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Farmers’ knowledge and creativity in eco-friendly pest management: Lessons in sustainable agriculture

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Informal knowledge of farmers is considered to be important for many difference practices required in sustaining both crops and ecosystems, especially when no solutions are known from scientific knowledge. Farmers practice trial and error to formulate crop management technologies specific to location. In this article, we document the indigenous practices used by soybean farmers of Chindwara district, Madhya Pradesh, India. A total of 125 soybean growing farmers were randomly selected from 7 villages of the Chhindwara block of Chhindwara district. Data were collected using PRA tools and personal interviewing. The farmers in the study developed notable innovations to control soybean pests such as use of *neem* extract, and use of solutions prepared from *dinkamali* and *besharam*’s (*Ipomoea carnea*) leaves, and the larvae of the same insect that affect crop. The farmers were implementing these practices because: they help reduce crop losses, they are compatible with the farming system, they are easy to handle, and the products used are locally available, eco-friendly, cost effective and compatible with the socio-cultural situations of farmers.

Keywords: Farmers’ knowledge, Farmers’ innovations, Indigenous pest management practices, Sustainability, Soybean crop, Madhya Pradesh

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Rich biodiversity and a complex system of indigenous technical knowledge are the two characteristic features of traditional farming systems in developing countries. The complex interrelation between these two components is well known with sustainable biodiversity management often heavily depending on local farmers' knowledge of the environment, plants, soils and ecological processes. One of the areas in agricultural production where this interrelationship holds immense practical utility lies in the realm of eco-friendly pest management[1]. The heavy and indiscriminate use of synthetic pesticides is a global environmental concern and the resultant ecological disruption has prompted policy makers to turn to local ecological knowledge in developing pest management strategies[2]. Notwithstanding lower average pesticide consumption in India as compared to developed countries in North America and Europe, India is now one of the leading pesticide producers in the world. The cause for concern is that injudicious pesticide use in India has caused many social-ecological problems, including acute human diseases and pollution of soil and water resources[3] which hold key to the sustainable agriculture. In addition, development of pesticide resistance in insects[4] and increasing agrarian distress caused by the over-application of pesticides[5] are serious emerging problems in Indian agriculture.

The advantage of farmers’ knowledge is that it is driven by local needs and is based on a set of appropriate socio-cultural norms. Farmers continuously refine their traditional knowledge, inherited from their ancestors, through local experimentation, careful observation and knowledge sharing, and this imparts an integrative and dynamic character to their knowledge[1]. Worldwide, farmers’ traditional knowledge has been instrumental in the evolution of diversified, resilient and productive agro-ecosystems. The synergistic interactions between soils, crops, flora and fauna in these diversified systems have improved soil fertility, minimized insect pest and disease outbreaks and improved crop productivity[1]. The cultural and technical knowledge of local farming communities, if carefully incorporated intp crop production programs, may provide lasting solutions to many agricultural problems. A study with Maya farmers in Guatemala,

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for example, revealed that although farmers' understanding of mechanisms behind biological and curative pest control is limited, their broad traditional knowledge of cultural (preventive) pest control practices has helped them avoid major pest problems in their traditional farming systems[2].

Local people and grassroots innovators continuously refine and build upon their ecological wisdom through selection and domestication of plants, agronomic manipulations, informal experimentation on eliminating insect pests and on disease management, use of plants as food and medicines and traditional agroforestry suited to specific conditions[6-8], resulting in enhancement of yield and quality of local crops. In fact, over the millennia, traditional farmers in Africa, India, North America and elsewhere have given the world an invaluable heritage of thousands of locally adapted crops and practices crucial in sustainable agricultural development[9-11].

In the backdrop of immense crop biodiversity, increasing pesticide usage (and its negative impacts), emergence of pesticide resistant pests and fundamental changes in social-economic relations, the present study sought to prepare an inventory of indigenous farmers' knowledge and practices (based on organic inputs) relating to insect pest management in the Chhindwada district of Madhya Pradesh. The study was designed with the following objectives: (i) to explore and document the indigenous insect pest management practices in soybean, maize, cotton, cauliflower and okra (ladyfinger) crop production; (ii) to document the availability of bioresources required for these local practices; (iii) to estimate the time frame and extent of adoption of the practices; (iv) to assess the farmers' perceptions regarding efficacy levels; and (v) to explore how such practices may be continued.

