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Efficacy of Different Bait and Attractant Combinations in Attracting Pumpkin Fruit Fly *Zeugodacus (Zeugoodacus) Tau* (Walker) (Diptera: Tephritidae)

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A B S T R A C T

An experiment was conducted to determine the efficacy of different bait and attractant combinations in attracting Pumpkin fruit fly *Zeugodacus (Zeugodacus) tau* from April 2018 to march 2019. Flies were trapped in self-made bottle type traps by using five different combinations T_1 (Cue-lure + Dichlorvos + Ethanol), T_2 (Protein hydrolysate + Cue-lure + Dichlorvos + Ethanol), T_3 (Jaggery + Cue-lure + Dichlorvos + Ethanol), T_4 (Fruit pulp + Cue-lure + Dichlorvos + Ethanol) and T_5 (Molasses + Cue-lure + Dichlorvos + Ethanol). The number of flies trapped was counted at weekly intervals. Maximum flies were annihilated during 20th standard week of 2018 in treatment with protein bait (79.50 flies/ trap/ week) and found it as superior. The rate of male annihilation in treatment with molasses as bait and without bait (Control) did not differed significantly. Mean numbers of flies/ trap annihilated in different treatments were: 400.25 (no bait), 733.25 (protein bait), 503.00 (jaggery as bait), 480.75 (fruit pulp as bait) and 406.25 (molasses as bait), respectively. Efficacy of these treatments in annihilation of male flies with respect to different baits was in the order: protein diet > jaggery ≥ fruit pulp > cue-lure (1ml) ≥ molasses.

Introduction

A dipteran family, tephritidae, includes the flies often called "fruit flies" and nearly 5,000 described species of tephritid fruit flies are categorized in almost 500 genera. Fruit flies are most economically important pest species in the world, attacking a wide range of fruits and fleshy vegetables throughout tropical and subtropical areas. From India 295 species of fruit flies belonging to 90 genera have been described (Agarwal, 2019) and flies belonging to the genera *Bactrocera* Macquart and *Zeugodacus* Hendel (Diptera: Tephritidae: Dacinae: Dacini) are most serious pests causing enormous losses to all kinds of fruits and vegetables. All Dacini members are frugivorous or florivorous and about 10 per cent of the 932 currently recognized species are pests of commercial fruits and vegetables (Doorenweerd *et al.*, 2018).

Among tephritids infesting cucurbits, *Z. cucurbitae*, *Z. diversa*, *Z. tau*, *B. zonata* and *Dacus ciliatus* are the most important and serious pests in India. Pumpkin fruit fly, *Zeugodacus (Zeugodacus) tau* (Walker) (=*Bactrocera (Zeugodacus) tau*) damages a number of host plants species belonging to 23 families, but plants belonging to the family Cucurbitaceae are most preferred. The losses caused in fruit crops by insect pests particularly by *Z. tau* have been estimated to be as high as 40 per cent of the production in Indonesia (Hasyim *et al.*, 2004). The array of control methods include insecticide sprays to foliage and soil, bait-sprays, male annihilation techniques, releases of sterilized flies and parasitoids, and cultural controls (Vargas *et al.*, 2015). Efforts have been made to manage fruit flies by using different insecticides, baits either in trap or as cover spray, male annihilation technique (MAT) using attractant and combined use of bait and attractant (Double Attack Method) (Boller, 1983). Area-wide control either using MAT or BAT is most desirable for effective management of fruit flies. Taking into consideration the present study of evaluation of efficacies of traps containing baits and attractant combinations in annihilation of males was conducted during 2018-2019.

