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Author: Al-Ayedh, H.

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EVALUATION OF DATE PALM CULTIVARS FOR REARING THE RED DATE PALM WEEVIL, *RHYNCHOPHORUS FERRUGINEUS* (COLEOPTERA: CURCULIONIDAE)

H. Al-Ayedh
Natural Resources and Environmental Research Institute. King Abdulaziz City for Science and Technology, P.O. Box 6086, Riyadh 11442, Saudi Arabia

Abstract

Development of red date palm weevil *Rhynchophorus ferrugineus* (Olivier) was evaluated on 4 popular cultivars of date palm, viz., 'Khalas', 'Sukkary', 'Khasab', and 'Sillaj' for 2 consecutive generations. The weevils reared on 'Sukkary' showed significantly better growth expressed in most parameters such as length, width and weight at larval, pupal and adult stages. Significantly greater numbers of eggs were laid on cv. 'Sukkary' as compared to the other 3 cultivars. This might be because of higher sugar content of cv. 'Sukkary'. Adult lifespan was significantly longer on cv. 'Khasab'. Though more cocoons were harvested from 'Khalas', frequency of adult emergence was better on 'Sukkary'. Male to female ratio was similar on all date palm cultivars.

Key Words: red date palm weevil, *Rhynchophorus ferrugineus* (Olivier), host plant food quality, fecundity, adult life span, date palm cultivars, growth assessment.

Resumen

El desarrollo del picudo rojo de la palmera dactilifera *Rhynchophorus ferrugineus* (Olivier) fue estudiado sobre 4 variedades populares de palmera datilifera, viz., 'Khalas', 'Sukkary', 'Khasab'y 'Sillaj' por 2 generaciones consecutivas. Los picudos criados sobre la variedad 'Sukkary' expresa un crecimiento significativamente mejor en la mayoría de los parámetros como el largo, ancho y peso de los estadios de la larva, pupa y adulto. Un numero de huevos significativamente mayor fueron ovipositados sobre la variedad 'Sukkary' en comparición con las otras 3 variedades. Esto posiblemente puede ser por que el contenido mayor de azúcar en la variedad 'Sukkary'. La duración de la vida del adulto fue significativamente mas larga en la variedad 'Khasab'. Aunque mas capullos fueron cosechados sobre la variedad 'Khalas', la frecuencia de la emergencia de adultos fue mayor en la variedad 'Sukkary'. La razón del número de machos a hembras fue similar sobre todas las variedades de palmera datilifera.

The red date palm weevil (*Rhynchophorus ferrugineus* Oliv., Coleoptera: Curculionidae) is the most devastating pest of date palm (*Phoenix dactylifera* L) with a wide geographical distribution. In the Arabian peninsula, it was detected on date palm in the mid 1980s (Gush 1997; Abraham et al. 1998; Murphy & Briscoe 1999). It was reported from Saudi Arabia for the first time in 1986 in Al-Katif Region (Al-Abdulmohsin 1987), from United Arab Emirates in 1986, and from the Republic of Iran in 1992. It spread to North Africa in Egypt in 1993 (Cox 1993). This polyphagous insect is also widely distributed in southern Asia and Melanesia where it feeds on a variety of palms including coconut, sago, date, and oil palm (Murphy & Briscoe 1999; Rajamanickam et al. 1995). Transfer of date palm offshoots as a planting material has played a major role in rapid proliferation of the pest in the Middle East (Abraham et al. 1998). Azam et al. (2000) noted that 88-96% infestation resulted from off-shoot removal and leaving the wounds without treatment.

Damage to date palm is mainly caused by the larval stage feeding within the trunk of palms. This concealed feeding habit of larvae makes it more difficult to detect infestation at an early stage. Often rotting of the internal tissues leads to the death of the date palm tree (Abraham et al. 1998). The weevil completes several generations per year within the same host until the tree collapses (Rajamanickam et al. 1995; Avand Faghih 1996). Yield loss due to infestation can be mild to severe (Gush 1997).