Research methodology

The present study was undertaken using a combination of field research methods: personal interviews, focus group discussions (FGD) and participant observation with small and marginal farmers in Chhindwara (southern part of Satpura plateau) district of Madhya Pradesh, India. Seven villages were randomly selected from the Chhindwara block of the study district. The key communicators of the villages (Village Pradhan, school teachers, progressive farmers and extension workers) were contacted and invited to collaborate. These key communicators provided an inventory of farmers of different economic means in the selected villages. In the second stage, using FGD, small-scale and marginal farmers growing soybean, maize, okra, cauliflower and cotton crops, were identified. Resource inventories (size of land holdings), irrigation potentiality, types of soil, cropping intensity, management system(s), farming experience, number of trainings received and secured enterprises other than agriculture) were used as indicators in determining the farmers' categories[13]. Based on opinions of the farmers themselves – that a 50 % (C.V.5%) threshold should be used to determine the resourcefulness of a given farmer – we selected those farmers possessing less than 50 % of the pooled resources and had at least 15 yrs' experience in agriculture. The criteria applied to document the existing indigenous practices for pest control were based on the assumption that such practices were traditionally adopted by resource poor farmers with small landholdings and are prone to different agricultural risks.

From the results of three FGDs, a total of 105 resource poor farmers (15 each from 7 villages) were randomly selected for the research. Participant observations coupled with a structured interview schedule (with open-ended and close questions) were used to record the responses of farmers on quantifiable variables. The accessibility as well as the period and extent of adoption of indigenous practices were measured using a self-rating scale. The quantitative data were statistically analyzed to draw inferences.

Results

We found that farmers had developed location specific indigenous knowledge for eco-friendly insect pest management in soybean, maize, cotton, cauliflower and ladyfinger crops, as briefly summarized in the succeeding paragraphs.

A. Identified indigenous pest control applications and their processing methods

1. Dry *mahua* flowers [*Madhuca longifolia* var. *latifolia* (Roxb.) A.Chev. syn *Madhuca indica* J.F.Gmel.]

The sudden emergence of an insect pest, locally called *baniya* or *gaygwalan kida*, in late 1990s, posed a grave threat to soybean cultivation in Chhindwara district. The insect, later identified as a species of the genus *Scolopendra*, voraciously fed on the leaf petioles, or occasionally the stems, of soybean, leaving the fields almost bare. A few years after the appearance of this notorious pest, a local innovative resource-poor farmer, Mr. Bhaiya Lal Sarathe (Fig. 1), of one of the study villages identified a preventive control measure for this pest based on *mahua* flowers (Fig. 2). While passing though a *mhaua* grove (Fig. 3), he had noticed that two *baniya* insects were struggling to get a share of fallen *mahua* flower for eating. From this observation he proposed and initiated the use of dry *mahua* flowers to control the insect infestation in soybean crop. Thus, a unique solution to reduce a damaging crop pest emerged, based on Mr. Bhaiya Lal Sarathe's ecological wisdom. Notably, although Mr. Sarathe observed insects feeding on fresh *mahua* flowers, he preferred to use dry flowers as a control, because the fresh flowers would not be available in the quantities required during the soybean crop season. Following his informal experimentation with *mahua* flowers, other soybean farmers from his own and neighbouring villages started adopting this practice.

Presently, 10-15 kg of dry *mahua* flowers are applied at the two-leaf soybean growth stage for one hectare of crop. This practice renders the pest inactive for about 3 weeks, providing ample time for the soybean seedlings to escape pest damage during the subsequent growth. In order to validate the practical utility of this practice, we conducted a study with 232 farmers and learned that 70.7 % of these farmers were adopting and applying this indigenous technological knowledge.

