Role of Attractants in Fruit-Fly Management

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Abstract

Tephritid fruit-flies are among the most important pests of many fruits and fruit-vegetables. Uses of attractants such as methyl-eugenol, cuelure and protein-bait-sprays have become the major pest control tactics against fruit-flies worldwide. At least eight Bactrocera fruit-flies are found in Nepal, of which B. dorsalis and B. zonata are attracted to methyl-eugenol whereas B. cucurbitae, B. tau, B scutellaris and B. yoshimotoi are attracted to cuelure. Two other species, believed to be present in Nepal, include B. latifrons (a solanaceous fruit-fly infesting wild Solanum spp.) and B. minax (a severe citrus-pest in the eastern mountains of Nepal), which are suspected to fall under non-responsive group. Various attractants and their importance in fruit-fly management programs are discussed.

Background

Fruit-flies belonging to the family Tephritidae (Diptera) are among the most important pests of many fruits and vegetables worldwide. More than 1000 species of tephritids have been described (Metcalf and Metcalf 1992). The sub-family Daciniae includes more than 700 described species (including *Bactrocera* and *Dacus*) originally confined to the tropical and subtropical areas of the old world. *Bactrocera* species have spread to North-America, Africa, Australia, Mediterranean-region, Caribbean, Hawaii, Pacific-islands and many countries in Asia. Pest fruit-fly species reported from Nepal belong to the genus *Bactrocera* only.

Under severe infestations, fruit-flies can cause complete crop failure. With due consideration to the potential damage to agricultural products, many countries including Australia, Japan, New Zealand and USA have strict quarantine requirements imposed on import of fresh-fruit and vegetables from fruit-fly infested countries. In addition to the direct crop loss, the added cost of treatment for disinfestations could affect the international trade opportunities. Billions of dollars have been spent to eradicate accidentally introduced fruit-flies from Florida and California (Metcalf and Metcalf 1992). In Nepal, importance of fruit-fly pest problems had been identified since early 1950s. *Bactrocera dorsalis* was the focus of the early studies, both monitoring and management (Pradhan and Adhikari 1990). The outbreak of this fruit-fly in the eastern Nepal (Bhojpur District) led to the implementation of special program to suppress it. The program greatly relied on insecticide (malathion) cover spray (Box 1) (Pradhan and Adhikari 1990).

Though pesticides have important role in pest management, their unintended impacts on environment and public health limits their wide acceptance. Cover arrays are among the most common pesticide application methods. This method requires bulk of toxic material spread over large geographical areas. It not only raises the cost (material and application) but also increases probability of unintended impacts such as ecological disturbances, pest resistance and resurgence.

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Use of insect attractant in pest management is preferred over cover spray due to its advantages such as reduced volume of pesticide use and cost of pest management, safety to applicators and natural enemies of pests, increased effectiveness and pest selectivity. This paper aims to discuss fruit-fly attractants that have the potentials of being utilised in fruit-fly management strategies and plans in developing nations like Nepal.

Chemical and physical attractants

Insects respond to various physical and chemical stimuli. The detail accounts of these attractants have been presented hereunder.

Physical attractants

Physical stimuli that have been used in pest management include colour, light, sound and shape. Two most common physical stimuli used in fruit-fly programs include the colour and shape of traps. Insects behave differently to various colours. Fruit-flies are usually attracted to the natural colour of the host-plants or their part such as flower and fruit. Many insects including fruit-flies respond positively to yellow colour (Vargas *et al.* 1991). Commercially available sticky traps and modified McPhail traps usually have yellow coloured component. Round traps that mimic the fruit shape (e.g. Ladd traps) were found superior than the flat traps (Alyokhin *et al.* 2000). For such physical stimuli to be effective, they have to be visible. When placed in farms, vegetation obscures the traps making them effective only for a short range. However, when used with other stimuli such as chemical attractant, they can enhance the effectiveness of the trap (Stark and Vargas 1992).

Chemical attractants

Several types of pheromones, allomones and synomones have been identified as chemical stimuli. Among which food and sex lures are the most widely used ones in pest management. Methyl-eugenol and cuelure, the most widely used attractants for attracting male flies of *Bactrocera spp*., have been identified as parapheromones or plant kairomones because of their origin (Metcalf and Metcalf 1992).