Quality of host plant tissue significantly affects survival and development of larvae, and influences weight, reproductive ability, longevity, and morphology of adult insects (Leather 1990; Albert & Bauce 1994; Dodds et al. 1996; Tammaru 1998). Egg size and quality and selection of oviposition sites also depend on the host plant vigor (Awmack & Leather 2002). On a poor-quality host plant, a female insect may lay either a few good quality eggs only or a large number of poor quality eggs (Rossiter 1991). Yamada & Umeya (1972) concluded that fecundity is determined by pupal size. Williams (1963) observed that the correlation between pupal weight and fecundity was greater than that between pupal length and fecundity in *Chilo sacchariphagus* Bojer. A significant correlation was noted between the fecundity of adults and pupal weight or length of *P. xylostella* (Wan 1970). Murphy & Briscoe (1999) documented variations in developmental and other life history parameters such as number of eggs per female, incubation period, larval and pupal duration, male and female life span in *Rhynchophorus ferrugineus* within and between countries.

Maternal diet effect is considered an important factor for suitability of hosts for optimal insect growth. Maternal effects have been documented in many cases (Mousseau & Dingle 1991; Rossiter 1991; Fox 1994, 1993; Bernardo 1996; Corkum et al. 1997; Mousseau & Fox 1998a, 1998b; McIntyre & Gooding 2000; Agrawal 2001). In many insects, maternal diet influences egg size and offspring quality (Fox 1993; Rossiter et al. 1993; Jann & Ward 1999). Maternal effects have also been shown to affect duration of offspring development and adult size (Roff 1992). A sound fundamental knowledge of the factors associated with dynamics of the pest population is essential for designing efficient and sustainable integrated pest management strategies for controlling red date palm weevil.

The objective of the present study was to evaluate the influence of host tissue genotype on growth and development of red date palm weevil for subsequent utilization in an artificial diet formulation program.

Materials and Methods

Cocoons of red date palm weevils were collected in Oct 2003 from infested date palm orchards of cv. 'Khalas', which is the predominant cultivar in Al-Ahsa region of Saudi Arabia. Mother colonies were established in the laboratory at King Abdulaziz City for Science and Technology, Riyadh. Individual cocoons were incubated on moist tissue paper in covered glass containers (7.0 cm diameter × 8.5 cm height) at 25°C. After adult emergence, individual pairs of males and females were transferred to separate containers of the same dimensions as above for mating. Longitudinally split pieces of sugar cane were introduced in the jars as food for these adults.

Subsequent rearing of the weevil was carried out inside the trunk pieces of 4 popular cultivars of date palm, viz., 'Khalas', 'Sukkary', 'Khashab', and 'Sillaj' to compare suitability of host tissue of different genotypes for colony development. Trunk pieces were obtained from 4- to 5-year-old plants of 1.5 m height by chopping off apical and basal portions. These trunk pieces, measuring average 81 cm in length, were cut longitudinally into 2 halves. On the inner side of each half, a cavity (30 cm long, 12 cm wide and 10 cm deep) was carved, and 5 mated females were introduced into the cavity before joining the 2 halves of each trunk piece. The halves were held together by winding steel wire around the trunk pieces. The pieces were kept in cages at ambient temperature (25°C ± 2) for egg laying. After 5 d the females were withdrawn and the trunk pieces were returned to the respective cages for hatching of the eggs and subsequent growth and pupation of the larvae. After 35 d, pupae form trunk pieces of each cultivar were harvested and incubated separately. Adults originating from the same cultivar were allowed to mate among themselves.

Two generations of weevil were reared consecutively inside the trunk pieces of respective cultivars with the same procedures as above. For egg laying, 10 mated females were introduces into the cavity of each trunk piece and 3 trunk pieces of each cultivar were maintained as replicates. After 48 h, females were withdrawn from the cavities and eggs were allowed to hatch *in-situ*. On hatching, 10 larvae were picked randomly from each trunk piece and length, width, and weight of individuals was recorded as well as length and width of the head capsule in order to follow larval development on host tissue of different cultivars. Data were recorded on the same larva at 4-d intervals until pupation.

