FRUITFLY PREDICTION MODEL BY USING MALE ANNIHILATION TECHNIQUE WITH DIFFERENT TYPES OF COST EFFECTIVE TRAPS IN GUAVA ORCHARDS UNDER THREE DISTRICTS OF PUNJAB

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ABSTRACT: Fruit fly, *Bactrocera zonata* and *Bactrocera dorsalis* (Diptera: Tephritidae) is a major pest of fruits especially guava and trade barrier of Pakistani fruits in foreign markets. Mass trapping of this pest by suitable selection of trap is necessary for its management by MAT (Male Annihilation Technique). Experiment was conducted in three different guava producing districts of Punjab i.e. Faisalabad, Sargodha, Toba Tek Singh. Three locations in each district were selected for the experiment with each 3 acres area. Three types of traps were used i.e. RT (Round Trap), JT (Jar Trap) and PBT (Pet Bottle Trap) with 6 traps/acre. Multiple linear regression equations and correlation were computed on the mean population data in all the traps for each year. Results showed that April, May and June (standard weeks 13-23) are peak activity periods of fruitfly in all the districts. Temperature exerted highly significant and positive impact, humidity had non-significant and positive while rainfall was non-significant and negative impact on per unit population fluctuation. PB trap had significant and positive correlation in all three districts during 2016. Maximum impact of temperature was 43.5 and 42.8% at Faisalabad, relative humidity 26.2 and 22.2% at Sargodha, Faisalabad and rainfall 26.3 and 15.1 % at Sargodha computed during 2015 and 2016, respectively. Pet bottle trap gave maximum adult catches at all districts with minimum cost 13.30 $/ha in a year. which is suitable for farmer's community to be used in prediction model.

KEY WORDS: Fruitfly, prediction model, traps, guava, weather conditions, cost

Fruit flies are renowned as one of the most damaging pests in the world feeding and attacking most of the fruits and vegetables due to their very wide host range, high reproductive potential and adaptability to certain climates. Worldwide tephritids fruitflies are most important threat to horticulture industry because most of fruit flies are polyphagous causing direct and indirect losses. Moreover extreme residues of pesticides against this pest are threat to exports (Sarwar, 2013). In fruits it not only attack the guava and mango but becoming a serious pest of guava fruit in Pakistan. Their damaging nature is a big hurdle for the promotion of export of fruits and vegetables by causing direct and indirect losses. *Bactrocera zonata* (S), Oriental fruit fly *Bactrocera dorsalis* (H) are most economically important fruitfly species in fruits (Sarwar, 2014b). In Pakistan, the fruit fly complex may cause losses from 20-90% in different areas of the country. They cause heavy losses to fruits at farm level with approx. 200 million US dollars annually (Stonehouse et al., 2002). In Egypt annual losses of peach fruitfly were estimated 190 million €. Female flies lay their eggs in the fruits and after emergence of maggots, they eat the pulp as result deteriorate the fruit by causing secondary infections with bacterial and fungal diseases with fruit drop (White &

Elson, 1994). Integrated Pest Management (IPM) is the best way for the proper management of fruitfly. MAT (Male Annihilation Technique) with methyl eugenol is a common method of management and a part of IPM (Afzal and Javed, 2001). Methyl eugenol is a plant component that is derived from essential oils of 200 plant species from 32 families. This disturbs male: female ratio. Thus female produce few progenies in the ecosystem (Zaheeruddin, 2007). For this mass trapping different types of traps are used. By using different color and shape traps are important to get high efficacy of fruitfly catches (Vargas et al., 1997). During last decade new powerful attractants has developed to make mass trapping more economical (Epsky et al., 1999). Recently in Spain about 30,000 ha of citrus are being treated with mass trapping (Navarro-Llopis et al., 2008). More studies are needed for trap density optimization, shape of trap, pre harvest placing time and dispensers covering entire growing season because efficacy of dispensers depends upon the climatic conditions. Objective of the study is to develop the prediction model for fruitfly in different districts of Punjab with different climatic condition under MAT technique by using different types of commercial and traditional available least cost pheromone traps having more efficacy and accuracy.

