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CORRESPONDENCE

Observation on urban rhesus monkeys

Certain ecological aspects and behaviour patterns of urban rhesus monkeys (*Macaca mulatta*) that I observed as an amateur might be of interest to some of your readers and those interested in investigating related problems in nature.

For more than four years, two rhesus monkeys (1 male and 1 female) inhabited certain localities of north Calcutta and exhibited some interesting foraging patterns.

While raiding my roof-top Bonsai garden every day during two seasons each year (just prior to the monsoon and again just before winter), they fed on the fleshy inner side of exposed roots of *Salmalia*, the bark of *Terminalia arjuna*, and all parts of *Ocimum sanctum* except its roots. *Andrographis paniculata*, which has a bitter taste, was also taken by them.

It is interesting to note that all these plants are medicinally important. Moreover, they also appeared to specifically consume those parts of the plants that are known to be medicinally useful. It is also noteworthy that none of the plants on which the monkeys fed died as a result of injury. They did not totally destroy any plant during any of their visits and also did not attack any particular plant on consecutive days. The fact that, in the course of 4 years, these limited resources were not exhausted is possibly significant. It should be of interest to note whether free-ranging monkeys display such sustainable exploitation of natural resources.

In course of their feeding, the monkeys also dispersed the seeds of *O. sanctum* and *A. paniculata*, thus compensating to some extent the loss that was inflicted.

Last year, the local police took away my study subjects. Soon, however, the empty niche of the rhesus was filled by human langurs (*Presbytis entellus*) who had not invaded the area during the last 4 years. In comparison with the rhesus monkeys, the langurs were far more destructive and did not exhibit any of the features of limited resource exploitation shown by the former.

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NEWS

Technological advances in the biological control of insects

Biological control, the corner stone of Integrated Pest Management (IPM), along with host–plant resistance is central to the pest management paradigm. To be more effective, it has to integrate diverse programmes involving natural enemies and microbials (bacterial, viral and fungal), besides kairomonal elements from host insects. With the advent of efficient, high quality mass rearing and delivery system and the ecofriendly, biorational techniques involved in microbial control, biological control has come to be considered as a technology-oriented exercise. Timely production of the highest quality material supported by adequate research, development and technology transfer become very relevant to efficient biological control. Interest in these aspects has led to increased commercialization of biocontrol production highlighting the need for a healthy competition among entrepreneurs. With this background, a symposium on 'Technological advances in the biological control of insects' was organized at the Entomology Research Institute on October 11 and 12, 1996 to take stock of the existing technologies and suggest modifications where needed.

M. S. Swaminathan (MSSR Foundation), in his inaugural address, highlighted the advances and progress made in the 'Green Revolution' era in increasing the food production in India particularly during the last 30 years. Swaminathan cautioned the entomologists on the use and abuse of chemical pesticides and the current problems with high input, high tech agriculture. He desired that a blend of host–plant resis-

tance and biological control would sustain in checking the pests of crops and that a relook into the whole gamut of pest management would be rewarding in the years to come. Swaminathan also emphasized the need for integrating information technology with Integrated Pest Management (IPM) to fill the gap in spreading the IPM. He suggested that use of computers to educate and spread the knowledge among farming community must be given due consideration. This would result in group action and would educate the farmers and bio-environmental management of agroecosystems.

T. N. Ananthakrishnan (Entomology Research Institute, Loyola College, Madras) in his introductory remarks indicated that though mass rearing has become a routine technology, increased efficiency and mechanization of beneficial arthropod production are important for future success of augmentation. To be effective the natural enemies have to be retained in target areas with prospects of efficient location of hosts and as such technology for managing the environment becomes equally important. Future challenges for developing augmentation technology exist in such areas as mass rearing, quality control, storing and application. Quality control has such components as production standard, production facility and monitoring the performance in the field. Production efficiency and field performance of natural enemies depend upon diverse parameters such as survival of immatures, size, fecundity, sex ratio, longevity and host-seeking ability. Maintenance of genetic variability is another component of quality control in mass rearing involving, hybridization of field collected material with that from laboratory line. Interinstitutional cooperation is vital for the success of commercial natural enemy production as well as maintenance of ethics in the production and distribution of natural enemies.