After pupation, cocoons were incubated individually in plastic jars lined with moist tissue paper. Ten pupae were randomly picked from each trunk piece of the 4 cultivars, and length, width, and weight of the pupae as well as the adults that emerged from the same were recorded for each cultivar. Frequency of adult emergence and male to female ratio were recorded for populations derived from the different host cultivars.

Egg laying efficiency of females reared on different cultivars was evaluated separately. Three individual pairs of male and female originating from each stem piece of the 4 cultivars were allowed to mate in 500-mL plastic jars. After 3 d, females were transferred to oviposition cages (26 × 16 × 9 cm) and provided with 2 perforated oviposition substrate boxes (50 mm diameter × 20 mm high) filled with shredded sugar cane tissue. The boxes were replaced on alternate days. The eggs were collected by suspending the oviposition substrate in 30% aqueous solution of glycerol in which eggs floated and substrate settled down. The average number of eggs per 3 females in each cultivar was recorded.

The experiment was laid out in a completely randomized block design and 3 replicates were maintained for each treatment. For all parameters, data were recorded for 2 consecutive generations. Analysis of variance was conducted with Fisher's test (SAS 2003). Means were separated by LSD at $t_{5\%}$.

Results and Discussion

Egg Laying Efficiency

Egg laying started 2-3 d after mating. Initially ovipostion rate was low but progressed rapidly and peaked after 2 weeks, remaining stable for about a month. Thereafter, a decline was observed in oviposition but it continued at very low rate till death of the female. Females reared on cv. 'Sukkary' laid significantly greater number of eggs ($F = 2.61$, $df = 3$, $P = 0.0254$) as compared to females from other 3 cultivars (Fig. 1). Egg laying efficiency of red date palm weevil is reported to be variable on different hosts. Hopkins & Ekbom (1999) have reported that oviposition in Coleoptera may continue till death but the fecundity depends on quality of the host plant. Awmack & Leather (2002) also noted that host plant food quality plays a major role in fecundity of herbivorous insects.

Larval Growth

Larvae reared on cv. 'Sukkary' were longer ($F = 9.93$, $df = 3$, $P = 0.0001$) and wider ($F = 14.45$, $df = 3$, $P = 0.0001$) as compared to larvae reared on the other three cultivars (Fig. 2). There was no significant difference ($F = 0.63$, $df = 3$, $P = 0.5944$) in the length of head capsule of larvae reared on the four cultivars, but head capsule width was significantly greater ($F = 2.96$, $df = 3$, $P = 0.0313$) for larvae reared on 'Sukkary'. Larvae reared on 'Sukkary' weighed 2.73 ± 0.08 g and were significantly heavier ($F = 11.36$, $df = 3$, $P = 0.0001$) than those reared on 'Khalas' (2.52 g ± 0.08), 'Khasab' (2.29 g ± 0.08) and 'Sillaj' (2.52 g ± 0.07) cultivars.

Quality of host plant tissue is known to have direct influence on various aspects of larval development (Leather 1990; Albert & Bauce 1994; Dodds et al. 1996; Tammaru 1998). Salama & Abdul-Razek (2002) reported that red date palm weevil can be successfully reared on sugarcane and banana fruits having higher sugar contents. The weevils also have been reared on artificial diets where sugar is a major component (Rahalkar et al. 1978, 1985). I analyzed the stem tissue of the 4 experimental cultivars for moisture, sugar, total protein, and major metal ion contents (data not presented). 'Sukkary' has substantially higher sugar content as compared to the other 3 cultivars, which might be the reason for better larval growth on this cultivar. Survival of some of phytophagous insects has been shown to be linked with availability of diets rich in carbohydrates (House 1974).