MATERIALS AND METHODS

Experiment was conducted in three different guava producing districts of Punjab i.e. Faisalabad, Sargodha, Toba Tek Singh during 2015-16 at farmer fields. Three orchards in each district were selected for the experiment. Each orchard comprised of 3 acres area. Three types of traps were used i.e. RT (Round Trap), JT (Jar Trap) and PBT (Pet Bottle Trap) in Male Annihilation Technique (MAT). MAT usually involved use of a male lure combined with an insecticide to reduce the male population of fruit flies to such a low level that mating with female flies does not occur. Round trap is commercially available while JT and PBT are handmade traps at home. Each orchard was installed with 18 traps (6 RT, 6 JT, 6 PBT). Each trap was treated with 0.5 ml of Methyl Eugenol (4-allyl-1, 2 dimethoxy benzene-carboxylate) + Spinosad insecticide (3:1) after every 14 days with the help of cotton wicks. Traps were hanged on trees at 1.5-2.0 m height. Data was collected at fortnightly intervals. Adult flies were collected, counted from every trap and identified in the laboratory. Meteorological data of all the districts was collected from Meteorological Department Lahore to compute the prediction model in relation with climatic conditions.

Statistical Analysis. Mean population in all the traps was transformed (SQRT (X+0.5)) to normalized the distribution in the trap evaluation. All means were separated using least significant difference (LSD) test at P 0.05. Multiple linear regression equations (Ryan, 1997) and correlation were computed to check the variability of population catches by each weather parameter. Further to measure goodness of fit, the values of coefficient of determination (R^2) were calculated for developed models (Agostid and Stephens, 1986).

RESULTS AND DISCUSSION

During experiment three types of pheromone traps i.e. Jar trap (JT), Round trap (RT), Pet Bottle trap (PBT) were used. Fruitfly population found throughout the year 2015. It remained at its minimum level during October-March. Population started to build up from the April till September. It remained at its maximum level from standard weeks 13 to 25 with average meteorological factors 31.42^{o}C, 49.94 % RH and 0.69 mm RF in all types of traps with population peak of 88.36, 71.21 and 38.21/trap in PBT, JT and RT, respectively as shown in Fig 1. Almost similar population trend was found during 2016. Population started to build up from the April till September. It remained at its maximum level standard weeks 17 to 29 with average meteorological factors 32.91^{o}C, 52.21 % RH and 2.40 mm RF in all types of traps with population peak of 91.36, 75.21 and 41.20/trap in PBT, JT and RT, respectively as shown in Fig 2 in district Faisalabad. Results of Correlation coefficient values between fruitfly population in different traps and weather factors during year 2015-16 are given in the table 1 which revealed that temperature exerted highly significant and positive correlation with fruitly population in all three types of pheromone traps during both years as well as on the cumulative basis. While relative humidity and rainfall exerted non-significant impact on fruitfly population except PBT had significant and positive correlation with fruitfly population in both years. Multiple linear regression equation for 2015-16 (Table 2) revealed that temperature and humidity have significant impact on the per unit population change of fruitfly in all types of traps. During 2015 impact of temperature was observed to be 43.5, 34.7 and 21.1 % in RT, JT and PBT, respectively in per unit change of pest population. Humidity exerted maximum impact 18.6 % in PBT followed by 17.7, 9.10 % in JT and RT, respectively. Rainfall exerted non-significant impact. During 2016 almost similar impact was found. Impact of temperature was observed to be 42.8, 32.3 and 25.3 % in RT, JT and PBT, respectively in per unit change of pest population. Humidity showed maximum impact 22.2 % in PBT followed by 16.4, 9.7 % in JT and RT, respectively. Rainfall had maximum impact 9.40 % in PBT.

