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## Significance of Moisture Percentage and Depth Levels of Pupation Substrate in the Quality Production of *Bactrocera zonata* (Diptera:Tephritidae)

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**Abstract:** The results on mean percent pupal recovery of *Bactrocera zonata* at different depths as influenced by moisture levels indicated that the depth of pupation was significantly affected by moisture percentage in pupation substrate. The 10-15% moisture level of the pupation substrate was useful in holding the pupae. The mean percent adult emergence of *B. zonata* pupated at different depths of sand with variable moisture levels showed that both moisture levels and depths affected the adult emergence of this fruit fly. The adult emergence was synchronous with the pupation at different depths in sand having respective moisture level. The pupal recovery and adult emergence indicated that 10 and 15% moisture levels were the best suited for optimal pupation and adult emergence of *B. zonata*.

**Key words:** Mass rearing, fruit fly, moisture content, *Bactrocera zonata*, pupation substrate

### Introduction

Tephritid fruit flies are among the major pests of fruit production throughout the world and represent the most economically important group of phytophagous diptera (Robinson and Hooper, 1989). Some, 4, 500 species have been described since the mid-1700's (Drew and Romig, 2000). From Pakistan it was reported that fruit fly *D. cucurbitae* normally caused 20 to 75% damage to melon production, whereas, about 80% of guava fruits in markets were infested by *D. dorsalis*. High infestation of guava has resulted in abandoning production of this popular fruit in Southern Pakistan and export of this fruit declined by about 50% in recent years. Besides direct losses, fruit fly infestation is a major trade barrier, resulting in economic losses to the growers (Kafi, 1986). Summer crop is generally damaged by fruit fly which renders the fruit unfit for human consumption. Due to this economic importance, the present study was started as a step towards management strategy of this pest, especially pupation depth will be helpful to take up the cultural operations against this pest.

The production and quality maintenance of adult flies can only be achieved if mature larvae are provided with suitable pupation substrate having adequate moisture level. Generally, low moisture content is recommended for pupation media, but only water has to be added if relative humidity is low. Higher moisture contents affect the pupation depth which may also affect the quality of flies. The larvae of *Dacus oleae* entered frequently in moist sawdust and pupated inside at more depth, whereas in dry or less moist sawdust, most of the larvae pupated on the surface. *D. oleae* had negative correlation with pupation depth in the moist sawdust and wetter the pupation substrate, shallower the depth of pupation (Tsitsipis and Papanicolaou, 1979). According to (Christenson and Richard, 1960) the moisture has little effect on the length of pupal life for *Anastrepha lundens*, but the adults can emerge from the infested fruits when they were buried in the soil up to the depth of 18 inches. It was observed that 10% moisture was optimum for healthier adult flies of *Dacus dorsalis*. They also observed that at 10% moisture level, most of the larvae pupated at 3.6 cm depth in fine vermiculite substrate which did not have any significant effect on adult emergence (Khattak *et al.*, 1984). The effect of moisture and pupation depth on the quality of *Bactrocera zonata* pupae have not been reported by any worker. Therefore, studies were conducted to evaluate the significance of moisture level in pupation substrate and levels of pupation depth on the quality of *B. zonata* in the laboratory.

### Materials and Methods

The present study was conducted at Nuclear Institute of Agriculture, Tandojam, during 1998. The mature larvae were taken from the laboratory culture maintained on wheat shorts diet. Sand was measured with the help of graduated glass cylinder and placed in wooden boxes. Water was added by volume for

moisture treatments (0 (dry), 5, 10, 15, 20 and 25%) and mixed thoroughly. The depth levels starting from 1 to 6 cm were separated from one another by placing 14 mesh nylon netting between the two layers. The mature larvae (500 each) from the laboratory culture were transferred to each set of experiment on the top of sand layers. The trays were covered with another tray and kept at an ambient temperature of  $25 \pm 2^\circ\text{C}$  and  $75 \pm 5\%$  R.H. After six days the pupae were collected from respective levels by sifting or sieving the sand through 16 mesh sieve and the number of pupae per level per moisture treatment was recorded. The pupae per moisture depth levels were kept separately to record the adult emergence. The data obtained were subjected to statistical analysis using ANOVA-II and Duncan's multiple range test (Steel and Torrie, 1984).

### Results and Discussion

The results of mean percent pupal recovery of *B. zonata* at different depths influenced by moisture levels (Table 1) indicated that depth of pupation was significantly affected by the moisture percentage of pupation substrate. The pupation was significantly higher (36.7%) at 1 cm depth in sand having 25% moisture level, followed by 5% moisture level (24.0%) and dry sand (26.4%). At 5% moisture level, maximum larvae (62.4%) pupated at 2 cm depth and (59.7%) at 20 percent moisture level. The pupation at 25 percent moisture level (49.8%) and dry sand (49.2%) was statistically similar at 2 cm depth. Pupation was significantly ( $P \leq 0.05$ ) higher (47.8%) at 3 cm depth of sand having 15% moisture level followed by 10 (41.3%), 20 (26.9%), 0 (11.0%), 25 (9.1%) and 5 (9.0%) percent moisture levels. At 5, 10 and 15% moisture levels of pupation substrate, the larvae penetrated upto 8 cm for pupation, however at 20 and 25% moisture levels the larvae pupated up to 4 cm depth, very few were found beyond 4 cm in dry and 5% moisture level containing sand. The results on pupal recovery at different depths indicated that 10-15% moisture level of the pupation substrate was useful in holding the pupae.