Materials and Methods

Studies pertaining to the efficacy of different bait and attractant combinations in attraction of the Pumpkin fruit fly *Zeugodacus (Zeugoodacus) tau* were conducted in Dr. Rajendra Prasad Central Agriculture University during the year 2018-2019. For annihilation of males, self-made plastic bottle traps (Fig. 1; B) were used (made of 1 liter mineral water bottle). Inside the bottle trap plywood block (Fig. 1; A) was used which was soaked in combination consisting of ethanol + cue-lure + dichlorvos 76% EC (6:4:1 V/V) + bait (5 per cent) for trapping of flies. These traps were hanged below the trees at about 2 m height in places having no direct sunlight. The five different treatments were used in attraction of fruit flies, T_1 (Cue-lure + Dichlorvos + Ethanol), T_2 (Protein hydrolysate + Cue-lure + Dichlorvos + Ethanol), T_3 (Jaggery + Cue-lure + Dichlorvos + Ethanol), T_4 (Fruit pulp + Cue-lure + Dichlorvos + Ethanol) and T_5 (Molasses + Cue-lure + Dichlorvos + Ethanol) (Fig. 1; C). The treatments were replicated four times. Impregnated plywood blocks were replaced at fortnightly interval and the number of flies trapped was counted at weekly intervals.

Results and Discussion

The data pertaining to efficacy of different bait and attractant combination in attraction of males of *Z. tau* is depicted in (Table 1&2, Fig. 2) Males flies were annihilated throughout the experimental period (April, 2018 - March, 2019) except during 1st and 2nd standard weeks of January, 2019 when temperature was very low. Besides, the rate of annihilation was also very low during 51st and 52nd standard weeks of 2018 and 3rd to 5th standard weeks of January, 2019 in all treatments. Maximum flies were annihilated during 20th standard week of 2018 in Treatment T_2 (with protein bait) (79.50 flies/ trap/week) followed by during 25th standard week (56.50 flies/trap/week) in the same treatment. Besides, the rate of annihilation was comparatively higher during 18th - 20th standard weeks of 2018, and again during 44th to 48th standard weeks of 2018. An overall perusal of data indicates that in most cases when more numbers of flies were annihilated, the treatments showed significant differences and treatment T_2 performed best; however, at low population significant difference was not observed with respect to annihilation of adult males of *Z. tau* in different treatments.

The rate of male annihilation in treatment T_5 (with molasses as bait) and T_1 (without bait) did not differed significantly during most standard weeks and it can be predicated that molasses was not effective bait.

The numbers of flies annihilated were high during May and June, 2018 and then a subsequent reduction in rate of annihilation of flies was observed during July to September, 2018. During October and November, 2018 and again an increase in the rate of annihilation was observed and considerably more flies were annihilated; however, the number of flies annihilated during different months did not exhibited a uniform pattern (Table 1).

During December, 2018 and January, 2019 rate of annihilation of flies was very low in all treatments. Maximum number of flies were annihilated in treatment T_2 (213.25 flies/ trap/ month) in May, 2018 followed by June (103.25 flies/ trap/ month). During the months of May and June, 2018 and October and November, 2018 the treatment T_2 was found significantly superior over others. During July – September, 2018 and December, 2018 the difference in treatments was non-significant.

Minimum flies were annihilated during January, 2019 in all treatments without any significant difference. Since these treatments differed in bait constituents only it may be concluded that the bait enhanced the annihilation rate of flies during its peak population and treatment T_2 (with protein bait) was significantly superior over others. However, treatments T_5 (with molasses as bait) and T_1 (without bait) were at par and showed no significant difference.

In all treatments, 10094 males of *Z. tau* were annihilated during the period of experimentation. Mean number of flies/ trap annihilated in T_1-T_5 were: 400.25, 733.25, 503.00, 480.75 and 406.25 (Table 2). Maximum flies were annihilated in T_2 with protein bait and this treatment was significantly superior over others. Treatments T_3 (with jaggery) and T_4 (with fruit pulp) were at par and similarly Treatments T_1 (without bait) and T_5 (with molasses) were also at par. Therefore, it can be predicted that molasses was not effective bait in terms of its efficacy in annihilation of males of *Z. tau* while protein bait was most effective.