Food lure: Fruit-flies can survive on sugar diet, but they require proteinaceous food to attain sexual maturity and oviposition. Studies conducted by McPhail during 1933-34 provided the insights not only for developing fruit-fly monitoring traps but also for devising protein bait sprays for their control (McPhail 1939). His experiments with various protein sources including fresh cow-hide with hairs suggested ammonia gas to be the source of attraction to the fruit-flies. Subsequently, hydrolysed proteins were used for fruit-fly management. Protein baits serve as a general-purpose attractant (for all fruit-flies species present in the location) with narrow radius of effectiveness. GF-120 has been manufactured in the USA for use with formulations containing highly effective insecticide spinosad. Recently, brewery waste, containing yeast cells, has been converted into fruit-fly bait in Malaysia (Promar) and Tonga (Royal Tongalure). Similar product has been manufactured in Vanuatu also (Loke *et al.* 1992). The baits manufactured from local brewery waste products need to be mixed with insecticides. These products have been found as effective as the commercial products and affordable by poor farmers in developing countries.

Methyl-eugenol (ME): Howlett had discovered the attractiveness of citronella oil to tephritid fruit-fly as early as 1912. Steiner rediscovered methyl eugenol as oriental fruit-fly attractant by 1952 (Steiner 1952). Thanks to the American soldier returning from World

War II, who inadvertently took some tropical fruit infested with oriental fruit-fly to Hawaiian Islands. This invader not just got established but spread over all the islands of Hawaii causing severe losses to many tropical fruits. Steiner found that methyl-eugenol was three times more attractive than methyl-isoeugenol, five times more attractive than isoeugenol and 25 times more attractive than citronella oil (Steiner 1952). Chemical analysis revealed that citronella oil contained 8% methyl-eugenol. methyl-eugenol was found to attract oriental fruit-fly within the periphery of 800 m. Subsequent evaluations have shown that methyl-eugenol was attractive to at least 58 species of *Bactrocera* (Steiner 1952).

Cuelure (CL): Encouraged with the magical effect of methyl-eugenol, scientists from Hawaii discovered Anasyl acetone to be attractive to melon fly, another pest species that had invaded Hawaii since 1907. In an endeavour to develop stable derivative of the compound, 4-(p-acetoxyphenyl)-2-butanone) butatone was synthesized by Barthel *et al.* (1957). This novel chemical was named cuelure. Cuelure is not found in nature; it easily hydrolyses into naturally occurring raspberry ketone (RBK) that is found in raspberries and cranberries. Subsequent tests revealed that cuelure (raspberry ketone) was attractive to at least 176 *Bactrocera* species.

Many of the *Bactrocera* species do not respond to both methyl-eugenol and cuelure. The rest are selectively responsive to one or the other chemical. None of the *Bactrocera* responding to both the chemicals has been reported. There are at least 6 species of fruit-flies reported from Nepal (Gyawali 2006; Shrestha 2006), based on the use of parapheromones (methyl-eugenol and cuelure). *B. dorsalis* and *B. zonata* respond to methyl-eugenol, and, *B. cucurbitae*, *B. tau*, *B. scutellaris* and *B. yoshimotoi* respond to cuelure (Table 1). Two other species, namely *B. latifrons* (solanaceous fruit-fly infesting wild *Solanum spp.*) and an emerging citrus pest in the eastern mountains of Nepal (suspected as *B. minax)*, also believed present in Nepal are non-responsive to the chemicals. Since many fruit-fly species not attracted to the chemicals, other tools such as protein baits and rearing infested fruits would complement fruit-fly diversity studies in Nepal.

Comparison of methyl-eugenol and cuelure

Longevity

Methyl-eugenol, cuelure and raspberry-ketone differ greatly in their release rate (Table 1). Cuelure (0.016) and RBK (0.00084 mg/hr) are considered slow releasing compounds compared to methyl-eugenol (1.1 mg/hr). The lower boiling point and higher release rate of methyl-eugenol probably make it more attractive with an effective range of 800m compared to cuelure with the effective range of about 30m. Methyl-eugenol traps have been found to be effective for about a year. Because cuelure evaporates very slowly, the traps have been found to be effective for more than a year. In fact, following a field exposure of plastic matrix plugs containing 2g cuelure, the plugs contained 0.9g cuelure after 52 weeks (unpublished data). On the other hand, effectiveness of plugs containing 2g methyl-eugenol declined sharply within 6 weeks of field exposure. Longevity of such traps was affected by the presence of shade. Super charged plugs containing 10 g methyl-eugenol lasted for about 26 weeks under shade, while their effectiveness declined sharply after 20 weeks when the traps were exposed to direct sun-light (unpublished data).