The results on mean percent adult emergence of *B. zonata* pupated at different depths of sand with variable moisture levels (Table 2) showed that both moisture levels and depths affected the adult emergence of this fruit fly. The adult emergence was synchronous with the pupation at different depths in sand having respective moisture levels. The adult emergence was significantly higher at 2 cm depth of sand having 5 (63.9%), 20 (59.9%) and 25 (52.0%) percent moisture levels. However, adult emergence at 3 cm depth was maximum from sand with 10 (42.2%) and 15 (47.4%) percent moisture levels. Considerable number of adults emerged up to 4 cm depth of 10 and 15% moisture levels containing sand and very few adults emerged from the pupae at 5-8 cm depth in 5, 10 and 15% moisture levels. The results on pupal recovery and adult emergence indicated that 10 and 15% moisture levels were the best suited for optimal pupation and adult emergence of *B. zonata* in sand.

## Siddiqui and Ashraf: Moisture and depth levels for pupation of *Bactrocera zonata*

Table 1: Mean percent pupal recovery of *B. zonata* at different depths influenced by moisture levels

Mean pupal recovery (%) at different depth levels (cm)								
Moisture (%)	1	2	3	4	5	6	7	8
0	26.4b	49.2b	11.0d	2.0d	1.6b	0.6b	-	-
5	24.0b	62.4a	9.0d	1.8d	0.9b	1.0ab	0.3b	0.3a
10	2.7d	23.4c	41.3b	21.7b	6.7a	2.4a	0.7b	0.4a
15	2.5d	9.3d	47.8a	28.8a	7.9a	1.8a	1.2a	0.3a
20	11.7c	59.7a	26.9c	1.6d	-	-	-	-
25	36.7a	49.8b	9.1d	4.3c	-	-	-	-

Table 2: Mean percent adult emergence of *B. zonata* pupated at different depths with various moisture levels

Average adult emergence at different depth levels (cm)								
Moisture (%)	1	2	3	4	5	6	7	8
0	18.6c	38.8c	1.8 e	1.8cd	1.6b	0.6b	-	-
5	22.3b	63.9a	9.5 d	1.2d	0.9b	1.0ab	0.4b	0.5a
10	1.8e	23.1d	42.2 b	22.9b	6.7a	2.4a	0.7b	0.4a
15	2.5e	9.4e	47.4 a	29.3a	7.9a	1.8a	1.0a	0.6a
20	11.6d	59.9a	26.9 c	1.5cd	-	-	-	-
25	34.2a	52.0b	9.3 d	4.5c	-	-	-	-

Mean values followed by different letters in respective column show significant variations ( $P \leq 0.05$ )

For the rearing of fruit flies, handling of pupae is very important, so that they may not be damaged by desiccation, over heating or concussion. The present studies indicated that 10 - 15% moisture content in pupation substrate was more suitable to obtain maximum percentage of pupal recovery. As the moisture level increased the pupation at more depth was also increased. However, when the moisture percentage increased more than 15% in the substrate, most of the pupation was taken place at 1 and 2 cm depth because excessive moisture is not suitable for the larvae. Similar results were reported by Al-Zaghal *et al.* (1987) who observed maximum pupae and empty puparia of *Dacus oleae* at the depth of 2.5-7.5 cm in the soil under olive trees in Jordan. The texture of the soil also affected the depth at which pupation occurs. As *Dacus dorsalis* prefers to pupate 2 and 3 cm soil depth (Ibrahim and Mohammad, 1978), whereas maximum pupation of this pest was recorded at 2.4 to 3.6 cm depth in fine vermiculite pupation substrate (Khattak *et al.*, 1984). Similarly Malem and Giliomee (1968) observed maximum pupation of *Dacus ciliatus* in dry sandy soils at the depth of 1 to 2 inches. Moreover, the density of larvae per unit area on the substrate may also affect the pupation depth or influenced by the size of substrate particles. Niaze (1974) recorded the pupation of cherry fruit fly *Rhagoletis* species in the soil at a depth of 1-4 inch. Relatively, smaller numbers were collected from the samples taken at the depth of 6 inches or more, removal of soil from such depths reduced the adults emergence by 99% while removal to a depth of 1 inch had no effect. Laudeho *et al.* (1975) collected 66-100% (average 83.5%) pupae of *D. oleae* by taking the samples down to a depth of 10 cm. The pupation substrate also affect the quality of fruit flies. Vargas *et al.* (1986) observed higher pupal weight adult eclosion and fecundity of Mediterranean fruit fly when larvae were allowed to pupate in boxes of vermiculite than those pupated in without any pupation medium. Vargas *et al.* (1987) have also reported reduced mortality of pupae at 40 to 60% relative humidity. The present studies revealed that significantly good quality of pupae were obtained when 10 to 15% moisture were added in the substrate. These findings are in contrast with those of Mitchell *et al.* (1965). They reported that 3 to 5% moisture content is required in either sand or vermiculite pupation substrate. These variations may be due to the difference in experimental design and nature of the substrate used. Furthermore, pupation could also be affected due to physical structure and moisture contents of the substrate at the time of entry by the mature larvae; these observations are in agreement with Cavalloro and Delrio (1975), who reached to the similar conclusion during their studies on the pupation.

On the basis of the results achieved, it was concluded that for rearing good quality of *Bactrocera zonata*, 10 to 15% moisture should be maintained in pupation substrate. By this the pupation will take place at appropriate depth, which will avoid the desiccation of the pupae and resulting in better quality of adult emergence. Studies presented in the paper are bi-polar; at one hand it leads us that through agricultural operations like ploughing and hoeing up to the depth of about 10 cm will stirred and scrape the soil and pupae of fruit flies will be exposed to the soil surface. In this way a large number of the immature stages could be normally killed by adverse climatic factors or biological conditions. The depth of soil management will depend upon moisture level of soil and at higher moisture, deep tillage practices are required to destroy this pest. On the other hand for artificial rearing, pupation substrate should contain moisture up to 15% at which maximum pupae can be obtained for successful artificial rearing.

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