Journal of Applied and Natural Science 7 (1) : 358 – 363 (2015)

JANS

Bio-friendly management of Guava fruit fly (*Bactrocera correcta* Bezzi) through wrapping technique

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Received: December 26, 2014; Revised received: April 6, 2015; Accepted: May 7, 2015

Abstract: Fruit fly (*Bactrocera correcta* Bezzi) is the major pest of Guava grown in Baruipur region of West Bengal, contributing upto 90% yield loss. The present study was undertaken during 2011-12 at farmers' field to validate the wrapping of individual fruits at tree and to standardize the wrapping material and the correct technique of wrapping. Performance of nine different types of wrapping materials (butter paper bag, polypropylene bag of 20µ gauge with and without paper piece inside, non-woven poly fabric bags of white, green and blue colour with 20 gsm and 40 gsm thickness) along with two chemical approaches were studied against untreated control. Fruit fly infestation varied between 1.32 % and 17.31% in all treatments using wrapping materials and 13.14% in case of combined use of pheromone trap (Bacu lure) and Dichlorvos spray as compared to 21.71% in sole use of Dichlorvos and 66.67% in control plots. Wrapping resulted in increased weight of individual fruits (112.58 g in butter paper bag compared to 68.40 g in control). Wrapping with transparent polypropylene bags (20µ gauge) with partial paper cover inside, resulted in lowest yield loss (1.66%), earlier fruit maturity, better fruit quality (in respect of colour and glossiness), highest market price (`30 per kg) and highest net profit (`1.357 lakh/ha). This material is durable enough to be reused for 4-5 times. The partial paper cover helped to prevent scorching injury to the fruit as well as to control the humidity inside the polypropylene bag.

Keywords: Fruit fly, Fruit wrapping, Guava, West Bengal

INTRODUCTION

Guava (*Psidium guajava*) is the fifth most important commercial fruit in India, cultivated in 2.05 lakh ha with an estimated annual production of 2.46 million tonnes (NHB, 2011). The fruit, often called 'apple of tropic' is a good source of vitamin C, pectin and minerals like calcium and phosphorus. The roots, bark, leaves and immature fruits, because of their astringency, are commonly administered to control gastroenteritis, diarrhoea and dysentery, throughout the tropics (Anonymous, 2010). Baruipur region of West Bengal is famous for guava cultivation since the pre independence period sharing around 30.15% of total state production (NHB, 2011; Anonymous., 2013).

Among various insect pests, *Bactrocera correcta* (Bezzi), often referred to as "guava fruit fly" (Bezzi, 1915), is the most important one affecting the crop economically in Baruipur. Crop loss varies from a few per cent to 100% depending on fruit fly population, locality, variety and season (Kumar *et al*., 2011). The female fruit fly punctures the fruits by its ovipositor and lays six or more banana shaped eggs into healthy, ripening fruits just beneath the skin. The sting sites appear as discoloured or blackish spots, which may exude distinctive blobs or filaments of gum. As the fruit skin is breached, secondary infection by bacteria induces decaying of fruit tissue. Eggs hatch within two to three days and the maggots feed on the decaying fruit tissue (Kumar *et al*., 2011). If host fruits are profusely available, a single female fly can lay eggs throughout her life, which may last for two or three months. Infested fruits are not generally marketed.

Several research workers (Pradhan, 1976; Gupta and Verma, 1992; Chinajariyawong *et al.,* 2003; Sood and Sharma, 2004; Shooker *et al.,* 2006; Oke, 2008; Singh *et al.,* 2008; Jiji *et al.,* 2009; Waseem *et al*., 2009; Sapkota *et al*., 2010) advocated various management options including use of hydrolyzed protein and sugar spray, pheromone trap, spraying of botanicals and chemical insecticides, field sanitation, poison food trap and bagging of fruits for management of fruit fly. Among these, bagging or wrapping the fruits has been found more practicable in guava (Mitra *et al*., 2008). Bagging is a superior option of fruit fly management over conventional practice of pesticide spray for its' efficacy and zero pesticidal residue in the fruit. Guava fruits bagged with biodegradable poly-films, 6-9 weeks before harvesting, effectively controlled fruit fly (*Anastrepha spp.*) and guava weevil (*Conotrachelus psidii*) (Bilck *et al*., 2011). Bagging not only keeps the female flies away from the fruits but also improves the texture, colour and quality of the fruits (Singh *et al.* 2007; Mitra *et al*., 2008). Martins *et al.* (2007) observed that

wrapping of guava fruit with paper bag one month prior to harvesting reduced black spot (*Guignardia psidii*) and anthracnose (*Colletotrichum* spp.) infestation. Wrapping can be done with a variety of materials like polypropylene, newly developed non-woven poly-fabric or with plain paper. Each material has its own positive or negative effect with respect to fruit-fly control, fruit quality and the cost involvement for it. Hence, finding the right wrapping material is very much important that can minimize fruit fly infestation, improve fruit quality, suit the local climate and obviously make the farming remunerative. Considering these aspects, the present investigation was framed with nine wrapping materials and two chemical options for the management of fruit fly in guava orchard.

