capacity of the land. In the course of their struggle, they have developed many technologies through their trial-and-error methods, and refine it by adding new inputs to their existing technical knowledge. These forms of indigenous knowledge, widely known as indigenous technical knowledge (ITK) world-wide, have been more and more recognized as valid and useful in the field of agriculture and farmers have increasingly been recognized as themselves innovators and experimenters[4]. However, the ability of farmers in the third world to monitor environmental occurrence around them has been ignored[5] which is also true for the farmers of northeastern region of India[6]. The local rural communities depend on ITK for their livelihood and to manage local ecosystem in a sustainable manner[7]. The overwhelming majority of populations in the most developing countries are small scale farmers and they represent hundreds of distinct language and ethnic groups in most cases, the knowledge system of these farmers has never been recorded systematically in written forms, hence, they are not easily accessible to agriculture researchers, extension workers and development practitioners[8]. Such knowledges which are transferred from generations to generations should be documented so as to consolidate this experience into a system[9]. There exists an extensive requirement for understanding the scope of traditional knowledge in India. Preserving, protecting and harnessing the traditional knowledge systems is timey needed in the areas of agriculture and medicine[10]. The ITK in agriculture, animal husbandry, fisheries and other land-based activities is being used since ages by the farmers, animal owners and other practitioners; however, the advancement in scientific knowledge in agriculture has questioned on

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rationality of ITKs and replaced these ITK-based practices. The problems of sustainability of modern scientific technologies and their impact on ecosystem and environment have evoked the interest on ITKs during the recent past[11]. The role ITKs in agricultural development both in research and extension is now well recognized. Over the years, documenting the traditional farm practices are gaining momentum due to pro community and pro-environment nature[12]. The pest and disease management of agricultural and horticultural crops were carried efficiently using locally available inputs[13] because the ITKs are environment-friendly and site specific and cost effective in nature. Keeping the above views in mind, the present study was conducted to identify the Indigenous Pest Management Practices (IPMPs) practised by the rice growing farmers, to know the perception of farmers on the efficacy of the identified IPMPs and to extract the rationality of these practices as perceived by plant-protection scientists.

Materials and Methods

A descriptive research design, following an *ex post facto* approach was utilized in the study. A multi-stage purposive cum random sampling design was adopted for study in order to select farmer respondents. The study comprised of two categories respondents *i.e.,* farmers and plant-protection scientists. The Indigenous Pest Management Practices (IPMPs) were collected from 120 farmers of 4 agricultural extension circles (*i.e.*, randomly selected 30 farmers from each circle) of Nalbari district of the Lower Brahmaputra Valley Zone (LBVZ) of Assam; later the scientific validation of the explored practices was judged by 25 plant-protection scientists/teacher of Assam Agricultural University, Jorhat of the Upper Brahmaputra Valley Zone (UBVZ). These two districts are situated in two banks of the mighty Brahmaputra River and separated by a shortest aerial distance of 174 km (https://www.distance.to/). The IPMPs were collected from farmers using semi structured schedule following four Focus Group Discussions conducted in the 4 sampled agricultural extension circles. The efficacy levels of explored Indigenous Pest Management Practices as perceived by farmers were recorded using pre-tested semi structured schedule through in-depth personal interview method. To measure the efficacy level of explored Indigenous Pest Management Practices, first efficacy level was sought from farmers in a 3-point scale *viz.*, highly effective (3), moderate effective (2) and less effective (1). Then efficacy score of each practice was calculated out 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

On the basis of efficacy score the explored Indigenous Pest Management Practices were categorized into three levels as follows:

Category	**Score range**
Less effective	1.00 - 1.66
Moderately effective	1.67 - 2.33
Highly effective	2.34 - 3.00

A questionnaire based on the explored IPMPs was mailed to 25 plant protection scientists of Assam Agricultural University, Jorhat campus who have responded in the study to find out the rationality level of the explored IPMPs. Rationality level of each of the identified indigenous plant protection practice was sought from scientists in a 3-point continuum *viz.*, rational, undecided and irrational assigning the score 2, 1, and 0 respectively. Each scientist respondent was also requested to furnish reason(s) if any of his/her response on rationality level which are slightly edited to make a common statement by keeping the meaning same. Then frequency and percentage distribution of scientists' respondents were calculated out according to their perceived level of rationality. Scientific reasons on the use rational IPMPs as furnished by scientists' respondents were also recorded and discussed in the following result and discussion section.

