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Socio economic impact of use of pheromone traps against Indian Gypsy moth, *Lymantria obfuscata* on apple orchardists of Chamba district

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Abstract
Horticulture occupies very important position in the predominantly agricultural economy of western Himalayas. Apple is one of the most important fruit crops of Himachal Pradesh, which constitutes about 49 per cent of the total area under fruit crops and about 85 per cent of the total fruit production. Indian Gypsy moth, *Lymantria obfuscata* is one of the major pests of apple and apricot in Kashmir and Himachal Pradesh feeding on apple foliage. This pest is one of the major causes to affect the quality of apple and production in apple growing areas of District Chamba. Therefore, efforts have been made through front line demonstrations (FLD) to demonstrate the benefits of sex pheromone traps to protect apple from the damage of insect pest and also to increase productivity. The trials were conducted in 2017 and 2018. The results revealed that the cumulative number of adults trapped per pheromone trap throughout the study time from April to June was 210 and 235 in 2017 and 2018, respectively. The benefit cost ratio was high in demo (3.03 and 2.80) as compared to check (1.58 and 1.50) in respective years. There was increase in yield in demo over check during both the years. The per cent increase in yield was 37.33 per cent in 2017 and 33.71 per cent in 2018. Technological and extension gaps existed in the district which can be bridged by popularizing package of practices and location specific integrated approaches.

Keywords: Apple, benefit cost ratio, front line demonstration, indian gypsy moth, pheromone traps, technology index, yield

1. Introduction
Horticulture occupies very important position in the predominantly agricultural economy of western Himalaya. Himachal Pradesh has emerged as the Horticulture state of India. Among all the fruits grown in the Himachal, apples are most widely and commercially planted. It has been recognized as the "apple state of India" for being adjudged as the best producer quality of apples. In the state of Himachal Pradesh, farmers are encouraged to grow the world's finest and choicest variety of apple [1]. Apple is one of the most important fruit crops of Himachal Pradesh, which constitutes about 49 per cent of the total area under fruit crops and about 85 per cent of the total fruit production [2]. Apples constitute a major part of the economy of Himachal Pradesh, with a turnover of Rs. 3000 crore and accounting for almost 10 percent of the gross domestic product [3]. Apple cultivation in Himachal Pradesh started in 19th century and first commercial plantation was established in Bundrole in Kullu valley by a retired British soldier, Capt. R.C. Lee [4]. The fruit occupied only 10 percent (134 hectares) of the total area under fruits in 1955, which was confined to a few pockets namely Mashu (*erstwhile* Shimla), Kullu, Mandi etc. from where it diffused to other parts of the state.

The major apple producing districts of Himachal Pradesh are Shimla, Kullu, Chamba, Sirmour, Lahaul and Spiti and Kinnaur. The apple fruit contributes more than 987 crore towards the gross domestic product. The production level has gradually touched to 540.30 mt with 5.6 t productivity in 2006 [1]. Chamba is known to be one of the promising districts in terms of horticulture crops. Chamba has shown 7.50 per cent growth in productivity per annum in 2013-2014, second highest to Lahaul and Spiti (9.40 per cent). Apple production in Chamba has shown growth rate of 4,500 Tonnes with an area of 7,500 hectares during 1973-74 to 2013-14 (Ravinder *et al*. 2018).

The "gypsy moth", *Lymantria* species are widespread and important defoliators of various types of cultivated and wild plants in the United States, Canada, Europe, Asia and Africa [5, 6]. Unlike winged but flightless, European gypsy moth, *Lymantria dispar* (L.)

(Lepidoptera: Lymantriidae), wingless Indian gypsy moth, *Lymantria obfuscata* Walker (Lepidoptera: Lymantriidae) which occurs in the Indian subcontinent is a polyphagous pest. Gypsy moth is a major pest of apple and apricot in Kashmir and Himachal Pradesh feeding on apple foliage [7, 8]. Besides apple it also causes serious damage to apricot, walnut, willow and poplar [9]. *L. obfuscata* is univoltine and overwinters in the form of egg masses. Even though insecticides are still advocated as a reliable and practical option to control this pest, it is very difficult to make applications in huge forest areas at farmer's personal level or without large scale community interventions sponsored by government agencies. Fortunately, many natural enemies of this pest have been reported coupled with the use of biorationals, namely sex pheromones for trapping moths [10, 11,1 2]. Pheromone-baited traps are the primary method for detecting and delimiting new isolated gypsy moth populations in previously uninfested areas. Pheromone-baited traps are a very sensitive tool that can be used to detect very low density populations that could not be detected using any other method. Every year, over 300,000 traps are deployed in the USA for detection/delimitation alone [13]. Monitoring of the adult population should be done when adults have started to emerge. The monitoring of the adult population of gypsy moth should be done by using delta traps baited with a dispar lure [14]. The best time for installing the pheromone-baited traps should be started in the first week of June. However, in practice field use of pheromone traps is limited and still not fully explored for managing this pest. Thus, the present study is aimed at inspiring and motivating farmers to use the integrated pest management practices which starts with monitoring and trapping of insect-pests with pheromone traps.

