ISSN: 0976-1675

www.rjas.org

Research Journal of Agricultural Sciences

© Centre for Advanced Research in Agricultural Sciences

Research Paper

DI: 6192-1805-241

Development of Disinfection Card and Mobile App for the Precise Application of Disinfectants in the Silkworm Rearing House

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Received: 18 May 2020; Revised accepted: 05 August 2020

A B S T R A C T

Among agriculture crops, Sericulture being one of the most assured income generating crops supporting the livelihood of many farmers in India. Of the several parameters determining the healthiness of mulberry silkworm (*Bombyx mori*) larvae and success of cocoon crop, the germ-free rearing environment is crucial. Thus, it is in vogue to perform disinfection of rearing house and equipment's before onset of rearing to grow disease free silkworms. Despite, scientific information's are available in this regard, still heavy cocoon crop loss is reporting at field. To uncover the lacuna underlies, we have conducted a systematic assessment on disinfection strategies being followed by the farmers and the problems associated with it. Surprisingly, the present analysis revealed that all most all farmers did not adopt appropriate procedure for disinfection of the rearing house. However, the type of disinfectants, concentration and quantity as per the floor area used and the disinfection procedure followed were uncommon in both the villages. Interestingly, while cent percent of farmers in Koregala village using Decol, farmers in H. Kodihalli were using Chlorophate. In addition, although, all farmers have been practicing an advanced method of silkworm rearing-shoot rearing, correspondingly suitable disinfection procedure has not been followed. Thus, in order to overcome these constrains, based on the lacunae detected in the present investigation, we have developed a farmer-specific and user-friendly key termed as "Disinfection Card and a mobile application - SeriApp" to enable the farmers to disinfect their rearing houses with ease and accurate.

Key words: *Bombyx mori*, Disinfection, Rearing house, Lacuna, Disinfectant

India is the second highest populated country in the world, wherein majority of them still lives in the villages and agriculture/sericulture is the strong base for their livelihood. Despite, there is substantial progress in the field of science and technology, but most part of the rural India is still facing the hardship of poverty much higher than the urban areas (https://data.gov.in/keywords/census). As a consequence, the government of India emphasis in its planning on poverty alleviation, better livelihood opportunities, provision of basic amenities and infrastructure facilities through innovative programs of wage and self-employment (Kapur 2019). In this context, Sericulture is proved to be one of the best cottage industries to overcome poverty as it is labour intensive and highly remunerative industry. So far, sericulture has created several direct and indirect employments for about 9.18 million people in India (http://csb.gov.in/wp-content/uploads/2020/03/Note-on-Seri-CSB-2019-20-3rd-qtr.pdf).

The success of sericulture is mainly attributed to the healthiness of the silkworms that further regulates the quality and yield of cocoon. By and large, the silkworms, being poikilothermic, are highly prone to various diseases caused by viruses, bacteria, fungi and microsporidia, which is a major constraint affecting the cocoon quality and yield (Dasgupta, 1950). These pathogens are extruded by infected silkworms along with the gut juice (most of the viral diseases and pebrine disease), fecal matter (Cytoplasmic polyhedrosis, Pebrine and bacterial disease) or through breakage of fragile integument (nuclear polyhedrosis,

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septicemia) and from the body surface (Muscardine and Aspergillosis) of the dead and fermented larva. Moreover, these pathogens cannot be easily destroyed and persist longer period (Kanika *et al*. 2011), which eventually contaminates the rearing habitat and affects the healthiness of the larvae. Since, no complete curative measures for any of the silkworm diseases are available it necessitates an appropriate preventive strategy than cure. Towards this, disinfection of rearing house is one of the most promising strategies that can prevent the incidence of diseases by restricting the proliferation of disease-causing organisms in the vicinity of the rearing house (Balavenkatasubbaiah *et al.* 2014). Although several disinfection methods are in practice but use of chemical disinfectants is proved to be the most effective one in destructing disease-causing organisms.