Figure 3 & 4 indicates the adult catches of Fruitfly in different types of pheromone traps in relation with weather factors at fortnight interval during 2015-16 of district Sargodha. During 2015 population remained at its minimum level during October-March. Population started to build up from the March till September. It remained at its maximum level from standard weeks 11 to 27 with average weather factors 29.17^{o}C, 57.08 % RH and 1.35 mm RF in all types of traps with population peaks of 85.11, 65.24 and 45.21/trap in PBT, JT and RT, respectively. During 2016 population remained at its maximum level from standard weeks 11 to 29 with average weather factors 30.33^{o}C, 60.05 % RH and 1.95 mm RF in all types of traps with population peaks of 91.34, 75.89 and 45.19/trap in PBT, JT and RT, respectively as shown in Fig 4. Results of Correlation coefficient values between Fruitfly population in different traps and weather factors during year 2015-16 are given in the table 3 which revealed that temperature exerted highly significant and positive correlation with fruitfly population in all three types of pheromone traps. While relative humidity and rainfall exerted non-significant impact on fruitfly population except PBT had significant and positive correlation with fruitfly population during 2016. Multiple linear regression equation for 2015-16 (Table 4) revealed that temperature, humidity and rainfall had significant impact on the per unit population change of fruitfly in all types of traps during 2015. The impact of temperature was observed to be 17.0, 16.6 and 16.5 % in JT, RT and PBT, respectively in per unit change of pest population. Humidity exerted maximum impact 26.2 and 25.9 % in PBT and RT, respectively followed by 14.3 % JT. Rainfall exerted 26.3, 24.8 % role in population fluctuation of JT, RT and 15.4 % in PBT. During 2016 temperature and rainfall had significant impact on the per unit population change of fruitfly while humidity had non-significant impact of fruitly population. Impact of temperature was 31.8, 30.3 and 29.6 % in JT, PBT and RT, respectively in per unit change of pest population. Humidity showed maximum impact 19.6 impact in RT, respectively. Rainfall exerted 15.1, 14.7 and 9.40 % role in population fluctuation in RT, JT and PBT, respectively.

Figure 5 & 6 indicates the adult catches of Fruitfly in different types of pheromone traps in relation with weather factors at fortnight interval during 2015-16 of district Toba Tek Singh. During 2015 population remained at its minimum level during October-March. Population started to build up from the March till September. It remained at its maximum level from standard weeks 11 to 29 with average weather factors 29.53ºC, 57.87 % RH and 1.07 mm RF in all types of traps with population peaks of 70.28, 62.00 and 52.36/trap in PBT, JT and RT, respectively. During 2016 population remained at its maximum level from standard weeks 11 to 29 with average weather factors 30.30ºC, 60.53 % RH and 1.15 mm RF in all types of traps with population peaks of 81.36, 70.69 and 50.36/trap in PBT, JT and RT, respectively. Results of Correlation coefficient values between fruitfly population in different traps and weather factors during year 2015-16 are given in the table 5 which revealed that temperature exerted highly significant and positive correlation with fruitly population in all three types of pheromone traps except PBT which had positive correlation with RH during 2016. While relative humidity and rainfall exerted non-significant impact on fruitfly population. Multiple linear regression equation for 2015-16 (Table 6) revealed that temperature have significant impact on the per unit population change of fruitfly in all types of traps while relative humidity and rainfall exerted non-significant impact on per unit population fluctuation. During 2015 impact of temperature was observed to be 19.7, 18.2 and 17.8 % in JT, RT and PBT respectively in per unit change of pest population. Humidity exerted maximum impact 7.0 % in RT. Rainfall exerted maximum 7.20 % role in population fluctuation in RT. During 2016 impact of temperature was observed to be 21.8, 21.1 and 7.1 % in RT, JT and PBT, respectively in per unit change of pest population. Humidity showed maximum impact 12.5 % impact in PBT. Rainfall exerted only 1.60 % role in population fluctuation in RT. Table 7 showed that PBT is more effective less cost of 13.30 $/ year as compared to JT and RT having 15.00 $ and 24.78 $ year/ha, respectively. Navarro-Llopis et al., 2008 reported that in Spain the cost of mass trapping including labor, traps and attractants amounts to 250 Euro/ha which is higher than our cost/ha.