Results

Description of identified indigenous plant protection practices of rice

A total of 33 IPMPs as followed during different phenological stages of rice have been identified. A brief description of each of the practices are mentioned along with the target pest and/or diseases, phenological stages of the crop in which these are practised, and the effect on target pest/disease as perceived by the farmers (Table 1). Out of 33 identified practices, the maximum numbers of practices (17) are followed in the tillering stage followed by at maturity stage (6) of the rice crop. The number of practices adopted to manage the various species of insect-pests were in a descending order of - rice hispa (8 practices) > stemborer (7) > birds (5) > rodent (3) > Gundhi bug (2)/caseworm (2)/crab (2). However, the farmers practised only 3 practices against rice diseases. It indicates that the traditional crop-protection knowledge is richer against the insect-pest than that of diseases; this may be attributed to the difference in size of a macroscopic insect-pest and a microscopic disease organism, since, it is easier to experiment trial and error method on a macroscopic entity than a microscopic one.

Effectiveness of identified indigenous plant protection practices perceived by the farmers

As shown in Table 1, out of 33 identified indigenous plant-protection practices, 6 were highly effective (Sl. No. 1 - 6); 10 practices were moderately effective (7 - 16) and 17 were less effective (17 - 33) as perceived by the farmers.

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

Rationality of the identified practices was judged by the plant-protection scientists as obtained through a questionnaire. Frequency and percentage distribution of scientists as respondents are shown in Table 2 according to their perception level of rationality.

Rational practices: Table 1 indicates that out of 33 indigenous practices identified, 21 practices (Sl No. 1-21) were rated rational by more than 50% of the scientists; these practices had an efficacy within the range of 1.32 - 2.83 as perceived by the farmers. The practices as rationalized by less than 50% scientists have been recognised as low rational; each of these practices had a low efficacy within 1.11 - 1.62 as perceived by the farmers. It may be inferred that efficacy of some rational practices, more particularly

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

Practice	Pest / Disease	Crop Stage	Nature of Effect	Efficacy Score*	Rationality**		
					R	U	IR
1) Erecting the topmost portion of bamboo and branches of tree as bird-perch in the rice field	Stem borer & leaf hopper	Nursery, tillering	Predation of pest by birds	2.66 (H)	20 (80)	4 (16)	1 (4)
2) Moving a kerosene-soaked rope over the crop and draining out available standing water	Caseworm	Tillering	Cases fall down from foliage on water and are drained out	2.83 (H)	15 (60)	10 (40)	0 (0)
3) Throwing branches of *Jermany ban Bihlongoni* & *posotia* on standing water	Hispa and caseworm		Repellency	2.74 (H)	14 (56)	7 (28)	4 (16)
4) Throwing peels of *Citrus grandis* on standing water	Stem borer		Repellency	2.43 (H)	14 (56)	10 (40)	1 (4)
5) Spraying tobacco leaves soaked water	Hispa		Alkaline tobacco solution attacks the pest.	2.40 (H)	17 (68)	8 (32)	0 (0)
6) Broadcasting goat's excreta	Hispa		Repellency	2.67 (H)	18 (72)	3 (12)	4 (16)
7) Using raw cowdung @ 250-300 kg/ha on standing water	Crabs		Repellency	1.91 (M)	15 (60)	7 (28)	3 (12)
8) Spraying cowdung slurry (1 kg raw cowdung in 10-12 lit of water)	Bacterial leaf blight, cattle		Cowdung slurry controls the B.L.B.; Repellency to cattle	1.69 (M)	15 (60)	10 (40)	0 (0)
9) Using throny branches of Ber (*Zizyphus* spp.) in the field	Hispa		Prevent the free movement of the pest.	1.74 (M)	13 (52)	9 (36)	3 (12)
10) Spraying boiled neem leaves and grinded seed solution	Leaf folder		Bitter taste & odd odour repel away the pests.	1.89 (M)	16 (64)	7 (28)	2 (8)
11) Application of aqueous solution of *"Keturi haldhi"* (Indian arrowroot) rhizome	Hispa & stem borer		Repellency	2.17 (M)	16 (64)	9 (36)	0 (0)
12) Throwing randomly the crashed rhizomes "*Keturi haldhi*" in the field	Stem borer, hispa			2.14 (M)	16 (64)	7 (28)	2 (8)
13) Hanging dead lizards/frogs/crabs inside inverted bamboo pipe touching stagnant water	Major pests of rice		Repellency due to foul smell	2.20 (M)	15 (60)	10 (40)	0 (0)
14) Small bamboo pole or branch is placed in each rice hill in low land situation	Crab		Crab while clasping rice seedling, the get it hard	1.83 (M)	16 (64)	10 (40)	0 (0)
15) *Posotia* leaves are dried, grinded and dusted in the field	Hispa		Repellency	1.74 (M)	16 (64)	7 (28)	2 (8)
16) Pouring kerosene oil directly on standing water	Hispa & Caseworm		Suffocation of pest	2.02 (M)	14 (56)	11 (44)	0 (0)
17) Drainage available water from the crop-field	Hispa and stem borer		Reduced movement due to non availability of water	1.32 (L)	13 (52)	12 (48)	0 (0)