For disinfection of the rearing house and rearing appliances different disinfectants viz. formalin (Kagawa 1980), bleaching powder (Kobayashi *et al*. 1968), iodine compounds (Kawakami 1970), and Chlorine dioxide (Balavenkatasubbaiah 1999) are suggested along with standard instructions. As per the recommendation, the disinfection must be carried out twice i.e. first one soon after completion of the crop and the other before initiation of the next crop. Albeit, a significant cocoon crop loss due to diseases during silkworm rearing has been recorded that varies between 15 and 20% at national level and about 30 to 40% due to specific diseases (Gupta *et al*. 2016). So, it has become a bottle neck problem to achieve assured cocoon crop at farmers level and offer a systematic investigation to detect lacuna in implementation of standard recommendation. To address this issue and a recent query, we searched for a solution, surprisingly, no studies that can suffice accurate information for the use disinfectants by the farmers are observed. However, a recent study (Shafi *et al.* 2018) states that most of the farmers do not pay much attention towards disinfectants and procedure to be followed for disinfection of the rearing house in all the seasons. This clearly indicates a wide gap as none of the farmers are competent in disinfection management skills during silkworm rearing. Keeping this skill gap in view, we have conducted a systematic survey not only to uncover ground truth and limitations associated with disinfection procedure followed by the farmers but also develop a farmer-friendly disinfection strategy.

MATERIALS AND METHODS

The present study was carried out in two villages of Mandya district namely Koregala from Malavalli Taluk and H. Kodihalli from Mandya Taluk, where the sericulture is being practiced by good number of households. Total sample size was 60 farmers with randomly selected 30 farmers from each village. The primary data was obtained based on the structured questioner and personal face to face interview of respondents. The data accrued was analyzed using percentage change statistical tool.

A mobile application - "SeriApp" was developed by setting up the environment to support Flutter SDK (software development kit) and enabling USB Debugging on the mobile. Inputs given on the home page are extracted for inbuilt conversion and calculation of data. It uses extendable widgets to output the disinfection information required.

RESULTS AND DISCUSSION

Farmer's awareness about disinfection

The survey revealed that all the farmers practicing sericulture in the study area were aware of the importance of disinfection (Fig 1A). But, despite, they supposed to do disinfection immediately after harvesting and marketing of cocoons and few days before start of next rearing irrespective of disease incidence, none of them practice this schedule of disinfection (Fig 1B). So, the fact is abandoned.

Disinfectants used for disinfection

As per the present data, common disinfectants used by the farmers were Astra, Bleaching Powder, Chlorophate, Decol and Formalin. Among them, inconsistently, cent percent farmers using Decol, followed by 37.93% of farmers using Astra for disinfection of rearing house in Koregala village. Besides, 17.24% of farmers were also using Chlorophate when there was severe crop loss in the village. Contrastingly, 100% of the farmers in H. Kodihalli were using Chlorophate while 33.33% and 16.66% of farmers using Astra and Decol respectively for disinfection. Interestingly, while 30% of the farmers prefer Bleaching powder, 3.33% of farmers were using formalin in H. Kodihalli due to the lack of knowledge but not in Koregala (Fig 1C).

Concentration and quantity of disinfectants

It is obvious from the present data that none of the farmers, irrespective type of rearing house they possess, follow recommended protocol with respect to concentration and volume of the specific disinfectant in accordance with total area of the rearing house for disinfection (Fig 1D). So, all the farmers were using disinfectants with rough estimation without giving much importance for concentration and total volume of disinfectant required for the rearing house.