As noted, the farmers use dry *mahua* flowers. This was a new innovation by a farmer namely Bhaiya Lal Sarathe, and later it has been diffused in other areas of similar social-ecological system through the farmer-led-extension. Farmers apply dry *mahua* flowers (Fig.1), without any other ingredients, @ 10-15 kg per hectare. These flowers are readily available to the entire community, without cost, since farmers plant *mahua* trees for its wood for timber and leaves as lean season animal fodder. The new insect pest (*Scalopendra* sp.), which infests the soybean crop at its young 2-3 leaf stage, is controlled effectively by applying *mahua* flowers at this stage. After coming into contact with *mahua* flowers, the insect becomes inactive for 15-20 days and the crop can develop safely without predation from this insect.

2. Green leaves of *besharam* (*Ipomoea carnea* Jacq.)

Chickpea is also a major crop cultivated by local farmers in the study region. Insect pest infestations, particularly armyworm (*Pseudaletia unipuncta*) and bollworms (*Pectinophora gossypiella* and *Helicoverpa species*), are a serious threat to profitable yields in chickpea. Up until the late 1990's, farmers used heavy applications of commercial insecticides to manage borer pests in their chickpea fields. An eco-friendly solution to this menace, based on the use of *besharam* (*Ipomoea carnea*, Fig.4) leaf extract, appeared in the beginning of the new millennium. This indigenous community-based knowledge is presently applied by many farmers to achieve cost effective and environmental friendly pest control for chickpea. In preparing this "green" pesticide, about 1000-1200 fresh leaves of *besharam* are boiled in 30-35 litres of water until the solution turns milky white. This preparation is cooled down and applied the next day to the chickpea crop. This decoction apparently contains anthacin glucoside, which might be responsible for its toxic effects on insect pests. A major limitation of this practice is the poisonous nature *of besharam* plant, which necessitates utmost care during preparation and handling of the solution due to its toxic impact.

3. Asfoetida (*Ferula assa-foetida* L.)

The insect-controlling properties of asfoetida (*hing*- dried latex exuded from the tap root of several species of *Ferula,* a perennial herb) have also been exploited by some farmers to manage insect infestations in the chickpea crop. To make this preparation, about 100-150 gm of asfoetida is boiled with 1 liter of water for 10-15 minutes. This solution is then further diluted by adding 150-200 liter of water. The solution is sprayed onto the crop. Although this asfoetida-based protective spray often provides very effective control against heliothis and some other insects, a major limitation in its widespread use is its higher cost. As such, this practice has not gained popularity among the resource-poor farmers.

4. Applying Ayurvedic *dinkamali* (*Gardenia gummifera* L.f.)

Dinkamali is an Ayurvedic medicine (Fig. 5) used for treating stomach disorders and ailments in humans by local community. It is available in the market @ Rs. 30 per 100 gm. For controlling *heliothis* infestations in soybean, and other insect pests in vegetable crops like cauliflower, tomato and cabbage, farmers use *dinkamalli* @ 250-300 gm/ha. The process of making the extract is essentially same as for the *asfoetida* solution except that it requires a longer period of boiling (25-30 minute).

5. Application of *Neem* leaf solution

Neem (*Azadirachta indica* A.Juss.) leaves are a well known green pesticide. Farmers take about 8-10 kg green *neem* leaves and boil them in 18-20 litres of water until the colour turns brown, the solution is reduced to about 10 litres (Fig. 6). About 5-6 litres of the resulting solution is mixed with 200-300 litres of water and sprayed on soybean crops to prevent stem borer infestation.

6. Applying extracts of larvae of the infesting insect

We identified a unique practice adopted by both resource-rich and resource-poor farmers (although more preferred by the latter) to control some major insect pests such as girdle beetle (*Blapstinus* spp.) and *Heliothis* in soybean and chickpea. In this practice, farmers collect the larvae of these pests from crop fields and boil them in water (2 to 2.5 kg larvae in about 2 l water) for 40-50 minutes, until the colour turns light brown and the solution reduced to about half its volume. The solution is then cooled for 5-6 hrs, and mixed with 250-300 L water and sprayed over the soybean crop to control the same larvae as in the solution. The solution has a notably foul odour, and this may reflect some of the repellent properties, but more detailed investigation of this solution and its effects are required.