Duyck *et al.,* (2004) out of six commercially available protein hydrolysates found that Solbait was most effective against male and females of melon fly. Bharathi *et al.,* (2004) reported that that banana and soybean hydrolysate were 85-95% more attractive to adult *Z. cucurbitae* than fishmeal, beef extract, bread and dog biscuit. Kumar and Agarwal (2005) reported that for trapping males of *Z. cucurbitae* the treatments containing soya powder 2g + cue-lure 1ml + malathion 50 EC 1ml was most effective. Jhala and Sisodiya (2008) reported that integration of MAT with BAT was the most effective strategy on small ground field as it resulted in the reducing melon fly infestation. Thakur and Gupta (2013) found protein hydrolysate as most attractive for *Z. tau* and Z. *cucurbitae* followed by yeast hydrolysate. Ekesi (2016) reviewed the use of protein baits and MAT in fruit fly suppression and suggested that these tactics reduce fruit fly populations by 80-90 per cent. The results of present experiment also suggest that efficacy of attractant increases when it is mixed with bait and protein bait was found most efficacious in annihilation of males of *Z. tau*.

Table.1 Mean number of *Zeugodacus tau* annihilated (male flies/trap/week) in different bait and attractant combinations during 2018-19

Month	Standard week	Treatment*					SEm (±)	C.D. (P=0.05)
		T_1	T_2	T_3	T_4	T_5		
April	14	5.75 (1.74)	17.25 (2.84)	10.00 (2.30)	9.75 (2.27)	6.75 (1.90)	0.725	2.257 (0.81)
	15	5.75 (1.74)	18.00 (2.89)	11.00 (2.39)	10.75 (2.37)	8.75 (2.16)	1.226 ((0.19)	3.818 (1.33)
	16	6.25 (1.83)	16.75 (2.81)	12.75 (2.54)	11.00 (2.39)	8.25 (2.11)	1.213 (0.19)	3.778 (1.32)
	17	7.75 (2.04)	19.00 (2.94)	13.00 (2.56)	12.25 (2.50)	11.00 (2.39)	0.932	2.904 (1.06)
Total		25.50 (3.23)	71.00 (41.26)	46.75 (3.84)	43.75 (3.77)	36.00 (3.58)	2.070 (0.72)	6.449 (1.86)
May	18	12.50 (2.52)	47.75 (3.86)	17.75 (2.87)	13.50 (2.60)	13.25 (2.58)	1.536 (0.42)	4.786 (1.56)
	19	22.75 (3.12)	52.00 (3.95)	27.50 (3.31)	19.00 (2.94)	13.50 (2.60)	1.352 (0.30)	4.214 (1.43)
	20	35.75 (3.57)	79.50 (4.37)	51.50 (3.94)	42.25 (3.74)	26.50 (3.27)	4.282 (1.45)	13.339 (2.59)
	21	19.25 (2.95)	17.50 (2.86)	15.25 (2.72)	10.25 (2.32)	12.00 (2.48)	2.744 (1.00)	NS
	22	19.00 (2.94)	16.50 (2.80)	13.75 (2.62)	24.00 (3.17)	12.25 (2.50)	2.28 (0.82)	7.103 (1.96)
Total		109.25 (4.69)	213.25 (5.36)	125.75 (4.83)	109.00 (4.69)	77.50 (4.35)	6.883 (1.92)	21.445 (3.06)
June	23	20.50 (3.02)	22.00 (3.09)	19.50 (2.97)	13.25 (2.58)	15.00 (2.70)	2.261 (0.85)	NS
	24	10.00 (2.30)	11.50 (2.44)	5.50 (1.70)	16.50 (2.80)	8.00 (2.07)	1.63 (0.48)	5.08 (1.62)
	25	15.25 (2.72)	56.50 (4.03	18.50 (2.91)	37.50 (3.62)	20.00 (2.99)	4.204 (1.43)	13.096 (2.57)
	26	8.75 (2.16)	13.25 (2.58)	14.00 (2.63)	17.25 (2.84)	13.50 (2.60)	1.796 (0.58)	NS
Total		54.50 (3.99)	103.25 (4.63)	57.50 (4.05)	84.50 (4.43)	56.50 (4.03)	6.061 (1.80)	18.900 (2.93)
July	27	7.25 (1.98)	12.25 (2.50)	12.50 (2.52)	18.00 (2.89)	7.00 (1.94)	1.646 (0.49)	5.129 (1.63)
	28	7.50 (2.01)	10.50 (2.35)	10.25 (2.32)	9.50 (2.25)	11.50 (2.44)	1.199 (0.18)	NS
	29	5.00 (1.6)	6.25 (1.83)	4.00 (1.38)	5.00 (1.60)	7.25 (1.98)	1.157 (0.14)	NS
	30	1.50 (0.40)	4.25 (1.44)	3.25 (1.17)	2.00 (0.69)	4.50 (1.50)	1.148 (0.14)	NS
Total		21.25 (3.05)	33.25 (3.50)	30.00 (3.40)	34.50 (3.54)	30.25 (3.40)	4.123 (1.41)	NS
August	31	3.50 (1.25)	2.75 (1.01)	1.50 (0.40)	3.00 (1.09)	3.75 (1.32)	0.766	NS
	32	6.50 (1.87)	6.75 (1.90)	10.75 (2.37)	12.75 (2.54)	5.75 (1.74)	1.43 (0.35)	4.456 (1.49)
	33	8.25 (2.11)	5.25 (1.65)	3.50 (1.25)	3.75 (1.32)	3.75 (1.32)	0.942	2.935 (1.07)