MATERIALS AND METHODS

The experiment was conducted in the farmers' plots at Baruipur, South 24 Parganas, West Bengal during April, 2011 to February, 2012, with the following treatments:

T_1: Control (no wrapping and no pesticide application)
T_2: Wrapping* with butter paper bag
T_3: Wrapping with transparent poly-propylene bag (20µ gauge)
T_4: Wrapping with transparent poly-propylene (20µ gauge) bag + paper within the poly-propylene bag as partial cover against sunlight
T_5: Wrapping with non woven poly fabric bag of green colour (40gsm$^{\epsilon}$)
T_6: Wrapping with non woven poly fabric bag of green colour (20gsm)
T_7: Wrapping with non woven poly fabric bag of white colour (40gsm)
T_8: Wrapping with non woven poly fabric bag of white colour (20gsm)
T_9: Wrapping with non woven poly fabric bag of blue colour (40gsm)
T_{10}: Wrapping with non woven poly fabric bag of blue colour (20gsm)
T_{11}: Chemical approach (Dichlorvos spray @ 0.05% over the whole plant at 10 days interval)
T_{12}: Pheromone trap (Bacu lure @ 1 trap per 2 plants) + Dichlorvos spray @ 0.05% at 15 days interval

*Each wrapping bag was of 15cm × 20cm size. Fruits of 2 cm diameter were bagged individually (at 20-25 days after fruit setting). Bags were tied at the fruit peduncle with a jute string. In case of T_3 and T_4, each poly-propylene bag was punctured at the bottom end for easy aeration and drainage of accumulated transpiration water.

$^{\epsilon}$gsm = gram per square meter; unit used to denote the thickness of the poly-fabric.

For implementing the nine wrapping treatments with one untreated control (T_1 to T_{10}), five orchards were used. 5 plants were taken for each treatment. Here five orchards were considered as five replications. To avoid any undesirable effect of the pesticide and pheromones on the behavior of fruit flies in the plots treated with wrapping materials, the two chemical based treatments (T_{11} and T_{12}) were employed separately in separate farmers' plots with similar plant age, plant spacing and crop variety. For this, additional five orchards were taken for each of T_{11} and T_{12}. Thus a total of fifteen numbers of guava orchards were taken for execution of the present experiment.

Each farmer's plot was of 0.065 ha area, with plant spacing of 12ft × 12 ft. Thus there were 50 plants in each plot. All selected orchards had 3 year old plants of Allahabad Safeda cultivar.

The bags were removed only after harvesting of the fruits. Quality parameters (colour and glossiness) of fruit were assessed using 10 point scale following unstructured scale method (Land and Shepherd, 1988). Fruit yield and cost of cultivation along with cost incurred for fruit fly control were worked out on hectare basis. The experiment was carried out following Randomized Block Design (RBD) model and data obtained was analyzed by analysis of variance according to the method as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The first objective of this study was to manage fruit fly infestation in guava fruits. The result as depicted in table 1 clearly shows that all the treatments involving wrapping material as well as chemicals, effectively reduced the fruit fly infestation. Minimum fruit fly infestation was observed in treatments with wrapping up of individual fruits with polypropylene bag (1.43% in T_3 and 1.32% in T_4) as compared to 66.67% in T_1. Next best results (2.32% to 3.71% infestation) were recorded in butter paper (T_2) and poly-fabrics of 40 gsm (T_5, T_7 and T_9). Thinner poly-fabrics of 20 gsm (T_6, T_8 and T_{10}) failed to provide much protection (15.19% to 17.31% infestation). It was probably due to permeability of thin poly-fabric to fruit fly ovipositor. Spraying with Dichlorvos (@ 0.05% over the whole plant at 10 days interval) alone also recorded significantly higher fruit fly infestation (22.71%). However, chemical spray in combination with pheromone trap (T_{12}) proved relatively better (13.14% infestation) as compared to 20 gsm poly-fabric wrapping (T_6, T_8 and T_{10}) and chemical spray alone (T_{11}). Similar result in case of Date Palm was recorded by Kehat *et al*. (1969) where Date bunches were well covered by dense-mesh netting as soon as the fruit begins to ripen, which satisfactorily protected the fruit from raisin moth (*Cadra figulilella* Gregs.). In apple, paper bagging reduced codling moth (*Cydia pomonella*) infestation from 24.5% to only 1.3% (Bentley and Viveros, 1992). Hofman *et al*. (1997) observed reduced incidence of anthracnose (*Colletotrichum)* and stem end rot *(Dothoriella* spp.) diseases in mango by bagging with white paper bag approximately 100 days before harvest.