7. Inter-planting ladyfinger (*Abelmoschus esculentus* (L.) Moench) with cotton

This is yet another popular indigenous pest management practice among the resource-poor cotton farmers of studied villages. Farmers usually plant three rows of okra around the cotton fields. Some farmers also grow 2-3 rows of okra in middle of their cotton field field. This practice considerably reduces the 'boll worm complex' problem in cotton, leading to about 10-15 % increase in cotton boll yield. Thus, this practice not only reduces the cost of production by reducing the need for pesticide application but also promotes crop diversification and ensures availability of okra fruits in the human diet. The farmers claimed that boll worms and other cotton pests prefer okra (which is in the same plant family as cotton, Malvaceae) as a host and this way infestation in cotton is reduced.

8. Marigold (*Tagetes erecta* L.) with maize

Maize is grown on a large scale in the Chhindwara district and constitutes one of the staple foods of the local people. Among different biotic and abiotic stresses, severe nematode infestations inflict major economic losses to maize growers. To overcome this problem in a cost effective and environmental friendly way, in the late 1990s farmers started intercropping maize with marigold. Initially tried by some creative farmers, this practice subsequently gained currency and became popular among almost all maize growers. Terthienyl type compound in marigold root, might be the toxic to nematodes, which suppress their population[12]. With the passage of time, this adaptive practice has acquired a commercial orientation for other usage with entry of private companies into the marigold trade.

9. Light trap with castor (*Ricinus communis* L.) oil

Early cauliflower and cabbage crops grown during the months of September and October are subject to severe infestations of diamondback moth (*Plutella xylostella;* Figs. 7 & 8). Initially, local farmers tried to manage this problem through insecticide applications but they failed to achieve any major gains, as this pest seemed have developed resistance to all the available insecticides. This situation prompted some local farmers to try alternative practices and a few of them started placing light traps (using electric bulbs) with polythene sheets sprayed with castor oil in the corners of the fields. During the night, the moths are attracted to the light and then become trapped on the polythene sheets (sprayed with castor oil and placed beneath the bulb).

B. Easy availability of bioresources for indigenous pest management practices

Mahua groves are abundant in the Chhindwara district and are major community assets in the study villages. This explains the easy availability of dry *mahua* flowers for alleviating the *baniya* pest problem in soybean crop (according to over 93% of the farmers' responses, Table 1). As well, the easy availability of *neem* leaves, as reported by over 86% of the respondents, is due to the high abundance of *neem* trees in this region. The green leaves of *besharam* is also readily available for use in pest management programs as revealed by over 100% % of the farmers' responses, respectively.

The use of *asfoetida,* although effective for some insect pests, is cost prohibitive for resource-poor farmers as reported by over 43% of the respondents. Similarly, the Ayurvedic preparation *dinkamali* used against some insect-pests is also available in limited

Figs. 1-7—Mr. Bhaiyalal Sarathe who developed idea of using dry *mahua* flowers as effective remedy against *gaygwalan*; 2−Dried *mahua* (*Madhuca indica*) flowers; 3−An illustration of *gaygwalan* insects struggling to get their share of fresh mahua flowers. Based on this observation, Mr Bhaiyalal Sarathe developed idea to use these flowers for controlling *Gaygwalan* pest in soybean, Art: Sh Amardas, Idea of art: Honey Bee; 4−Beshram (*Ipomoea carnea*) plant; 5−Ayurvedic material *Dinkamali* (above) and solution prepared from it (below); 6−Green neem leaves and the formulation prepared from its decoction of green *neem* leaves; 7−Attack of Diamond back moth larvae on cabbage crop

Table 1—Response of the farmers about easiness in availability of indigenous resources for use in insecticide formulations

Name of the indigenous practices	Extent of easiness in the availability		
	ME	E	LE
Dry *mahua* flower (*Madhuka latifolia*)	91.35	8.65	00.00
Green leaves of *neem* (*Azadirechta indica*)	86.54	6.73	6.73
Dry leaves of tobacco (*Nicotiana tobacum*)	86.54	6.73	07 6.73
Green leaves of *Ipomoea carnea*	100	00.00	00.00
Asafoetida	38.46	43.27	18.27
Aurvedic dinkamali	28.85	17.31	48.08
Larvae of *Heliothis* and Girdle beetle	100	00.00	00.00

ME = Most Easily, E= Easily, LE= Least easily
Data presented in parenthesis is indicating the percentage

Table 2—Response of the farmers about period and percentage of adoption of the indigenous practices