2. Materials and Methods

The present study is conducted for the mass trapping of gypsy moth, an important and destructive pest of apple in Ulansa village of Chamba district. Ulansa village is located in Bharmaur block, Tehsil Holi of Chamba district. The present study was conducted for two consecutive year's i.e. 2017 and 2018. The agro-climatic zone is temperate, high hills. Since the area is highly temperate, the flowering in apple trees comes in late March and hence the pheromone traps were laid in this zone during late March and first observation of trapped males was taken on 10th April every year. The geocordinates of this village are Latitude 32º45'23'' N and Longitude 76º45'34'' N. The total area of this village is 349 hectares with population of 1,136 peoples according to census 2011. This village is predominant by the apple orchardists. The crop was being affected by the insect pest from last three years. The farmers were adopting the control measures after the severe incidence of this pest and thus were not getting the maximum yields and were facing huge loss to economy every year. Thus, the initiative was taken by Krishi Vigyan Kendra, Chamba to inculcate the farmers about the importance of monitoring of this insect pest for adopting suitable management practices.

The trial was conducted as Front Line Demonstration (FLD) on cluster basis in this village. Cluster based approach was adopted and the farmers were given pheromone delta traps with disparlure capsules for monitoring and detecting the population of gypsy moth in this affected area. Total 60 farmers were approached and selected for this clustered approach. Each farmer was distributed 10 delta traps. 5 delta traps were used per hectare for apple orchards as per the recommendations of the university. These traps were triangular in shape, 6-10 inches long and 3-4 inches wide per side. Traps were open from both sides and sticky inside to capture the adult males. Delta traps were placed about 5 to 6 feet off the ground on tree trunks, and poles. These traps were baited with synthetic lure that mimic the natural pheromone to attract the males. The attracted males got struck in the sticky glue inside. Pheromone capsules were inspected weekly, and were removed and replaced after 4 weeks. The counting of adults trapped in 20 traps was done at 10 days interval, at random. Average value of these 20 traps was taken for further studies.

The orchards where no traps were used were taken as Farmers Practice (FP). The data was collected from front line demonstration's fields as well as from control field (FP) and finally estimated the technology and extension gaps. To estimate the technology gap, extension gap and technology index following formulae have been used [15].

Technology Gap = Potential yield - Demonstration yield.
Extension Gap = Demonstration yield - Farmer's yield.
Technology Index (%) = (Technology gap / Potential yield) x 100.

Complete data was collected from farmers about demo and check on fruit yield, cost of cultivation, gross returns, net returns, benefit cost ratio and per cent increase in yield.

3. Results and Discussion

3.1 Male Trapping

Male flight activity of *L. obfuscata* in apple crop was observed in April, May and June both years *viz.* 2017 and 2018. This coincides with the flowering time and fruit setting time of the apple crop. Figure 1 represents the average number of male adults trapped at ten days interval in both years from randomly selected 20 pheromone traps. The results revealed that average cumulative number of adults trapped per pheromone trap throughout the study time was 210 and 235 in 2017 and 2018, respectively. The study also reveals that the population was fluctuating throughout the study months but there was decline in population in the month of June in both years. These results are getting the support from the research done by Sharov *et al*. [15] while doing their research on effect of synthetic pheromone of gypsy moth trap catch and mating success beyond treated areas.

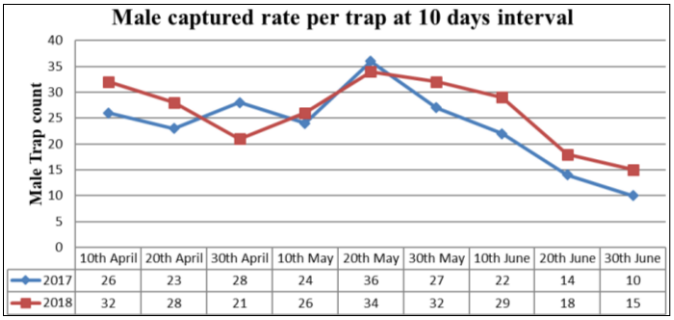

Fig 1: Average adults trapped per pheromone trap in 2017 and 2018.