Several scientists worked on the population fluctuation of fruitflies by male attractants. Many scientists reported that population peaks on March, April, May and June (Sarada et al., 2001; Latif & Abdullah, 2005; Selvaraj et al., 2006; Boopathi et al., 2012; Boopathi, 2013) which are in agreement with our findings as it may be due to the availability of ample guava fruit in our peaks and ideal temperature for the activity. The lowest no of catches were recorded from December-March showing no significance population which is confirmed by Rashid & Naveed (2017), Draz et al. (2016), Mahmood & Mishkatullah (2007). Draz et al. (2016) showed maximum peaks in the month of August, October, November and December, these findings are not in agreement with our results. Agarwal & Kumar (1999), Abdel Galil et al. (2010) also recorded peaks June, July and September of Bactrocera spp with the ripening season of citrus, mango and guava. Mawatawala et al. (2006) and Ye (2001) also observed similar population trends. During our studies temperature had highly significant and positive correlation with population catches while humidity had positive but non-significant effect. Many scientists i.e. Gajalakshmi et al. (2011), Boopathi (2013), Gupta et al. (1990), Khan et al. (2010), Paw et al. (1991), Banerji et al. (2005), Allwood & Drew (1996), Kumar et al. (2012), Win et al. (2014), Kann & Venugopala (2006), Sarada et al. (2001) reported that temperature had significant and positive while humidity have non-significant correlation with population catches which confirmed our findings. While in case of rain fall most of the scientists reported its negative and non-significant effects which are not in accordance with our studies where in District Sargodha rainfall had its significant and positive correlation while in case of Sargodha and Toba Tek Singh rainfall had mostly non-significant and negative correlation. There was significant difference of population catches among the taps, as PB trap was more effective and captured more population than R and J trap. Herman et al. (2005) and Llopis et al. (2008) also reported that there were significant differences among the traps in the trapping efficacy, attracting and killing flies. Chandaragi et al. (2012) confirmed that bottle trap gave significantly higher population catches as compared to cylindrical, sphere, PCI and open trap.

CONCLUSION

Findings of these studies can be used as prediction model of fruitfly in different districts. Pet Bottle trap is most effective and least cost for prediction because a farmer can easily manufacture it by hand at home. As fruitfly remain active throughout the year but its peak activity starts from April-July in all districts of guava orchards. For its proper management an IPM activity must be initiated from the month of March. During its low activity periods i.e. October-February hibernating place must be destroyed in order to avoid its population breakout during active periods. Overall Male Annihilation Technique is very helpful to reduce the male population of fruitflies in the ecosystem and it will be more effective if it combined with other techniques such as sanitation and protein baits.

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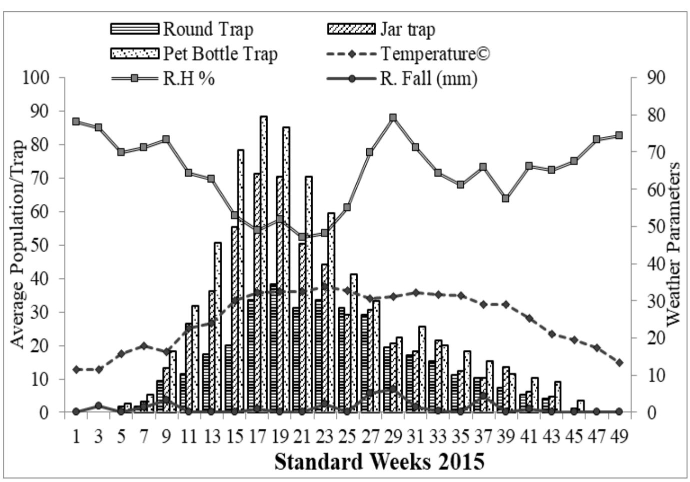

Figure 1. Adult catches of Fruitfly in different types of pheromone traps in relation with weather factors at fortnight interval during 2015 of Faisalabad.

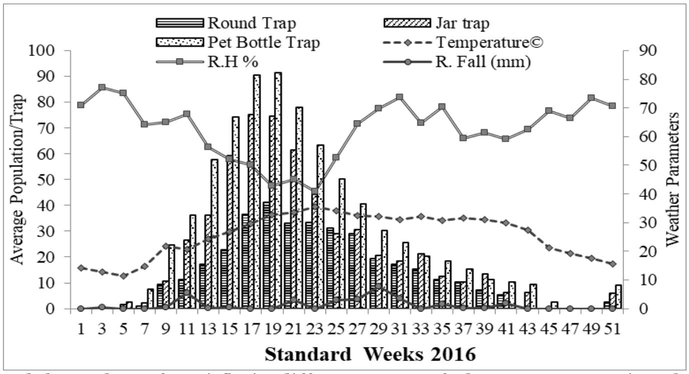

Figure 2. Adult catches of Fruitfly in different types of pheromone traps in relation with weather factors at fortnight interval during 2016 of Faisalabad.