Table 1. Effect of fruit wrapping and other treatments on fruit fly control, production and quality of guava fruit.

Treatment	Fruit fly incidence (no. of infested fruits in %)	Individual Fruit Weight (g)	Days taken from fruit set to maturity	Colour*	Glossiness*	Longevity of wrapping material (in days)	Market Price (`/ kg)	Yield (t/ha)		
								Total Yield	Market-able Yield	Yield loss %
T_1 (Control)	66.67	68.40	136.58	4	5	-	20	9.18	3.10	66.23
T_2	3.71	112.58	127.21	6	7	92	25	8.76	8.39	4.22
T_3	1.43	99.80	106.34	3	6	360	20	8.35	8.22	1.56
T_4	1.32	104.45	107.83	8	8	360#	30	8.43	8.29	1.66
T_5	2.66	108.27	112.65	8	8	240	30	8.65	8.37	3.24
T_6	17.31	97.76	118.96	7	7	120	25	8.56	6.87	19.74
T_7	3.01	103.58	109.24	6	7	240	25	8.45	8.16	3.43
T_8	16.92	95.65	117.62	5	6	120	25	8.37	6.78	19.00
T_9	2.32	109.36	110.65	8	8	240	30	8.66	8.40	3.00
T_{10}	15.19	101.54	119.63	7	7	120	25	8.58	6.86	20.05
T_{11}	21.71	72.28	137.11	4	5	-	20	9.88	6.81	31.07
T_{12}	13.14	70.90	135.43	4	5	-	20	9.82	7.31	25.56
CD (0.05)	0.89	1.78	2.07	-	-	-	-	0.74	0.46	1.23

* Using 10 point scale; # poly-propylene bags last longer and reused for 4-5 times, but in each case fresh paper is required for inside cover

Table 2. Economics of the treatments.

Treatments	Added input cost involvement for fruit fly control treatment (`/ha)	Added labour cost involvement for fruit fly control treatment (`/ha)	Cost involvement for crop cultivation only (`/ha)	Gross Cost involvement (`/ha)	Market Price (`/kg)	Gross Income (`/ha)	Net Profit (`/ ha)	BC ratio
	A	B	C	D= (A+B+C)		E	E-D	E/D
T1	0	0	52000	52000	20	62000	10000	1.19
T2	49500	34200	52000	135700	25	209750	74050	1.55
T3	13500	30500	52000	96000	20	164400	68400	1.71
T4	22500	38200	52000	112700	30	248400	135700	2.20
T5	36000	32000	52000	120000	30	251100	131100	2.09
T6	27000	32000	52000	111000	25	171750	60750	1.55
T7	33000	32000	52000	117000	25	204000	87000	1.74
T8	27000	32000	52000	111000	25	169500	58500	1.53
T9	36000	32000	52000	120000	30	252000	132000	2.10
T10	27000	32000	52000	111000	25	171500	60500	1.55
T11	3800	4000	52000	59800	20	136200	76400	2.28
T12	4500	3800	52000	60300	20	146200	85900	2.42

Individual fruit weight was highest (112.58 g) in butter paper wrapping (T_2) treatment followed by wrapping with 40 gsm poly-fabric of blue colour (109.36 g in T_9) and 40 gsm poly-fabric of green colour (108.27 g in T_5). The next best treatment was T_4 (poly-propylene bag + paper piece within the poly-propylene bag) which resulted to average fruit weight of 104.45 g. It is clear from the table 2 that all the wrapping treatments resulted to better individual fruit weight than the non-wrapping control (T_1) and chemical spray treatments (T_{11} and T_{12}). It was so because, few amount of fruit thinning became obvious during execution of the wrapping practice. A similar finding of increase in fruit size in apple was observed by Bentley and Viveros (1992) due to fruit bagging and thinning.

Earliness in yield is an important character recorded by 'days taken from fruit set to marketable maturity'. This character has a direct effect on market price of the produce. Early crop fetches higher market price than late harvested crops. In the present experiment, earliest maturity was observed in two polypropylene wrapping treatments (T_3 and T_4) and both were statistically at-par. Earliness in maturity was also achieved by wrapping with poly-fabrics of 40 gsm (T_5, T_7 and T_9) treatments. This finding was also supported by Berrill (1956) that in banana unsealed plastic covers accelerated bunch maturity. In mango, days to ripen became shorter in bagged fruit (Hofman *et al.*, 1997). Mango fruits bagged with commercially available plastic or paper bags 7 weeks before normal harvest resulted in hastened softening and colouring of plastic bagged fruits (Shorter *et al*., 1997). The trapping of solar heat in the poly-wrapping treatments might be the most possible cause for earliness in fruit maturity. Butter paper wrapping (T_2) though recorded highest fruit size (112.58 g) with good appearance, but it failed to bring earliness in maturity (127.21 days). Poor longevity (92 days) of the butter paper is another disadvantage as compared to polypropylene wrappings.