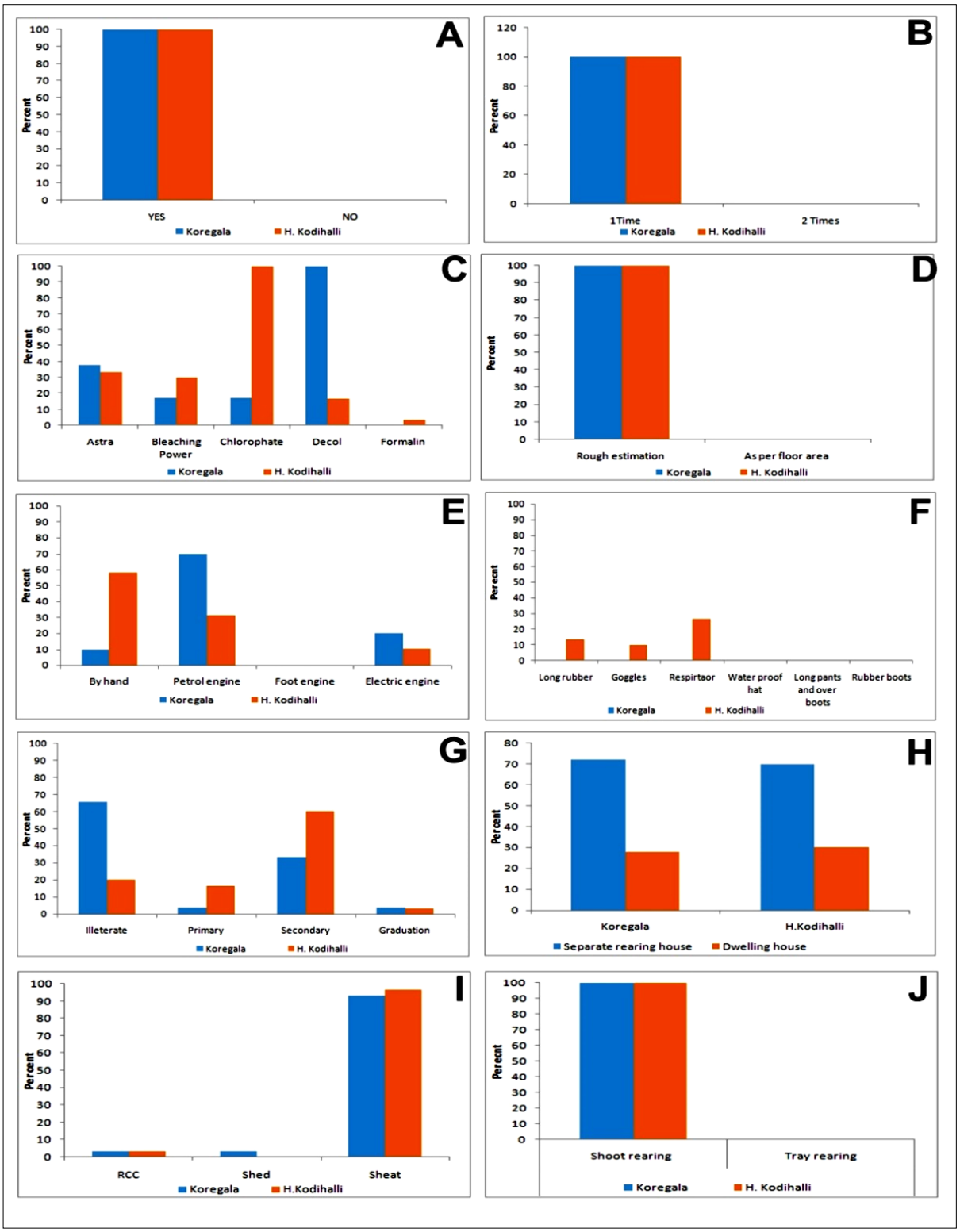
Appliances for disinfection

Different types of appliances such as engines operated by manual (hand and foot), electricity and petrol were in use for spraying of disinfectants. Among them, petrol, electric and hand operated engines were used by 70, 20 and 10% of the farmers in Koregala village while it was 31.03, 10.34, and 58.62% respectively in H. Kodihalli village (Fig 1E).

Preventive measures during disinfection

Although, it is well known that the chemicals used for disinfection are toxic and hazardous, and suggested use some protective materials like face mask, spectacles etc., but none of the farmers in the present study area practice any appropriate precautionary measures during disinfection of the rearing house (Fig 1F).

Education background of the farmers



A: Disinfection practice followed by the farmers, B: Frequency of disinfection, C: Different disinfectants used for disinfection, D: Quantum of disinfectants for disinfection of the rearing house, E: Mode of disinfection followed by the farmers, F: Protective appliances used by the farmers during disinfection, G: Education level of farmers practicing silkworm rearing, H: Rearing house owned by the farmers, I: Type of rearing house possess by the farmers, J: Silkworm rearing method being practiced by the farmers

Fig 1 Disinfection parameters followed during disinfection of the silkworm rearing house by the farmers in Koregala and Kodihalli villages

In the study area, most of the farmers were either uneducated or less educated. Surprisingly, 65.51% of farmers practicing sericulture in Koregala were illiterate while few of them (3.44%) have got primary education. Interestingly, 3.44% of the farmers were graduates while some farmers having education till secondary school level. In contrast, the farmers of H. Kodihalli were considerably better educated accounting 60 and 16.66% of them were having education till secondary and primary school levels. In addition, while 3.33% were graduates, 20% of farmers were illiterates (Fig 1G).