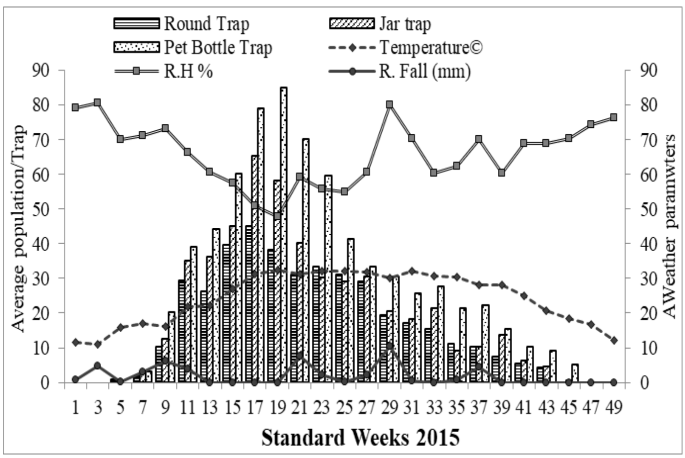

Figure 3. Adult catches of Fruitfly in different types of pheromone traps in relation with weather factors at fortnight interval during 2015 of Sargodha.

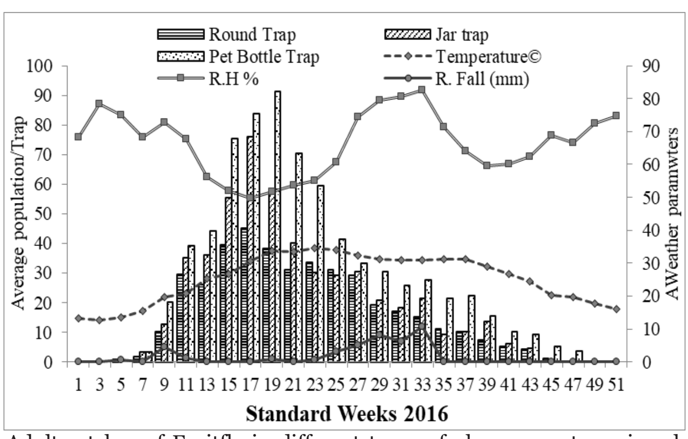

Figure 4. Adult catches of Fruitfly in different types of pheromone traps in relation with weather factors at fortnight interval during 2016 of Sargodha.

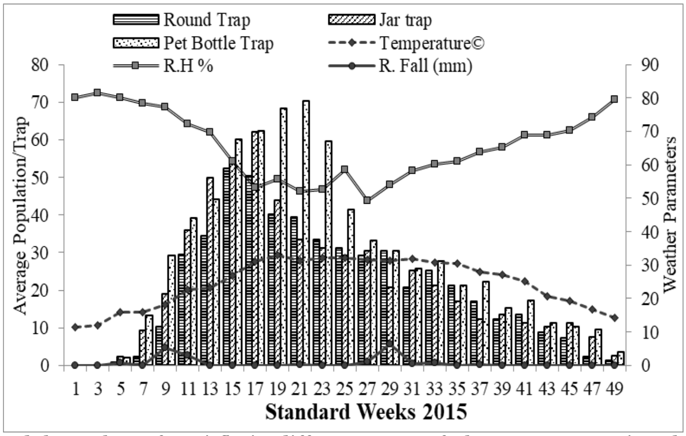

Figure 5. Adult catches of Fruitfly in different types of pheromone traps in relation with weather factors at fortnight interval during 2015 of Toba Tek Singh.