	34	6.25 (1.83)	9.50 (2.25)	6.00 (1.79)	5.50 (1.70)	7.50 (2.01)	1.332 (0.28)	NS
	35	7.50 (2.01)	8.75 (2.16)	9.75 (2.27)	10.00 (2.30)	5.75 (1.74)	1.02 (0.01)	NS
Total		32.00 (3.46)	33.00 (3.49)	31.50 (3.44)	35.00 (3.55)	26.50 (3.27)	3.208 (1.16)	NS
September	36	6.00 (1.79)	9.00 (2.19)	11.75 (2.46)	5.25 (1.65)	5.75 (1.74)	1.073 (0.07)	3.344 (1.20)
	37	6.00 (1.79)	5.25 (1.65)	7.50 (2.01)	8.00 (2.07)	5.00 (1.60)	2.064 (0.72)	NS
	38	6.75 (1.90)	6.25 (1.83)	8.25 (2.11)	8.25 (2.11)	6.75 (1.90)	0.851	NS
	39	5.25 (1.65)	9.00 (2.19)	8.50 (2.14)	5.00 (1.60)	8.75 (2.16)	1.186 (0.170)	NS
Total		24.00 (3.17)	29.50 (3.38)	36.00 (3.58)	26.50 (3.27)	26.25 (3.26)	2.971 (1.08)	NS
October	40	10.00 (2.30)	13.25 (2.58)	10.50 (2.35)	8.75 (2.16)	8.00 (2.07)	0.956	2.9 (1.06)
	41	5.50 (1.70)	9.00 (2.19)	9.25 (2.22)	5.50 (1.70)	5.00 (1.60)	0.985	3.07
	42	6.50 (1.87)	9.50 (2.25)	6.25 (1.83)	4.50 (1.50)	8.25 (2.11)	1.536 (0.43)	4.786 (1.56)
	43	9.25 (2.22)	21.75 (3.07)	14.00 (2.63)	12.00 (2.48)	13.50 (2.60)	1.352 (0.30)	4.214 (1.43)
Total		31.25 (3.44)	53.50 (3.97)	40.00 (3.68)	30.75 (3.42)	34.75 (3.54)	3.038 (1.18)	9.446 (2.24)
November	44	10.25 (2.32)	21.00 (3.04)	17.50 (2.86)	12.50 (2.52)	12.50 (2.52)	4.282 (1.45)	13.339 (2.59)
	45	13.25 (2.58)	11.25 (2.42)	10.50 (2.35)	8.25 (2.11)	10.50 (2.35)	2.744 (1.00)	NS
	46	14.50 (2.67)	20.25 (3.00)	10.50 (2.35)	10.00 (2.30	13.75 (2.62)	2.28 (0.82)	7.103 (1.96)
	47	12.25 (2.50)	16.25 (2.78)	10.75 (2.37)	10.00 (2.30)	13.75 (2.62)	2.261 (0.85)	NS
	48	10.25 (2.32)	12.00 (2.48)	6.25 (1.83)	9.50 (2.25)	11.50 (2.44)	1.63 (0.49)	5.08 (1.62)
Total		60.50 (4.10)	80.75 (4.39)	55.50 (4.01)	50.25 (3.91)	62.00 (44.27)	4.670 (1.054)	14.548 (2.67)
December	49	5.75 (1.74)	8.00 (2.07)	5.00 (1.60)	3.50 (1.25)	5.00 (1.60)	4.204 (1.44)	13.096 (2.57)
	50	1.50 (0.40)	4.75 (1.55)	6.00 (1.79)	4.75 (1.55)	5.50 (1.07)	1.796 (0.58)	NS
	51	1.00 (0.00)	2.00 (0.693)	1.25 (0.223)	1.00 (0.00)	0.75	1.646 (0.50)	5.129 (1.63)
	52	1.00 (0.00)	1.00 (0.00)	1.25 (0.22)	1.25 (0.22)	1.00 (0.00)	1.199 (0.18)	NS
Total		9.25 (2.22)	15.75 (2.75)	13.50 (2.60)	10.50 (2.35)	12.25 (2.50)	2.078 (0.73)	NS
January	1	0.00	0.00	0.00	0.00	0.00	-	-
	2	0.00	0.00	0.00	0.00	0.00	-	-
	3	0.25	1.50 (0.40)	0.25	0.25	0.25	0.359	NS