T. M. Manjunath (Pest Control (India) Ltd. Bangalore) emphasized that with the increasing significance of biological control as the foundation of integrated pest management, there is a growing demand for biocontrol agents. The success of such programmes depends mainly on the efficient and economic mass-production, ready availability, timely application and adequate releases of quality biocontrol agents. Recent advances made in the *in vivo* and *in vitro* rearing technology for biocontrol agents like *Trichogramma* and other parasitic wasps, *Chrysoperla*, ladybird beetles, phytoseiid mites, indicated this trend. Progress has been made in the methods of packing, storage and application techniques of natural enemies and the role of commercial insectaries and other organizations, including extension agencies, in transferring and popularizing the biocontrol technology and IPM, is commendable.

Speaking on the commercial production of biopesticides, M. Swamiappan (Tamil Nadu Agricultural University, Coimbatore) indicated that about 35 biocontrol agents comprising predators, parasitoids and insect pathogens have been found to be very promising and amenable for mass production and field use. A healthy competition among entrepreneurs is required so that biopesticide production units will be playing, an effective role in making available quality and cost-effective products for the farming community. Quality control norms are to be standardized for each and every product as they are living biocontrol agents. Streamlining is necessary in this new line of entrepreneurship by generating documents for registration, data for quality control, consideration of certain ethics and code of conduct for the production so that the real concept of biological control is perceived in order for the goals and aims to be achieved.

Highlighting the need for improved technology for mass rearing of Trichogrammatids and their facticious host *Corcyra cephalonica*, Navarajan Paul (IARI, New Delhi) opined that mass production of suitable facticious host is an important component in any biological control programme so as to ensure timely production of sufficient quantity of natural enemies for field releases. Among the facticious hosts, the Rice Meal Moth is an important facticious host that is multiplied all over the country for production of various natural enemies including Trichogrammatids. Studies indicated that the progenies of *Trichogramma chilonis* and *T. exiguum* reared on the eggs of *C. cephalonica* recorded higher fecundity and longevity as compared to those reared on *Sitotroga cerealella*. The present method of mass production of *Corcyra cephalonica* is labour intensive and the labour involved in the mass production is amenable for exposure to the moth scales which are known to cause allergic reactions in many individuals. A Close Type Rearing System has been developed in which exposure of the workers to moth scales is minimized and the manual moth collection is totally eliminated. Among the rearing media used for larval rearing, maize was found to be the best, resulting in high productivity moths and better quality of the egg parasitoids. A simple cleaning device for removal of scales from *C. cephalonica* eggs was developed with a cleaning efficiency of 95%. With the use of modified oviposition cage that could be fitted below the Closed Type Rearing System, eggs could be cleaned directly without exposing the worker to scales with a cleaning efficiency of 99%. A manual operated egg card making machine has been fabricated in which *Corcyra* egg cards containing approximately 1 ml of eggs, could be prepared in six seconds. Exposure of *Corcyra* egg cards containing 0–24 h old eggs for 2 minutes to UV radiation from a 30 W lamp from a distance of 5 cm sterilized the host eggs completely, thereby eliminating the larval hatching from unparasitized eggs. A suitable illumination chamber to provide 100 lux light intensity was developed for efficient parasitoid rearing. A parasitization chamber, in which 20 ml of eggs could be exposed simultaneously for parasitization, was developed which resulted in uniform parasitization and lesser proportion of runts at 1:7 mother to daughter card ratio with an exposure period of 48 h. The economics of mass production of *T. brasiliensis* both by conventional and improved methods was worked out considering an average production of 70 ml *Corcyra* eggs per day.

D. N. Yadav (Gujarat Agricultural University, Anand) discussed the mass rearing techniques for the predators *Chrysoperla cornea* and *Mallada boninensis* developed by using eggs of rice moth *Corcyra cephalonica*. The techniques involved (1) Larval rearing in a group in a round galvanized iron sheet cage, (2) Two-phase larval rearing in multicelled plastic louvers, (3) Single phase larval rearing in Biotech Bioassay trays. The feasibility of these rearing

techniques was tested for both the species. Results revealed that larval rearing in bioassay trays and two-phase larval rearing in multicelled plastic louvers proved effective for both the species. In the case of *C. carnea*, the percentage adult recovery was maximum (90.23) when larvae were reared in biotech bioassay tray followed by two phase larval rearing in multicelled plastic louvers (75.64%) and group rearing of larvae in round galvanized iron sheet cage (55.7%). In the case of *M. boninensis* when larvae were reared in biotech bioassay tray, the adult recovery was 71.56% followed by larval rearing in multicelled plastic louver (67.09) and group rearing (13.91). The data on fecundity, longevity, genetic deterioration, egg production, storability of the predator at low temperature are given. Advantages and disadvantages were also discussed.