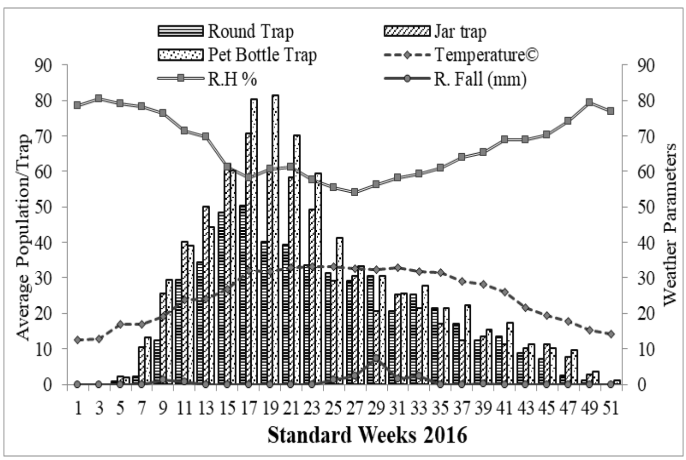

Figure 6. Adult catches of Fruitfly in different types of pheromone traps in relation with weather factors at fortnight interval during 2016 of Toba Tek Singh.

Table 1. Correlation coefficient values between Fruitfly population in different traps and weather factors during year 2015-16 of Faisalabad.

Year	Traps Type	Temperature (°C)	Relative Humidity (%)	Rain Fall (mm)
2015	RT	0.552**±0.554	-0.153±0.700	0.101±1.118
	JT	0.512**±0.773	-0.031±0.906	0.253±1.262
	PBT	0.459*±1.0810	0.067*±1.04	0.269±1.515
2016	RT	0.609**±0.618	-0.112±0.918	0.147±0.123
	JT	0.537**±0.941	-0.025±1.168	0.141±1.352
	PBT	0.513**±1.054	0.073*±1.21	0.117±1.512
Cumulative	RT	0.604**±0.521	-0.133±0.525	0.128±0.708
	JT	0.589**±0.714	-0.073±0.720	0.152±1.152
	PBT	0.496**±0.739	-0.003±0.813	0.165±0.976

Table 2.Multiple linear Regression models and coefficient of determinants between weather factors and adult catches of fruitfly in different traps during 2015-16 of Faisalabad.

Regression Equation	R^2 (%)	Impact	P
2015			
RT			
$Y^{**} = -7.29+2.31X_1^{**}$	43.5	43.5	0.000
$Y^{**} = -21.0+3.22X_1^{**}+1.31X_2^{*}$	52.6	9.10	0.000
$Y^{**} = -26.7+3.75X_1^{**}+1.87X_2^{*}-1.22X_3^{ns}$	54.7	2.10	0.003
JT			
$Y^{**} = -8.01+2.65X_1^{*}$	34.7	34.7	0.003
$Y^{**} = -33.1+4.03X_1^{**}+2.26X_2^{*}$	52.4	17.7	0.001
$Y^{**} = -35.2+4.24X_1^{**}+2.48X_2^{*}-0.41X_3^{ns}$	51.8	1.40	0.002
PBT			
$Y^{*} = -6.40+2.58X_1^{*}$	21.1	21.1	0.031
$Y^{**} = -40.0+4.55X_1^{*}+3.00X_2^{*}$	39.7	18.6	0.002
$Y^{*} = -42.2+4.75X_1^{*}+3.21X_2^{*}-0.43X_3^{ns}$	39.9	0.20	0.015
2016			
RT			
$Y^{**} = -7.46+2.60X_1^{**}$	42.8	42.8	0.000
$Y^{**} = -23.9+3.44X_1^{**}+1.62X_2^{*}$	52.5	9.70	0.000
$Y^{**} = -30.6+4.32X_1^{**}+2.19X_2^{*}-1.52X_3^{ns}$	59.9	7.40	0.001
JT			
$Y^{**} = -10.1+3.3X_1^{*}$	32.3	32.3	0.000
$Y^{**} = -37.7+4.78X_1^{**}+2.66X_2^{*}$	48.7	16.4	0.001
$Y^{**} = -48.0+5.96X_1^{**}+3.45X_2^{*}-2.11X_3^{ns}$	56.8	8.10	0.001
PBT			
$Y^{*} = -8.85+3.01X_1^{*}$	25.3	25.3	0.010
$Y^{**} = -43.7+5.10X_1^{**}+3.42X_2^{*}$	47.5	22.2	0.001
$Y^{**} = -57.7+6.40X_1^{**}+4.45X_2^{*}-2.71X_3^{*}$	56.9	9.40	0.000

Table 3. Correlation coefficient values between Fruitfly population in different traps and weather factors during year 2015-16 of Sargodha.