	4	0.75	0.75	0.50	0.75	0.75	0.423	NS
Total		1.00 (0.00)	2.25	0.75	1.00 (0.0)	1.00 (0.00)	0.454	NS
February	5	0.50	1.50 (0.40)	0.50	0.75	1.00 (0.00)	0.540	NS
	6	1.50 (0.40)	4.50 (1.50)	3.25 (1.17)	3.00 (1.09)	3.75 (1.32)	0.339	1.055 (0.04)
	7	2.00 (0.69)	7.50 (2.01)	4.25 (1.44)	3.25 (1.17)	2.50 (0.91)	0.703	2.189 (0.78)
	8	2.75 (1.01)	13.75 (2.62)	8.75 (2.16)	5.50 (1.70)	3.00 (1.09)	1.048 (0.04)	3.264 (1.18)
Total		6.75 (1.90)	27.25 (3.30)	16.75 (2.81)	12.50 (2.52)	9.75 (2.27)	0.173	3.653 (1.27)
March	9	4.75 (1.55)	12.75 (2.54)	8.25 (2.11)	7.50 (2.01)	6.00 (1.79)	1.154 (0.139)	3.595 (1.28)
	10	4.75 (1.55)	15.50 (2.74)	7.00 (1.94)	8.50 (2.14)	6.75 (1.90)	0.808	2.516 (0.92)
	11	5.25 (1.65)	16.25 (2.78)	9.00 (2.19)	7.50 (2.01)	9.25 (2.22)	0.907	2.826 (1.03)
	12	4.25 (1.44)	13.50 (2.60)	12.00 (2.48)	11.00 (2.39)	7.25 (1.98)	0.872	2.717 (0.99)
	13	5.75 (1.74)	16.25 (2.78)	11.75 (2.46)	9.25 (2.22)	9.00 (2.19)	1.283 (0.24)	3.997 (1.38)
Total		25.00 (3.21)	70.50 (4.25)	49.00 (3.89)	40.25 (3.69)	35.25 (3.56)	1.902 (0.64)	5.926 (1.77)

* Mean of four replications; Figures in parentheses are loge transformed values; NS = Non-significant
T1 Control = [ethanol + cue-lure + dichlorvos (6:4:1 V/V)]
T2 = [(Protein hydrolysate 5%) + ethanol + cue-lure + dichlorvos (6:4:1 V/V)]
T3 = [(Jaggery 5%) + ethanol + cue-lure + dichlorvos (6:4:1 V/V)]
T4 = [(Fruit pulp 5%) + ethanol + cue-lure + dichlorvos (6:4:1 V/V)]
T5 = [(Molasses 5%) + ethanol + cue-lure + dichlorvos (6:4:1 V/V)]