Name of the indigenous practices	Extent of period and of adoption		
	From last 15 years	From last 10 years	From last 5 years
Dry *mahua* flower (*Madhuka latifolia*)	0.00	00.00	100
Green leaves of *neem* (*Azadirechta indica*)	28.85	48.08	23.08
Dry leaves of Tobacco (*Nicotiana* sp.)	24.04	43.27	23.08
Green leaves of *Ipomoea carnea*	24.04	57.69	18.27
Asafoetida solution	14.42	67.31	18.27
Aurvedic dinkamali solution	32.69	38.46	28.85
Larvae of *Heliothis* and Girdle beetle	05.77	28.85	65.38

*Data presented in parenthesis are indicating the percentage

quantities as revealed by over 16% of soybean growers. About one third (29%) of the sampled farmers indicated that use of dead larvae themselves as a management practice was the most feasible practice for them (Table 1).

C. Timing and extent of adaptation of indigenous pest management practices in the soybean crop

In this section, information on the period and extent of development and adoption of different indigenous pest management practices is presented with reference to the base year 2000. The adoption of different indigenous practices used against insect pests for soybean and other crops was variable (Table 2). Dry *mahua* flowers were used by almost all the farmers over the last five years to manage the *gaygwalan* infestations because it was the only effective measure available to use against this notorious pest. A higher percentage of the farmers (over 48%) reported that they had been using *neem*-

Table 3—Response of the farmers about efficacy of identified indigenous practices

Name of the indigenous practices	Controlled major pest	Extent of efficacy		
		MEf	Ef	LEf
Dry *mahua* flower (*Madhuka latifolia*)	*Scalopendra* sp. Identified new pest)	86.54	09.62	03.85
Green leaves of *neem* (*Azadirechta indica*)	*Oberia brevis* and *Diacrisia oblique*	94.23	03.84	01.92
Dry leaves of Tobacco (*Nicotiana tobacum.*)	Larvae of *Heliothis* and pod borer	88.46	07.69	03.85
Green leaves of *Ipomoea carnea*	Larvae of *Heliothis* and spotted bollworm	86.54	09.62	03.85
Asafoetida solution	Larvae of *Heliothis* and Melonogromyza	67.31	19.23	13.46
Dinkamali solution	*Heliothis* and other small insects	64.42	28.85	06.73
Larvae of *Heliothis* and Girdle beetle	Larvae of *Heliothis* and Girdle beetle	54.81	40.38	04.81

*MEf = Most effective, Ef = Effective and LEf = Least effective
*Data presented in parenthesis are indicating the percentage

based preparations over the last ten years. Also from this time, about 58% of the farmers had adopted *besharam*-based bioinsecticide, while the corresponding figure was about 67% for use of *asfoetida*. Despite the costliness of asfoetida, farmers continued using it due to its high efficacy in pest management.

The extent of adoption of *dinkamali* was about 39% over the last ten years. The larvae based bio-pesticide practice was more widely acceptable among the farmers and was adopted by more than 65% of them over the past 5 yrs, while about one-third June under 30%) of the farmers had been using it since 1990.

D. Efficacy of indigenous pest management practices

As noted, the majority (86.54%) of the farmers (nearly 87%) had adopted the application dry *mahua* flowers due to their potential efficacy against the damaging pest *gaygwalan* (Table 3). About 94% of the farmers found *neem* leaf based insecticide to be most effective in controlling *Oberea brevis* and *Spilarctia obliqua* insect pests in chick pea crop. A very small number of farmers (under 2%) suggested that this practice was the least effective. The use of the *besharam*-based insecticide was very effective in controlling the *Heliothis* and spotted bollworm larvae, as reported by nearly 87% of the farmers.

Given that *asfoetida* and *dinkamali* are very costly, their use in pest management programs has become popular only among the resource-rich farmers. Regarding efficacy level of these substances, a majority of the farmers (over 67%) believed that this practice is most effective against the larvae of *Heliothis* and *Melonogromyza,* while one third (33%) of the farmers indicated that *asafoetida* was only moderately effective to least effective against this insect. A similar perception was held in the case of the *dinkamali*-based solution. Application of the biopesticide prepared by boiling the larvae of the girdle beetle was reported to be one of the most effective adaptive practices for controlling girdle beetle, as confirmed by about 55% of the soybean farmers.