Year	Traps Type	Temperature (°C)	Relative Humidity (%)	Rain Fall (mm)
2015	RT	0.523**±0.614	0.164±0.710	0.182±1.910
	JT	0.515**±0.593	-0.013±0.806	0.272±0.864
	PBT	0.448**±0.611	0.098±1.101	0.156±1.205
2016	RT	0.414*±0.688	0.341*±0.81	-0.178±1.123
	JT	0.420*±0.761	0.032±0.468	-0.206±1.452
	PBT	0.438*±0.954	0.244*±1.01	-0.204±1.212
Cumulative	RT	0.475**±0.521	0.152±0.495	0.039±0.808
	JT	0.453**±0.414	0.010±0.720	-0.019±0.852
	PBT	0.465**±0.539	0.115±0.620	0.078±1.621

Table 4.Multiple linear Regression models and coefficient of determinants between weather factors and adult catches of fruitfly in different traps during 2015-16 of Sargodha.

	Regression Equation	R^2 (%)	Impact	P
2015				
	RT			
	$Y^* = -3.64+1.86X_1^*$	16.6	16.6	0.051
	$Y^{**} = -39.4+3.76X_1^{**}+3.24X_2^*$	42.5	25.9	0.003
	$Y^{**} = -54.7+5.15X_1^{**}+4.93X_2^{**}-2.23X_3^{**}$	67.3	24.8	0.000
	JT			
	$Y^* = -3.18+1.72X_1^*$	17.0	17.0	0.052
	$Y^* = -24.9+2.98X_1^{**}+2.04X_2^*$	31.3	14.3	0.032
	$Y^{**} = -38.5+3.96X_1^{**}+3.55X_2^{**}-2.04X_3^{**}$	57.6	26.3	0.001
	PBT			
	$Y^* = -3.76+1.97X_1^*$	16.5	16.5	0.028
	$Y^{**} = -41.4+3.94X_1^{**}+3.20X_2^{**}$	42.7	26.2	0.001
	$Y^{**} = -52.3+4.80X_1^{**}+4.53X_2^{**}-2.24X_3^{**}$	58.1	15.4	0.000
2016				
	RT			
	$Y^{**} = -7.10+2.68X_1^{**}$	29.6	29.6	0.003
	$Y^{**} = -32.0+3.68X_1^{**}+2.13X_2^*$	48.0	19.6	0.002
	$Y^{**} = -57.8+6.00X_1^{**}+4.49X_2^{**}-3.14X_3^{**}$	63.1	15.1	0.000
	JT			
	$Y^{**} = -6.21+2.20X_1^*$	31.8	31.8	0.004
	$Y^{**} = -15.5+2.65X_1^{**}+0.969X_2^{ns}$	38.8	07.0	0.055
	$Y^{**} = -37.6+4.31X_1^{**}+2.66X_2^*-2.12X_3^*$	52.1	14.7	0.002
	PBT			
	$Y^{**} = -7.59+2.50X_1^*$	30.1	30.1	0.007
	$Y^{**} = -25.0+3.26X_1^{**}+1.61X_2^{ns}$	42.6	12.5	0.062
	$Y^{**} = -46.2+5.10X_1^{**}+3.48X_2^{**}-2.35X_3^*$	56.9	9.40	0.039

Table 5. Correlation coefficient values between Fruitfly population in different traps and weather factors during year 2015-16 of Toba Tek Singh.