(*Contd*.)

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

Practice	Pest / Disease	Crop Stage	Nature of Effect	Efficacy Score*	Rationality**		
					R	U	IR
18) Beating empty tin/drum around the field	Birds	Maturity	Sound drives away from field.	1.64 (L)	18 (72)	6 (24)	1 (4)
19) Carcass a crow is tied long pole in the centre of a rice field	Birds		The carcass frightens the grain feeding birds	1.66 (L)	19 (76)	6 (24)	0 (0)
20) Using bell in the field operated from distance with a long rope	Birds		Due to sound production, birds get frightened and leave	1.33 (L)	16 (64)	7 (28)	2 (8)
21) Rice field is encircled by reels of audio tapes/ cassette rolls	Birds		Tapes reflect sunlight & produce sound due to wind to scare them	1.56 (L)	13 (52)	10 (40)	2 (8)
22) Using bamboo pipe (2 inch), inside which a thin metal wire is placed horizontally with the help of two bamboo pole	Birds		Birds while sitting, the metal wire makes the bamboo pipe roll which frightens the birds to fly.	1.59 (L)	10 (40)	13 (52)	2 (8)
23) Pouring water in rodent burrows	Rodents		Rodents come out and are killed by the farmers easily.	1.60 (L)	7 (28)	15 (60)	3 (12)
24) Application of solution of neem leaves and grinded seeds + soap and/or detergent powder + raw turmeric	Fungal and bacterial diseases	Tillering & panicle initiation	Repellency	1.36 (L)	10 (40)	13 (52)	2 (8)
25) Dusting of ash	Brown spot	Panicle initiation	Ash checks spreading of infection	1.11 (L)	12 (48)	11 (44)	2 (8)
26) Use of dead crabs or frogs fixed in bamboo stick in different places of main field	Gundhi bug	Milky	Attract gundhi bug at milky stage to dough stage	1.26 (L)	8 (32)	10 (40)	7 (28)
27) Burning of crop-residues or using light at night in the field	Gundhi bug		Gundhi bug jumped into the fire and get killed	1.63 (L)	12 (48)	11 (44)	2 (8)
28) Burning rice stubbles	Stem borer	After harvesting	Hibernating stage of the pests get killed	1.36 (L)	12 (48)	9 (36)	4 (16)
29) Fumigating the rodent burrows with smoke of burnt paddy husk	Rodents		Rodents get suffocated and killed inside.	1.32 (L)	9 (36)	11 (44)	5 (20)
30) Digging of the rodents' burrows	Rodents		Rodents' shelters are destroyed	1.56 (L)	8 (32)	10 (40)	7 (28)
31) Tipping of rice seedling in the nursery	Major insect pests	Before transplantati on	Removal of eggs of pests, check its entry in main field	1.62 (L)	10 (40)	6 (24)	9 (36)
32) Trimming the edges of borders of the rice plots	Hibernated insect pests		Pests hibernated in the border edges are killed	1.19 (L)	19 (26)	6 (24)	0 (0)
33) Summer ploughing	Stem borer	Before sowing	Mechanical injury to pests & exposure to sunlight & predators	1.45 (L)	13 (22)	10 (40)	2 (8)

*In efficacy score column: L: Low; M: Moderate; H: High. **Figures in the parenthesis indicate percentage in Rationality columns; R: Rational; U: Undecided; IR: Irrational.