Appearance of the harvested fruit along with its size and shape were the main factors governing the market value of the produce. Best quality fruit with respect to colour and glossiness was obtained from the treatments T_4 (poly-propylene bag + paper piece within the poly-propylene bag), T_5 (green poly-fabrics of 40 gsm) and T_9 (blue poly-fabrics of 40 gsm), which fetched the highest market price (Rs. 30/- per Kg). Partial cover to direct sunlight, protection from dust and other air pollutants as well as penetration of only greenish/ bluish light (in case of T_5, and T_9) were supposed to be the main causes for improvement of fruit appearance in these treatments. Fruits harvested from the non -wrapping treatments (T_1, T_{11} and T_{12}) were poorly priced due to their poor appearance. In T_3, patches of scorched surface as well as partial discolouration appeared on the mature fruit due to the effect of direct sunlight and excess heat generated within the poly-propylene bag. Thus the produce was poorly priced, though this treatment gave best protection against fruit fly and brought earliness in maturity. Kitagawa *et al.* (1992) observed in mango and other tropical fruits that paper bagging of individual fruit was effective not only in controlling diseases and insects but it also enhanced the appearance of the fruits and reduced chemical residue. Bagged apples with light-yellow coloured spun-bound fabric bags resulted in the development of attractive red color over non-bagged apples (Sharma *et al.,* 2013). Pre-harvest bagging of pears improved skin finish, resulting in a fruit with a more attractive colour (Amarante *et al.* 2002a). Bagging reduced the level of blemishes that are mainly caused by fruit friction against leaves and thin twigs during periods of strong winds (Amarante *et al.* 2002b).

Yield is the most crucial factor for any agricultural production system. In the present experiment almost half of the treatments (T_2, T_3, T_4, T_7) were recorded statistically at-par marketable yield irrespective of appearance of the produce and the market price. Yield loss was lowest in T_3 (1.56%) and T_4 (1.66%) followed by T_9, T_5, T_7 and T_2. Yield loss was as high as 66.23% in the control plot (T_1) followed by the two chemical treatments T_{11} (31.07%) and T_{12} (25.56%). In Granny Smith apples as much as 30 to 40% additional yield in grade 1 fruit was apparently achieved with bagging and protecting codling moth infestation (Bentley and Viveros, 1992). In pear, bagging with micro-perforated polypropylene bags increased the percentage of fruit accepted for export from 27.2% to 63.2%, mainly by reducing bird damage and skin blemish (Amarante *et al.* 2002b).

Depending upon quality, size and appearance of the produce, fruits of treatment T_4, T_5 and T_9 fetched highest market price and thereby recorded maximum profit (`1.357 lakh, `1.311 lakh and `1.32 lakh per ha, respectively). Chemical treatment $T_{12}$ though secured highest BC ratio (2.42) due to lower cost involvement in fruit-fly management (`8.3 thousand per ha) but its' profit margin was much lower (`0.859 lakh per ha) than the better performing wrapping treatments. Among the profitable treatments (T_4, T_5 and T_9), T_4 is superior over T_5 and T_9 due to easy availability of the wrapping materials (poly-propylene bag and news paper) in the local market as well as its better longevity.

Conclusion

The present study clearly showed that the treatment T_4 *i.e.*, 'wrapping of individual fruits with transparent poly-propylene (20µ gauge) bag and paper piece within the poly-propylene bag for partial cover to sunlight' was the best option for guava fruit fly management. The next best options were wrapping of fruit with 40 gsm poly-fabric of blue and green colour respectively. All these three treatments not only reduced yield loss due to pest attack, but also improved the fruit appearance, there by market price. For individuals with small sized

plantation, bagging is a very practicable pest management option without use of hazardous pesticides. This technique though takes more time and labour than spraying, but helps growing pesticide free guava that can be fit for export market. In this respect, further study regarding the effect of wrapping on the biochemical properties of harvested fruits is required which were not covered in the present experiment.

ACKNOWLEDGEMENTS

We acknowledge Mr. Anindya Pal of Reliance Industries Ltd. (Polymer Business) for supplying the non-woven poly-fabric bags of different colours and thicknesses (gsm). We also acknowledge the supports rendered by the progressive farmers of Baruipur region, particularly by Sri Panchanan Das, Sri Swapan Das and Sri Sudarsan Mandal.

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