Year	Traps Type	Temperature (°C)	Relative Humidity (%)	Rain Fall (mm)
2015	RT	0.416*±0.594	-0.239±0.620	-0.195±1.610
	JT	0.434*±0.513	-0.261±0.706	-0.130±0.862
	PBT	0.395*±0.981	-0.214±1.040	-0.142±1.085
2016	RT	0.417*±0.528	-0.265±0.718	0.076±1.023
	JT	0.450*±0.921	-0.276±1.168	-0.267±1.452
	PBT	0.434*±1.154	0.30*±0.714	0.253±0.730
Cumulative	RT	0.424**±0.421	-0.253±0.495	-0.065±0.848
	JT	0.410**±0.114	-0.269±0.720	-0.021±0.752
	PBT	0.428**±0.729	-0.241±0.920	-0.004±1.141

Table 6.Multiple linear Regression models and coefficient of determinants between weather factors and adult catches of fruitfly in different traps during 2015-16 of Toba Tek Singh.

	Regression Equation	R^2 (%)	Impact	P
2015				
	RT			
	$Y^* = -3.86+1.74X_1^*$	18.2	18.2	0.044
	$Y^{ns} = -29.6+3.64X_1^* + 1.82X_2^{ns}$	25.2	7.00	0.051
	$Y^{ns} = -35.0+4.28X_1^*+2.33X_2^{ns} -1.93X_3^{ns}$	32.4	7.20	0.069
	JT			
	$Y^* = -4.86+2.11X_1^*$	19.7	19.7	0.026
	$Y^* = -31.1+4.21X_1^*+2.01X_2^{ns}$	26.0	6.30	0.037
	$Y^* = -36.0+4.78X_1^*+2.47X_2^{ns} -1.65X_3^{ns}$	31.5	5.50	0.044
	PBT			
	$Y^* = -3.80+2.03X_1^*$	17.8	17.8	0.037
	$Y^* = -31.0+4.28X_1^*+2.16X_2^*$	24.7	6.90	0.028
	$Y^* = -36.6+4.94X_1^*+2.68X_2^* -1.86X_3^{ns}$	29.5	5.20	0.046
2016				
	RT			
	$Y^* = -4.75+1.8X_1^*$	21.8	21.8	0.006
	$Y^* = -31.0+3.93X_1^*+2.00X_2^{ns}$	30.2	8.40	0.011
	$Y^{ns} = -33.9+4.32X_1^*+2.22X_2^{ns} -0.99X_3^{ns}$	31.8	1.60	0.035
	JT			
	$Y^* = -5.16+2.09X_1^*$	21.1	21.1	0.018
	$Y^* = -31.5+4.17X_1^*+2.01X_2^{ns}$	27.7	6.60	0.024
	$Y^* = -33.9+4.49X_1^*+2.19X_2^{ns} -0.78X_3^{ns}$	28.5	1.10	0.016
	PBT			
	$Y^* = -5.39+2.26X_1^*$	20.6	7.10	0.020
	$Y^* = -35.3+4.62X_1^*+2.28X_2^*$	27.7	12.5	0.024
	$Y^{ns} = -36.3+4.76X_1^*+2.35X_2^{ns} -0.33X_3^{ns}$	27.8	0.10	0.062

Where: X_1=Average Temperature (°C), X_2=Relative Humidity (%), X_3=Rainfall (mm), *=Significant, **= Highly Significant, ns= Non-Significant, R^2= Coefficient of determination, RH=Relative Humidity, RF= Rainfall

Table 7. Cost effectiveness of different traps.

A	B	C	D	E	F	G	H	I	K
RT	0.86	5.21	3.0	6.0	0.065	0.39	4.69	9.91	24.78
JT	0.21	1.30	3.0	6.0	0.065	0.39	4.69	6.00	15.00
PBT	0.10	0.63	3.0	6.0	0.065	0.39	4.69	5.32	13.30

A= Traps, B= Cost/ Trap ($) C= Total cost of traps/ acre ($) (6 traps acre), E= Quantity of ME/6 traps (0.5 ml/trap), F= Total quantity of ME (ml)/month/acre (2 visits), G= Cost of ME/ml ($), H=Cost of ME/ month (E+F) ($), I= Cost of ME/ Year Rs ($), J= Total Cost /Year (C+H) Rs ($), K= Cost/ha ($), 1 USD=115 Rs, ME: Methly Eugenol