Table 2* — Type based summary of rational and irrelevance free Indigenous Pest Management Practices (IPMP)

Type of IPMP & No. of practices identified	Rational practices		Irrelevance free practices[1]	
	No. & % of rational practices	No. of practices with high & medium efficacy	No. & % of practices free from irrelevance	Practices with high & medium efficacy
1. Mechanical, Physical, Cultural (16)	6 (37.5%)	2 (1 H & 1M)	3 (18.8%)	1 M
2. Plant-origin (08)	8 (100%)	8 (3 H & 5 M)	2 (25%)	1 H, 1M
3. Animal-origin (06)	5 (83.3%)	4 (1 H; 3 M)	3 (50.0%)	2 M
4. Chemical (Kerosene) (02)	2 (100%)	2 (1H; 1M)	2 (100%)	1 H, 1 M
5. Mixture (01)	Rationality is undecided			

*Based on table 1. H: High efficacy; M: Medium efficacy; [1]Practices which are not irrelevant as perceived by all scientists.

the practices with low and medium efficacy, can be improved at farmers' level with scientific intervention.

Undecided practices: Three practices (Sl. 22-24) were undecided by more than 50% scientists. All the 3 practices are of low efficacy as perceived by the farmers and hence, are of less impact on rice pest management.

Irrelevant practices: 23 practices have been identified as irrelevant by 4-36% scientists. These include practices with all three categories of efficacy as perceived by farmers. On the other hand, 10 practices (Sl. No. 2, 5, 8, 11, 13, 14, 16, 17, 19, and 32) were free from irrelevance as rationalized by all the scientists; of these 5 are medium and 5 are of low efficacy as perceived by farmers. Thus, there is every possibility of improving the efficacy of few or all of these 10 practices under the supervision of scientists.

Discussion

Information of Table 1 has been summarized in Table 2. All the 33 identified IPMPs are categorised into 5 types (Table 2). The rational (*i.e.,* the practices which are rationalized by more than 50% scientists) and irrelevance free practices (*i.e.,* the practices which are not irrelevant as perceived by all scientists) have been correlated to efficacy as perceived by farmers in Table 1. Out of the 8 plant-origin IPMPs, all (8) were rational with high and medium efficacy score; of these 2 practices were irrelevance free of which 1 had high and 1 had medium efficacy. However, out of 16 cultural IPMPs (including mechanical, physical ones), only 6 (37.5%) were rational with only 2 practices with high and medium efficacy. The rest of the IPMPs are also summerised in Table 2. Scientific justifications behind the efficacy of few rational practices are highlighted along with pertinent information:

IPMPs such as bamboo-perches facilitate the insectivorous birds for sitting and thereby enhance predation. By sitting on a perch, birds can scan/visualize the presence of pests on and around the foliage in a better way within a short range of vision. It saves the energy, otherwise needed, for flying to and fro the trees outside the crop-field. Birds can utilize this saved energy for predation of more preys, which in turn provide more control of pests. This practice has also been followed against rice pests in other zones of Assam e.g. in the Upper Brahmaputra Valley Zone[11,13], North Bank Plain Zone[14]. In Manipur, some parts of *Clerodendrum serratum*, or even the entire plants, are erected as bird perches on the bunds in and around the paddy fields[15].

Kerosene oil acts as physical poison, especially to caseworm. Kerosene or its pungent smell enters the two cut ends of the cases rendering the immature living inside suffocate and die. This practice has also been recorded in other zones of Assam[11,13,14].

Chromolaena odorata (L.) R. M. King & H. Rob. (Family: Asteraceae) is known locally in various names such as Jarmany bon, Bagh Dhaka bon, Koli bon, Nogorbera etc. in different parts of Assam.