Type of rearing house owned by the farmers

Irrespective of the education level, about 72% of farmers in Koregala and 70% of farmers in H. Kodihalli village were having separate rearing houses. Among different types of rearing houses, 93.11 and 96.66% of farmers were constructed sheet type of rearing houses in Koregala and H. Kodihalli villages respectively. Only a few numbers of farmers in Koregala and H. Kodihalli were having RCC type rearing house accounting 3.44 and 3.33% respectively. Apart from this, only 3.44% of farmers owned shed type rearing house in Koregala village while none in H. Kodihalli (Fig 1I).

Silkworm rearing method: Interestingly, all the farmers in both the study areas were practicing an advance technology - shoot rearing method (Fig 1J), which is more popular, cost effective and highly advantageous over leaf feeding method of late age silkworm rearing.

Mobile application - SeriApp

The length, width, and height of the rearing house, when provided as input, are processed in the app to compute the data based on the standard values stated in the disinfection card. Inputs with '_', '-', ',' are not considered as valid inputs. By forming different widgets for different disinfectants, the conversion ratio and percentage are dynamically calculated and displayed the required quantum of water and disinfectants along with the respective units (Fig 2), which is calculated based on the floor area of the rearing house.

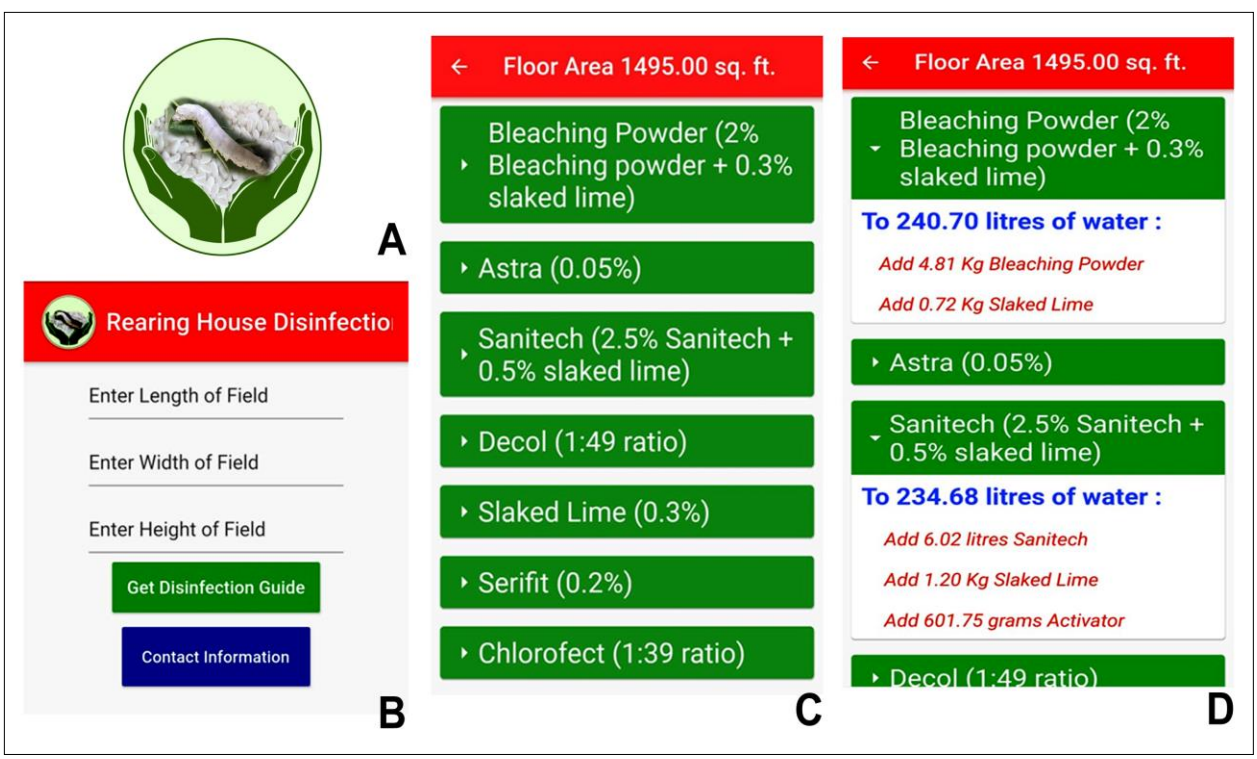


Fig 2 A mobile application - SeriApp.

A. Logo of the App denotes protection of the silkworm larvae from the infection and thus, signifies the successful harvest of the cocoon crop by Seri-farmers.
B. Home page to input the rearing house dimensions (Length, Width, and Height) with a provision for navigation.
C. A separate window depicts separate widgets with an expandable button for different disinfectants that are in practice.
D. Upon click, each widget displays a precise quantum of water and disinfectants required for the disinfection of the rearing house based on the floor area displayed in the toolbar.

Among various factors that govern the success of silkworm rearing for the production of cocoons that are both qualitatively and quantitatively good, pathogen free rearing environment is an utmost important one. To dethrone pathogen load to minimal before onset of rearing and also break multiplication cycle of the pathogens causing diseases in the preceding rearing, disinfection of rearing house and its surrounding area play a significant role (Balavenkatasubbaiah *et al.* 2014). Despite disinfection of the rearing house is in vogue and diseases prevail

throughout the year, there is either partial or complete crop loss in all the silkworm rearing areas in India. Though facts might be varying, but a precise reason underlies is obscure that needs to be investigated. Hence, to uncover the exact cause and develop a suitable remedy, we have undertaken the ground level study keeping the farmers conditions in view, which is lacking.