Trap placement

It has been seen that many farmers hang fruit-fly traps on poles along crop border such as *zucchini*, probably anticipating that most of the flies would get trapped at their entrance to the crop field. However, both the efficiency and longevity of such traps would impaire due to direct exposure to sunlight (unpublished data). Study conducted in Hawaii by hanging the traps on open field without vegetation caught fewer melon-flies compared to the traps hung on the *Leucaena leucocephala*. Nishida and Bess (1957) indicated that melon-fly spent a considerable part of their life on non-host trees such as amaranthus, castor and corn (roosting host) and visit the host plants during day time in search of oviposition site. It is probable that the flies initially on *roosting sites* would be attracted to the trap. Hanging traps in shade may also have added advantage due to higher relative humidity required for hydrolysis of Cuelure to Raspberry-ketone especially during the dry season. Similarly, shade could slow down the rate of methyl-eugenol evaporation thereby increasing the longevity.

Table 1: Comparison of methyl eugenol (ME), cuelure (CL) and raspberry-ketone (RBK)

	Methyl-eugenol	Cuelure	Raspberry-ketone
Source	Ten plant families	Synthesized	Raspberries, cranberries
Mode of action	Phagostimulant	?	?
Molecular weight	178	206	164
Boiling point	254	345	340
Release rate	1.1	0.016	0.00084
Attractive range	800 m	30m	?
Species attracted	58	176	176
Pest species attracted	8	24	24
Attracted Species in Nepal*	*B. dorsalis, B. zonata*	*B. cucurbitae, B. tau, B. scutellaris, B. yoshimotoi*	

Source: Metcalf and Metcalf (1992).

Fruit-fly pest status in Nepal

Oriental fruit-fly, *Bactrocera dorsalis* Hendel, has been reported as major pest of citrus in eastern (Dhankuta), central (Ramechhap), western (Kaski, Baglung, Parbat), mid-western (Dailekh) and far-western (Baitadi) regions of Nepal. The pest also attacks other fruits such as mango and guava. Similarly, melon fly, *B. cucurbitae* (Coquilette) has been reported as major pest of many cucurbits from terai to high mountains of the country (Pandey *et al.* 1997). Population dynamics of other fruit-fly species has been studied by Shrestha (2006). Studies on distribution and severity of fruit-fly species such as *B. tau*, *B. zonata*, *B. scutellris* and *B. yoshimotoi* are lacking. So called *Bactrocera minax* has been established as a severe pest of oranges in the eastern mountains of Nepal.

Conclusion

Fruit-flies can be managed through multiple tactics such as physical barriers, field-sanitation, mass-annihilation, protein-baits and promotion of biological control agents. Fruit-fly attractants such as methyl-eugenol and Cuelure have played key role in the monitoring and management of several *Bactrocera* species.

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*Gyawali, 2006.

Huge information is available on oriental fruit-fly (*B. dorsalis*) and melon-fly (*B. cucurbitae*) from extensive studies in Hawaii and elsewhere. However, little is known about other species such as *B. tau* and *B. zonata*. It is still unclear about the pest status of fruit-flies such as *B. scutellaris* and *B. yoshimotoi*. The suspected citrus fruit-fly *B. minax* requires further studies. Studies on biology and behaviour of these fruit-fly species would enable us design long-term fruit-fly management strategy.

Fruit-fly protein baits are available in many countries including pacific island countries. There is no fruit-fly protein bait available in Nepalese market. Protein bait application is the only viable fruit-fly control method, especially for non-responders such as *B. minax*. Studies should be initiated to convert brewery waste to fruit-fly bait. Additionally, due to high mobility of these pests, efforts must be placed as a campaign on area wide pest management.

With ever-expanding international trade and Nepal's membership in the WTO, Nepal has begun importing fruit from countries such as New Zealand and China. Such an increase in international trade increases the risk of unwarranted pest infestation. We must be careful to keep foreign pest species out of country border. The impact of invasion of Mediterranean fruit-fly (*Ceratitis capitata),* probably the worls's worst fruit-fly species that infested more than 253 host plants, is beyond our imagination.

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Text Box 1: Fruit-fly pest control

Fruit-fly has emerged as an important pest of many citrus fruits. Its outbreak has resulted up to 10% loss in sweet orange (Junar) in Bhojpur district. Based on the studies and experiences, it is important to follow following control measures.