Polygonum hydropiper L. (Family: Polygonaceae) and *Vitex negundo* L. (Family: Lamiaceae) are known as Bihlongoni and Posotia, respectively in Assam. Like the tobacco and neem, all these cited plants also contain some toxic principles to insect-pests. Since *P. hydropiper* has an irritating sensation to human skin and tongue, it may have similar action to unsclerotised body parts of insect too. Use of parts of Jarmany bon has also been reported as an indigenous practice against rice pest in Tinsukia district of Assam[13]. *Polygonum* sp. is also used against rice pests in North Bank Plain Zone of Assam[14].

Peels of *Citrus grandis* (L.) Osbeck (Rutaceae) has pungency which repels the insects. It may be due to citral (an acyclic monoterpene aldehyde present in oil part of citrus fruits) or other specific molecule may be responsible for such repellant action. The essential oil contained in the peels and leaves of Citrus aurantifolia possess potential larvicidal and ovicidal activity against *Aedes aegypti* as reported from Assam[16].

Being a congeneric species of *Citrus*, the presence of such potential larvicidal and ovicidal molecule in *C. grandis* cannot be ruled out; however, it needs confirmatory research. *C. grandis* has also been reported against rice pests from other parts of Assam[11,14]. Similar reports of using plant parts against rice pests have also documented from the other parts of India, e.g. broadcasting of 75-150 kg of *Cleistanthus collinus* leaves 3 days after transplanting controls yellow stemborer; likewise, 0.4 to 0.5 kg fresh, tender branches of *C. collinus* are planted erect or spread in the standing water in summer rice in West Bengal[8]. Wild sugarcane (*Saccharum spontaneum*) has also been reported to control of leaf-roller, caseworm in Odisha; likewise, fresh leaves of *C. collinus* and *Boswellia serrata* are spread @ 5 kg leaves per 100 m^2 to control caseworm and in Jharkhand state, the leaves of *C. collinus* (@10 kg per 100 m^2 area) is also used for controlling gallfly, *Pachydiplosis oryzae* in rice which results a pest suppression of 70-80%[8]. Application of leaf extracts of *V. negundo,* kerosene along with leaf extract of other plant species are also applied against rice pests by tribal farmers of Tamil nadu[17]. Extract made from wild tobacco leaves (*Nicotiana rustica*), seeds of *Melia azadirachta*, *Mesua ferrea* and bark of *Alstonia scholaris* are mixed along with ash and used against rice pests in Darrang District of Assam[18]. Likewise, parts of aloevera, neem, *Coleus aromaticus*, *Pongmiaa glabra* etc. are traditionally used against rice pests in Kanyakumari[19]. Mahua leaves mixed with kerosene and cowdung is an ITK practised against rice pests in Chattisgarh[20].

Burning of dry leave, crop-residues or other agricultural matrix acts as light trap to attract the nocturnal positively phototactic pest species; this is practised in other zones of Assam[13] and also by the hill farmers of Uttarkhand[21]. Farmers also burn bicycle-tyres to attract and kill rice pest in some parts of Assam[11]. Due to summer ploughing larvae and pupae get injured and exposed to predators. Wood ash also causes physical irritation and injury to insects. Cutting the top portion of rice seedling helps to reduce the pest infestation in the main field by preventing the entry of egg-masses of many pests.

Conclusion

Scientists can use the IPMPs for further study on their efficacy and suitability in other agro-climatic regions. Efficient IPMPs can also be used in technology blending programme to generate low cost, eco-friendly, location specific module(s) with high social acceptability. Through extensive demonstrations of suitable IPMPs as a component of IPM module(s), the extension machinery can bring a revolution of organic farming. It is noteworthy that Assam has experienced invasions of three exotic pests recently *viz.*, Papaya mealybug[22], Rugose Spiralling Whitefly[23,24] and Fall Armyworm[6]. The rational IPMPs can be screened to assess its efficacy against these recently invaded pests too.

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Conflict of Interest

There is no conflict of interest among the authors.

Author Contributions

All authors planned the work. IB collected & compiled the data; all authors analysed and edited the data and prepared the draft MS. AKS improved the MS; all authors finalize the MS.

Prior Informed Consent

Prior informed consent was obtained from all stakeholders who voluntarily agreed to study and publish.

Data Availability

Data would be made available from the concerned authors on request.

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