Table 4—Factors responsible for the continuance of the indigenous practices

Factors	Percentage of response	Ranks
Prevents maximum losses	61.53	VII
Compatible to the farming system	64.42	VI
Easy to handle	50.00	X
Easy availability of inputs	72.12	II
Based on local knowledge	65.38	V
Efficacy	69.23	IV
Eco-friendly	70.19	III
Cost effective	80.78	I
Needed little skill	55.76	IX
Compatible to the socio-cultural situations	60.57	VIII

E. Factors responsible for the continuance of indigenous practices of pest management in the soybean crop

A set of factors seemed to be the enabling force responsible for the continuance of indigenous adaptive practices of pest management in soybean, maize and vegetable crops. The majority of the farmers (over 80%) reported that the cost effective nature of the indigenous practices was the strongest motivating factor for their adoption (Table 4). Besides cost effectiveness, the ready availability of the inputs used, their eco-friendly nature and the perceived efficacy of these practices were the other three factors (in decreasing order) responsible for their adoption. A general assumption is that the indigenous practices are still in vogue in certain social-ecological systems because they have locally evolved, are compatible with local requirements, give economic efficiency and need little skill in preparation, handling and application.

Discussion and conclusion

In spite of institutional efforts to popularize the modern technology (in this case insecticide applications) in crop production among the region's farmers, locally available solutions and indigenous practices seem to enjoy wider acceptability, particularly with the resource-poor farmers. In most cases, the pest management practices being adopted by the farmers in our research are attributed to the indigenous technological knowledge and innovative knowledge of the farmers themselves[13]. It seems that farmers possess important ecological knowledge and wisdom in identifying and applying such locally available resources as dry *mahua* leaves, dead insect pest larvae and "trap" crops as ecofriendly pest management practices[14]. These techniques are not only compatible with the socio-cultural norms of the farmers but are also sustainable and amenable to continued use. Similar results have been reported elsewhere with implications for sustainable agricultural production[10,14,15]. These studies revealed that indigenous practices are generally ecofriendly[16], sustainable and economically viable for the resource poor farmers as compared with the recommended commercial cropping pest control practices, which are costly and are environmentally more detrimental.

Besides cost effective management of insect-pests, these indigenous adaptive practices enable the farmers to develop knowledge networks among grassroots innovators who freely share information, management practices and seeds as inputs to crop production to make their farming systems less dependent on external resources[17]. Available evidence amply demonstrates that adoption of indigenous practices helps to facilitate the development of efficient and diversified cropping systems and agricultural resources. Such locally applied production systems, based on organic inputs[16], have greater resilience and adaptive capacity in the face of change in both climatic and socio-economic scenarios. The crop management practices of these farmers in general, and their indigenous practices of pest management in particular, hold the potential to overcome problems such as resource degradation and crop losses. Such innovative practices potentially constitute a source of hypotheses for participatory technologies important for developing sustainable agriculture. It is not always necessary to look outside local social-ecological systems to find solutions for every agricultural problem; farmers themselves are developing some effective measures and innovative ideas that need to be tapped and integrated into the broader perspectives of adaptation and sustainability[18]. Otherwise, the top-to-bottom driven technologies and policies might render local agriculture more vulnerable and endanger the particular and special attributes of unique agricultural systems.

The indigenous practices for plant protection in soybean and other crops as identified and documented here might be integrated with ongoing research at various agricultural research centres, eventually leading to the development of viable packages for crop protection and their dissemination to local and regional farming communities more broadly. Although the Indian Council of Agricultural Research (ICAR), New Delhi has made significant achievements in documenting, refining and validating such practices and their blending with scientific recommendations[19] through mission-led projects on indigenous technical knowledge in agriculture, more strategic research and effective extension systems would be required to promote the farmers' practices, and sustain the related institutions for developing sustainable agriculture. Such refined and validated practices will also be more acceptable to farmers on account of their compatibility with the social norms[19]. There is an urgent need to create reciprocal learning platforms between scientific and farming communities for further showcasing and refining the existing grassroots innovations and practices towards more sustainable life ways.

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