1. *Apply 5% BHC or 5% malathion dust as soil treatment, and spray weeds surrounding the orchard with 0.05% malathion in the beginning of the spring season.*
2. *Cover spray malathion or methyl parathion (0.05%) at new flush.*
3. *Apply paste of sugar or jaggery or proteinex mixed with malathion on tree trunks at monthly interval.*
4. *Use pheromone traps charged with methyl-eugenol and malathion.*
5. *Apply cover spray (as in step 2) after fruit set.*
6. *Apply cover spray (as in step 2) two to three weeks before fruit ripening.*
7. *Destroy fruit-fly infested fruits regularly by deep burying, boiling or burning.*
8. *Repeat application of BHC or malathion (5% dust) during fruit drop season.*

(Pradhan and Adhikari 1990)

References

Alyokhin, A. V., R. H. Messing, and J. J. Duan. 2000. Visual and olfactory stimuli and fruit maturity affect trap captures of oriental fruit-flies (Diptera: Tephritidae). Journal of Economic Entomology 93: 644-649.

Gyawali, B. K. 2006. The Fruit-fly, Bactrocera spp. and their composition in Lalitpur, Nepal (Diptera: Tephritidae). *In* I. Press [ed.], National IPM Conference. Plant Protection Society Nepal, Lalitpur, Nepal.

Loke, W. H., K. H. Tan, and S. Vijaysegaran. 1992. Semiochemicals and related compounds in insect pest management - Malaysian experiences., pp. 111-126. *In* A. A. S. A. Kadir and H. S. Barlow [eds.], Pest management and the environment in 2000.

McPhail, M. 1939. Protein lures for fruit-flies. Journal of Economic Entomology 32: 758-761.

Metcalf, R. L., and E. R. Metcalf. 1992. Plant kairomones in insect ecology and control.

Nishida, T., and H. A. Bess. 1957. Studies on the ecology and control of melon fly Dacus (Strumeta) cucurbitae Coquilett (Diptera: Tephritidae), pp. 44, Technical Bulletin No 34. University of Hawaii, Honolulu.

Pandey, R. R., Y. D. Gc, and A. K. Vaidya. 1997. Report on management of fruit-fly, survey of egg parasites of citrus green stink bug and monitoring of pests of rice and maize, 1995-1996., pp. iii + 11 pp., Working Paper - Lumle Regional Agricultural Research Centre.

Pradhan, R. B., and S. Adhikari. 1990. Fruit-flies and its control, pp. 6. Entomology Division, Kathmandu.

Shrestha, K. B. 2006. Surveillance of fruit-fly in fruits. *In* i. Press [ed.], National IPM Conference. Plant Protection Society of Nepal, Lalitpur, Nepal.

Stark, J. D., and R. I. Vargas. 1992. Differential response of male oriental fruit-fly (Diptera: Tephritidae) to colored traps baited with methyleugenol. Journal of Economic Entomology 85: 808-812.

Steiner, L. F. 1952. Methyul eugenol as an attractant for oriental fruit-fly. Journal of Economic Entomology 45: 241-248.

Vargas, R. I., J. D. Stark, R. J. Prokopy, and T. A. Green. 1991. Response of oriental fruit-fly (Diptera: Tephritidae) and associated parasitoids (Hymenoptera: Braconidae) to different- color spheres. Journal of Economic Entomology 84: 1503- 1507.

[Queries from the participants of the seminar:

Recollecting the fruit-fly havoc and the management campaign in Bhojpur, Mr. R. B. Shah mentioned that the fly species in Bhojpur was almost 80% controlled by methyl-eugenol. In this context, he suggested the fly in Paripatle should be different from that in Bhojpur so far methyl-eugenol did not attract it. Memorising the story of fruit-fly that out-broke in Nepal ever since 1985/86 and realizing the difficulties in identification of the existing species, Dr. K.P. Poudel suggested to make necessary efforts on developing appropriate protein-baits which are in general non-selective to fruit-fly species. Though the baits are generally prepared from brewery by-products, Dr. Poudel added, their preparation should also be tried from locally available protein materials. The presenter, in response to the queries, suggested that future programs should emphasize 'preparation of appropriate protein-bait' so far it can put down majority of fruit-flies. While concluding the paper, the chairperson of the session aspired that the fruit-fly problem in the country would get proper solution as soon as possible.]