Referring to the role of entomopathogenic nematodes in the biological control of insects, C. V. Sivakumar (Tamil Nadu Agricultural University, Coimbatore) indicated that species of *Steinernema, Heterorhabditis bacteriophora* and *H. indicus* have established in Tamil Nadu, and the bacterial symbiont associated with *Steinernema* sp. closely resembles *Xenorhabdus poinarii*, while *X. luminescens* is associated with *H. indicus*. The virulence of *S. carpocapsae* and the native isolates has been established against a number of major insect pests. Plant host-induced variation in the susceptibility of *Spodoptera litura* larvae to *S. carpocapsae* exist. Virulence of *S. carpocapsae* is altered by the host insect on which it multiplies.

Foliar application of *S. carpocapsae* has been found effective against the groundnut leaf miner, *Aproaraema modicella* on groundnut and *Spodoptera litura* on sunflower. Addition of a phagostimulant to nematode spray suspension increases the effectiveness of *S. carpocapsae* against *S. litura*.

K. S. S. Nair (Director of Kerala Forest Research Institute, Peechi, Trissur) discussed the new design of a light trap, in view of biological control operation requiring more accurate monitoring of pest populations. An indigenously designed novel light trap, powered by a Solar Photovoltaic (SPV) System for use in remote areas where electricity is not available, was discussed. The light source is a 20 V 'black-light' tube which is switched on automatically at dusk, controlled through the SPV system facilitates automatic operation for pre-set periods. The insect can be trapped into a bottle or a net-covered, walk-in chamber from where live insects can be selectively collected. Efficiency of the trap is reported on the basis of taxa of insects collected. The trap has several advantages over conventional light trap-facility to operate without electricity, operation for specific time periods, use of a black-light tube for greater effectiveness and facility for collection of live insects. A portable model with a 12 V black-light tube has also been developed and is under test.

S. Jayaraj (MSSR Foundation, Madras) highlighted the importance of Nuclear Polyhedrosis Virus (NPV) isolated from two ecosystems in Tamil Nadu, from the points of view of its pathogenicity, safety, bioefficacy, shelf-life, mass culturing techniques and field release. The virus biopesticide shows great promise in *Helicoverpa* management. Various methodologies concerning the establishment of laboratory colony of the pest, insect culturing techniques, equipments and materials needed for (a) Adult handling, (b) Egg collection and storage, (c) Egg sterilization, (d) Egg/larval handling, and (e) Pupal harvest and storage were discussed. The ingredients and methods of preparing semi-synthetic diet for the larvae were highlighted. Egg surface sterilization techniques and adult handling methods were explained, and methods of culturing NPV in the host insect and the extraction, purification and formulation of the virus also discussed. The standardization and quality control of the NPV were given much emphasis (Figure 1).

N. Ramakrishnan (Indian Agricultural Research Institute, New Delhi) discussed the growth of polyhedrosis virus in silk worm tissue culture, which provides a useful technique involved in tissue culture and difference cell lines can be developed and employed for various forms of biological research besides production of insect viruses. Todate a total number of 1600 viruses have been reported, causing diseases in about 1100 species of insects and mites. About ten insect viruses (nuclear polyhedrosis viruses and granulosis viruses) are used in large scale which are produced on the living host. The accompanying technological development in this form of production are (i) effective and cheap mass rearing media for host insect, (ii) automation in mass rearing of the host including inoculation and collection of viruses, (iii) quality control, standardization and formulation, (iv) the application technology and (v) marketing strategies. The possibilities of increasing the production of the virus by administering the host larvae with methoprene and improving the efficacy by genetic manipulations are discussed. Constraints in *in vivo* production were also explained.