Table.2 Total number of male flies of *Zeugodacus tau* annihilated in different bait and attractant combinations during 2018-19

Treatment	**Number of flies**				**Total**	**Mean (Flies/trap)**
	R_I	R_{II}	R_{III}	R_{IV}		
T_1	454.00	419.00	365.00	363.00	1601.00	400.25 (5.99)
T_2	845.00	742.00	708.00	638.00	2933.00	733.25 (6.59)
T_3	533.00	543.00	484.00	452.00	2012.00	503.00 (6.22)
T_4	558.00	495.00	434.00	436.00	1923.00	480.75 (6.17)
T_5	438.00	403.00	393.00	391.00	1625.00	406.25 (6.00)
Total	**2828.00**	**2602.00**	**2384.00**	**2280.00**	**10094.00**	

Figures in parentheses are $\log_e$ transformed values; C.D.(P=0.05)=44.665(3.79), SEm((±) =14.337(2.66)

Fig.1 A) Plywood block B) Self-made bottle trap
C) Bottle traps with different bait and attractant combinations

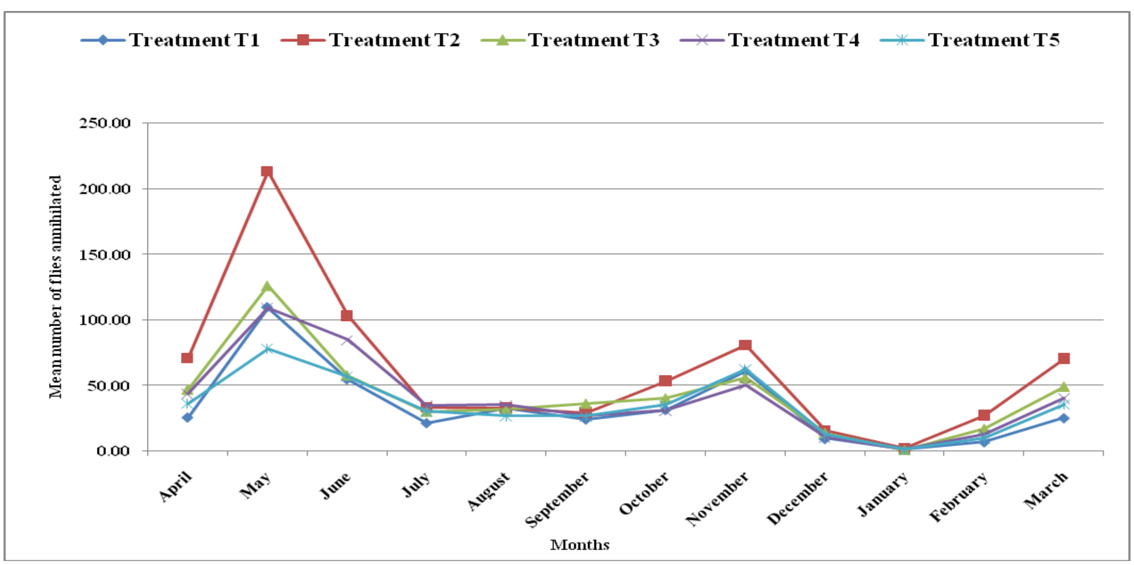

Fig.2 Mean number of *Zeugodacus tau* trapped (males/trap/month) in different bait and attractant combinations during 2018-19

Mean numbers of flies/ trap annihilated in different treatments were: 400.25 (no bait), 733.25 (protein bait), 503.00 (jaggery as bait), 480.75 (fruit pulp as bait) and 406.25 molasses as bait), respectively. Efficacy of these treatments in annihilation of male flies with respect to different baits was in the order: protein diet > jaggery ≥ fruit pulp > cue-lure (1ml) ≥ molasses. Therefore, it can be predicted that molasses was not effective bait in terms of its efficacy in annihilation of males of *Z. tau* while protein bait was most effective.

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