3.2 Yield parameters

The results indicated that the demonstration of pheromone traps and then adopting the package and practices of gypsy moth control in time recorded higher crop yield. Average yield recorded in demo plot was 7.5 q/ha and 8.9 q/ha during 2017and 2018, respectively. There was 37.33 per cent and

33.71 percent increase over check in respective years (Table 1). The yield was higher in demo plots compared to check plot was due to timely application of insecticides and adoption of integrated insect management techniques. The results are supported by work of Butani [17] who reported that the larvae of Indian gypsy moth defoliates the trees completely and results in failure of fruit formation. Gupta and Tara [18] in their studies also reported that this pest defoliates the leaves and their feeding increases with the subsequent instars and the caterpillars feed voraciously on the entire tender leaves including the veins. In severe attack the caterpillars defoliate the host plants completely thereby retarding the growth of the trees.

Table 1: Yield and yield difference of apple under front line demonstrations and check.

Year	Yield (q/ha)		Percent increase over check	Technology Gap (q/ha)	Extension Gap (q/ha)	Technology Index %
	Demo	Check				
2017	7.5	4.7	37.33	5.9	2.8	44.03
2018	8.9	5.9	33.71	4.5	3	33.58
Mean	8.2	5.3	35.52	5.2	2.9	38.805

The potential yield of apple in Chamba district is found to be 13.4 q/ha (average). The technology gap is the difference between the potential yield and demonstration yield and it was 5.9 q/ha and 4.5 q/ha during 2017 and 2018, respectively (Table 1). The technological gap may be attributed due to the low chilling hours required for breaking dormancy and initiation of opening of the flowers and other environmental factors [19]. Further the extension gap is the difference between demonstration yield and farmers practices (check) and was 2.8 q/ha and 3.0 q/ha during 2017 and 2018, respectively (Table 1). This emphasized the need to educate the farmers through various extension means for the adoption of integrated approach for the management of insects pests associated with apple and to bridge the wide extension gap. The technology index shows the feasibility of the improved technology at the farmer's fields. The lower is the value of technology index; the more is the feasibility of technology demonstrated. The technology index was reduced from 44.03 per cent to 33.58 per cent in 2017 to 2018, respectively, which shows the higher feasibility of the demonstrated technology in the village (Table 1).

3.3 Economic impact

Economic analysis of yield performance revealed that due to lower cost of cultivation, participating farmers in FLDs realized higher price compared to that in the local checks during the period under study. Cost of cultivation was lower in demo due to timely monitoring of the insect pest with pheromone traps and thus adopting integrated insect management practices for the control of gypsy moth, compared to indiscriminate use of insecticides without any recommendation. Net profit was highest in demo plot compared to check plot (Table 2). The reason for this was higher yields and good quality apple fruits compared to check. The benefit cost ratio in demo plot was 3.03:1 and 2.80:1 during 2017 and 2018, respectively. The results were in conformity with the findings of Rakshit *et al.* [20] who reported that by adopting the Cuelure technology benefits over 15 years ranged from 187 million Taka or $2.7 million to 428 million Taka or $6.3 million. The projected rate of return on the BARI investment in pheromone research ranges from to 140 to 165 percent. Similar studies were carried by Bento *et al.* [21]. The data show a benefit-to-cost ratio of US$ 2,655 to US$ 26,548 per dollar spent on research with estimated yield loss prevented in the range of 5-50%, respectively. This study demonstrates that, in addition to the priceless benefits for the environment, sex pheromones are invaluable tools for growers as their use for monitoring populations allows rational and reduced use of insecticides, a win-win situation. Hence, the awareness and adoption of recommended scientific package of practices have increased the socio economic status of farming community.

Table 2: Economics of frontline demonstrations and farmer's practice.

Year	Economics of demonstration (Rs./ha)				Economics of check (Rs./ha)			
	Gross cost	Gross return	Net return	B:C ratio	Gross cost	Gross return	Net return	B:C ratio
2017	9,580.00	78,950.00	59,370.00	3.03	21,450.00	55,380.00	33,930.00	1.58
2018	22,210.00	84,550.00	62,340.00	2.80	23,640.00	58,900.00	35,260.00	1.50
Mean	20,895.00	81,750.00	60,855.00	2.92	22,545.00	57,140.00	34,595.00	1.54

From the present study it could be concluded that front line demonstration was successful in changing the outlook of the farmers towards eco-friendly approaches for pest management. Higher production under front line demonstration over farmer's practices has created better awareness among the farmers and motivated other Farmer's to adopt such practices for the management of insect pest. Technological and extension gaps existed which can be bridged by popularizing package of practices with emphasis on other agronomic practices like use of improved varieties, proper seed rate and spacing, timely irrigation, proper use of plant protection measures, weed management etc. Thus, the farmers can get the higher returns and achieve maximum yields by adopting scientific methods of integrated pest management rather than adopting the un-recommended and untimely sprays of chemical insecticides which are hazardous both to human beings and our environment.

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