R. J. Rabindra (TNAU, Coimbatore) explained that insect culture technology along with molecular techniques is currently being extensively used in developing improved viral pesticides which can give a boost to biocontrol. The successful development of baculovirus expression vector systems has given an impetus to the development of cell culture technology and consequently baculoviruses have emerged as promising ecofriendly pest management agents. Insect cells are routinely used for cloning of viruses, development of mutants and viral strains with desirable attributes like enhanced virulence and persistence. Recent advancements in molecular techniques have enabled the construction of recombinant viruses with greater pest control potential. The most crucial process of cotransfection of the cloned DNA and the wild type viral DNA takes place in insect cells grown in a suitable medium. Commercial application of the baculovirus expression vector system has opened the avenue for large-scale production of insect cells through liquid fermentation technology and *in vitro* production of viruses in insect cells. Various *in vitro* techniques have been developed for increasing cell yields and optimising virus production. Cell fusion techniques may provide hybrid cells capable of yielding greater amounts of virus.

P. Narayanasamy (Annamalai University, Annamalainagar) highlighted technological aspects of mycoinsecticides. Fungi, in particular, are reportedly very effective against the brown planthopper (BPH) and other pests of rice as field ecosystem is quite conducive for the fungal parasite. The fungi which were predominant included,

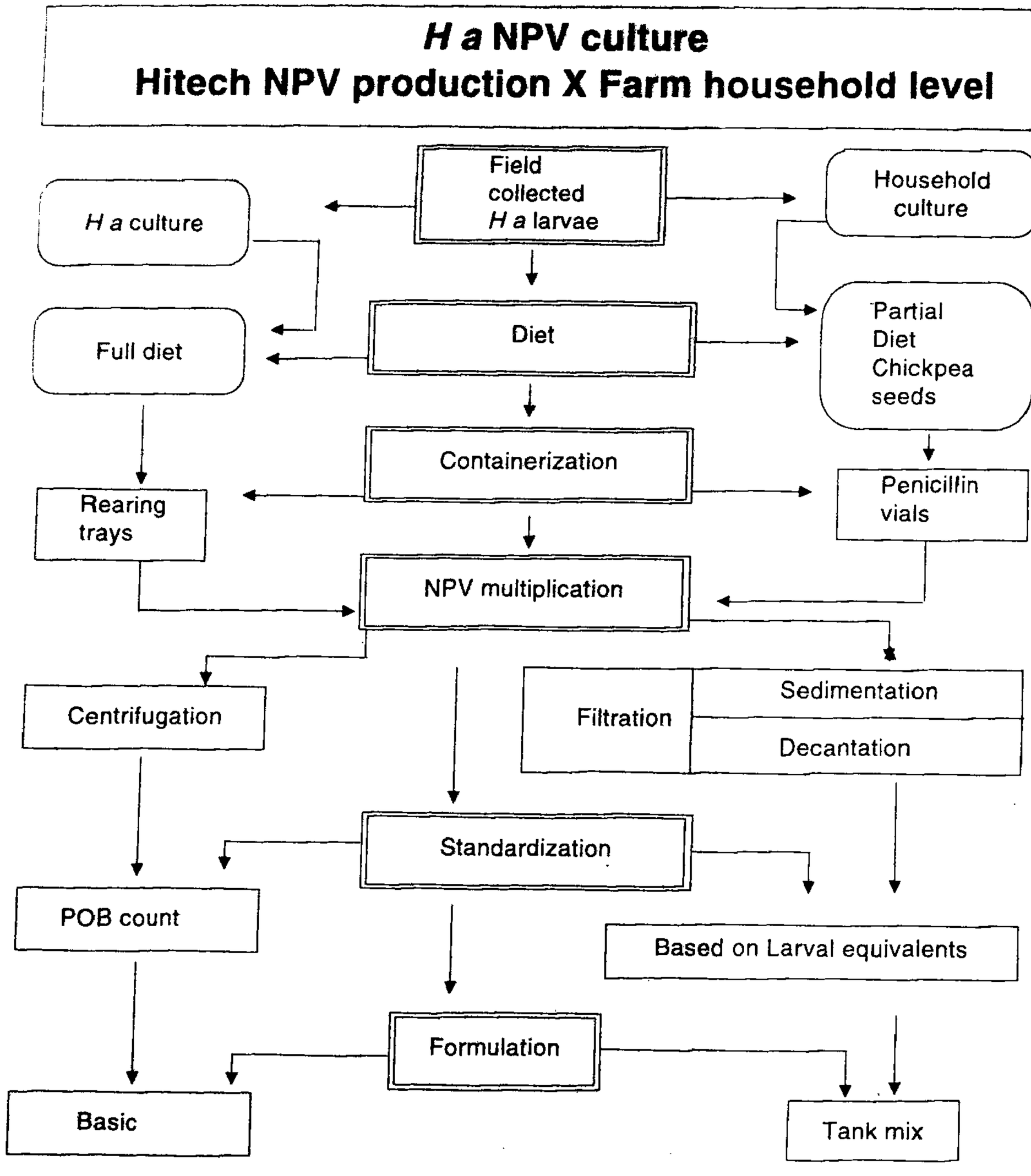

Figure 1.

Pandora delphacis, *Metarrhizium flavoviride* var. *minus*, *Beauveria bassiana*, *Zoophthora radicans*, *Nomourea rileyi* and *Paecilomyces farinosus*. The fungus *Pandora delphacis* which occurs in many districts of Tamil Nadu is a potential cure to the BPH menace. Hence the pathogen, after checking for various cultural characteristics was subjected to development as mycoinsecticide.

Two mycoinsecticide formulations such as dust (10%) and wettable powder (70%) were prepared with broken sorghum. These formulations were evaluated under field conditions. Of these, mycoinsecticide 70% WP was found to be more potent in killing the BPH to 66.15% than other treatments tested. Moreover, efficacy of the formulation was found uniform when tested at Coimbatore, Mandya and Hyderabad. It is significant that the cost of a kilogram of the product is only Rs. 10/-, which is far less than the chemical insecticides. The potential for the use of mycoinsecticide appears more valuable for pest problems of rice plant and hence it needs encouragement and mass use by the farming community.

S. Uthamasamy (Tamil Nadu Agricultural University, Coimbatore), coordinating the discussions, laid stress on such aspects as quality control in biological control; improvement of technology; new area of research; registration of biocontrol products/laboratories; training and implementation technology and industry/institute inter-