The present study revealed a major drawback of disinfection practice followed by the farmers, irrespective of the educational level of the farmers in both the villages, is the frequency and accuracy of disinfection. However, disinfection procedures followed by these farmers does not fall within the line of scientific recommendation suggested for a rearing house. Moreover, the present study explicit a clear disparity between scientific recommendation and the procedure being followed in their rearing house; wherein all most all the farmers follow a rough estimation of volume of disinfectants required for disinfection of the rearing house. But it is quite astonishing that although there are quite a number of different disinfectants are available along with precise prescription for their use, still farmers were not acquainted with it and use them accordingly. So, it clearly indicates the complexity in computing the varied chemical compounds present in a disinfectant to derive a required concentration and volume of the disinfection solution in accordance with the floor area of the rearing house.

Table 1 Farmer-friendly disinfection card for preparation of accurate volume of disinfection solution as per floor area of the rearing house

DISINFECTION CARD

Department of Studies in Sericulture Science, University of Mysore

Farmer name: Mahadevegowda

Floor area of rearing house: 65 × 23 = 1495 sq. ft. with an additional height of 1.75 ft.

Total disinfection solution required = 240.70 L
(140 ml per sq.ft floor area or 1.5 L per sq.m floor area of the rearing house. Nataraju and Balavenkatasubbaiah (2014)

Disinfectants	Quantum of disinfectants	Quantum of slaked lime	Amount of water (L)	Procedure for preparation
Bleaching powder (2%Bleaching powder +0.3% slaked lime)	4.81 Kg	0.72 Kg	240.70	Add 4.81 Kg of Bleaching powder and 0.72 Kg of slaked lime in 5 litre of water. Mix well and then make up the volume to 240.70 L adding water. Leave it for 10 minutes, collect the supernatant and use it for disinfection of the rearing house.
Astra (0.05%)	120.35 g	--	240.70	120.35 g of Astra shall be mixed with 10 L of water. Leave it for 2 hours and make up the volume to 240.70 L adding water. Mix thoroughly and use.
Sanitech (2.5% Sanitech 0.25% of activator crystals + 0.5% Slaked lime)	6.02 L Sanitech 601.75 g Activiator	1.20 Kg	234.68	Solution A: 601.75 g of activator is added to 6.02 L of Sanitech. Mix well and leave it for 5 minutes or till the solution changes to yellow. Solution B: Small amount of water shall be added to 1.20 Kg of slaked lime and add add 234.68 L of water. Mix A and B thoroughly and use.
Decol (1:49 ratio)	4.91 L	---	235.79	4.91 L of Decol is mixed with 235.79 L of water. Mix thoroughly and use.
Slaked lime (0.3%)	0.72 Kg	---	240.70	0.72 Kg of slaked lime shall be mixed with small amount of water. Leave it for few minutes. Collect the supernatant and make up the volume with 240.70 L of water and use it for disinfection.
Serifit (0.2%)	0.48 Kg	----	240.70	0.48 Kg of serifit granules added to 240.70 L of water. Mix thoroughly, leave the solution for 30 minutes and then use it for disinfection.
Chlorofect (1:39 ratio)	6.17 L	----	234.53	6.17 L of chlorofect is added to the 234.53 L of water. Mix thoroughly and use for disinfection.

Note: 10% extra for disinfecting surrounding area of the rearing house.
+ 35% extra for disinfecting rearing trays if in case of tray rearing method followed

The present study is further revealed a huge gap in disinfectants being used by the farmers that varies between two villages and among farmers in inconsistent manner. It is due to lack of awareness on the specifications and importance of each disinfectant to be used, and lack of skill for the use of disinfectants in a precise quantity as per the

recommendation against the dimension of the rearing house for disinfection. In support of the present inference, a recent study (Shafi *et al.* 2018) states that most of the farmers were not paying much attention for the disinfection procedure and disinfectants to use for rearing of silkworms in all the seasons. This ignorance could be due to the fact that the information currently available along with the disinfectants may not be farmers friendly to adopt with ease. So, to make the disinfection procedure user/farmer friendly, considering farmers need and specifications of the disinfectants, we have fabricated a "disinfection card" (Table 1) for calculation and preparation of disinfection solution required for the rearing house with ease. Moreover, variation in the concentration of the disinfectants used undoubtedly affecting the success of cocoon crop. Hence, it is imperative to create awareness on knowhow for the accurate preparation of required concentration and quantum of disinfection solution based on the type and dimension of the rearing house they possess. Further, handling of these chemicals without precautionary measures may also induce some serious health problems in the farmers.

For the benefit of farmers, the disinfection card is designed in such a way to show the total amount of different disinfectants, water and other compounds required as per the floor area in the line of scientific recommendation. Once the total area of the rearing house is calculated which remain constant for a farmer, the concentration and volume of any disinfectants shall be calculated and it has become easy tool for the farmer to use as and when he is in need. Since, the disinfection card and a mobile application - Sericulture Disinfection Mobile Application (SeriApp) developed in the present study has significance from the point of framer's utility, we strongly suggest that the disinfection cards shall be distributed to all the farmers practicing sericulture with proper instructions. Also supply glows and masks to the farmers to use during disinfection.

Furthermore, SeriApp developed as a silkworm rearing house disinfection guide, aiming to help Seri-farmers to use a very precise quantum of disinfectants of interest while preparing disinfection solution with ease and accuracy. The SeriApp designed is simple and offers a user-friendly interface and is widely accessible. Seri-farmers can simply enter the length, width, and height of their respective rearing house through the Home Page. The input data is computed with the inbuilt program as per the standard recommendations to the respective disinfectants (Nataraju and Balavenkatasubbaiah 2014). The output can be obtained upon clicking the disinfectant of interest and prepare required concentration and quantum of the disinfectant solutions as per the output. The app developed is first of its kind in sericulture and has ample scope for expansion (under progress in our laboratory) with specific modules for different applications.

This study not only uncovered the complexity exist in understanding the better usage of varied disinfectants but also developed a ready reckoner for disinfection of the rearing house with ease and accurate. Besides, we are of the strong opinion that a periodical scientific awareness and skill development program for the farmers must be organized such that farmers can overcome these constrains and harvest good quality and quantum of cocoons. By this way we could achieve sustainable sericulture by reducing cocoon crop loss at field.

Acknowledgement

We would like to thank Mr. Jagadeesh, Proprietor of Kirangere Chawki Rearing Center and Siddegowda, Koregala for guiding and supporting us for the collection of data during field visit.

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