actions. S. Jayaraj presided over the concluding session which generated newer ideas in the area of biocontrol technology.

Quality control in biological control

Spurious materials, adulterations, substandard and poor genetic stocks are being marketed and it was suggested that there should be a network system within the All India Coordinated Research Project on Biological Control of Crop Pests of ICAR, State Agricultural Universities (SAUs), ICAR Institutes to monitor the quality of the biocontrol products marketed in our country. Further, the ICAR, Department of Biotechnology (DBT) and State Departments of Agriculture should enforce this aspect of biological control which would go a long way in improving the quality of biocontrol products.

Improvement of technologies

The urgent need for improving the existing technologies was also stressed, variations in the effectiveness of existing biocontrol products, arbitrary recommendations and very poor impact of such products on target pests are reported. Hence, an earnest effort should be made to refine the technologies which would sustain the momentum gained in this area of biocontrol.

New area of research

A very large number of natural enemies are available for exploitation in the management of pests. The biocontrol potential of reduviids, anthocoreids, spiders need to be studied. Further, new pathogens such as fungi, bacteria, nematodes offer scope for research and a need to be studied. Recent reports indicate that poly DNA viruses suppress the immunological reactions of the host and hence there is need for initiation of research in this area.

Registration of biocontrol products/laboratories

There is need for regulating the mass production of biocontrol agents to enable the farmers to get quality products from registered laboratories. A guideline on quality parameters, storage, transport and field release should be supplied along with the products for the benefit of users. This would educate the farmers on proper handling of these products for effective check of the target pests.

Training and implementation technology

Farmers, involved in the production and use of biocontrol agents should be trained by institutional trainings, farm-based trainings and other innovative approaches would spread the message of biointensive approach in pest management. The communication media and computers should be utilized to the maximum extent in educating the people. Software for biological control targeting crop-based approaches *vis-à-vis* pest-based approaches would pay rich dividends.

Industry/institute interactions

An effective interaction between agro input industries and research organizations in promoting the concept of biological control would be useful, as we enter a new era of pest management in the 21st century.

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