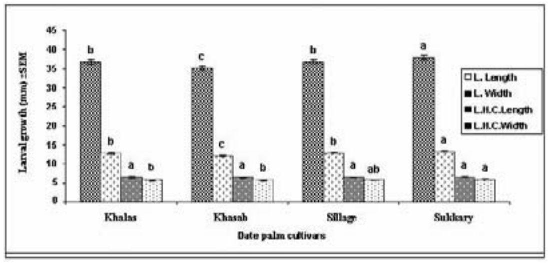

Fig. 2. Size of the larvae of red date palm weevil reared on different cultivars of date palm.

Pupal Growth

Pupal length was significantly greater ($F = 2.45$, $df = 3$, $P = 0.0767$) when reared on cv. 'Sukkary' (31.50 mm ± 0.60) than the pupae derived from cvs. 'Khalas' (31.10 mm ± 0.29), 'Sillaj' (30.29 mm ± 0.62), and 'Khasab' (29.67 mm ± 0.45). There was no significant difference ($F = 0.72$, $df = 3$, $P = 0.5453$) in the width of pupae reared on the 4 cultivars. The average pupal length and width on the different cultivars were 30.53 mm and 11.11 mm, respectively. Viado & Bigornia (1949) recorded average pupal length and width of red date palm weevil reared on coconut to be 33.5 mm and 18.5 mm, respectively. In another study, Nirula (1956) reported average pupal length and width on coconut palm as 35 mm and 15 mm, respectively. The variations in results between the current and previous studies may be due to differences in food quality of the host genotypes. There was no significant difference in pupal weight on different cultivars ($F = 1.97$, $df = 3$, $P = 0.1331$) (Fig. 3). The pupal weight and size play a significant role in insect fecundity (Yamada & Umeya 1972; Williams 1963; Wan 1970).

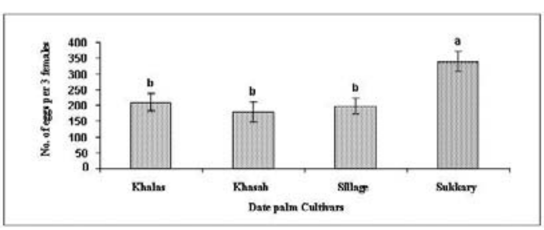

Fig. 1. Egg laying efficiency of red date palm weevil females reared on different cultivars of date palm.

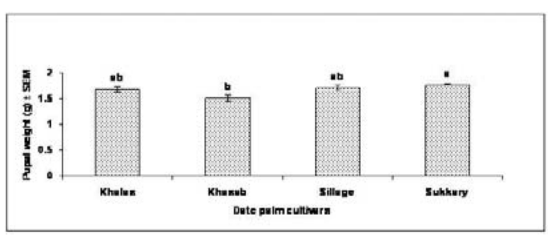

Fig. 3. Weight of the red date palm weevil reared on different cultivars of date palm.

Adult Growth

Male adults reared on cv. 'Sukkary' were significantly longer ($F = 4.26, df = 3, P = 0.0059$) than those reared on the other three cultivars (Fig. 4). Females reared on 'Sukkary' and 'Khasab' were significantly longer ($F = 2.27$, $df = 3$, $P = 0.0806$) as compared to cvs. 'Khalas' and 'Sillaj'. In the current study average length of males and females was 30.76 mm and 32.75 mm, respectively. Viado & Bigornia (1949) recorded average body length as 39 mm for reared males and 41.50 mm for females. In another study, Nirula (1956) reported length and width of red date palm weevil as 35 mm and 12 mm, respectively, on coconut. In the current study, the length and width of male and female were slightly shorter than those reported by (Viado & Bigornia 1949; Nirula 1956). This difference may be due to variation in the rearing environmental conditions and food source, i.e., internal tissue of the cultivars on which the larvae were reared.

Male width was slightly influenced by genotype of the cultivars ($F = 3.79, df = 3, P = 0.0111$). Males reared on 'Sukkary' and 'Sillaj' were similar but significantly wider than the males developed on 'Khalas' and 'Khasab' with no significant difference. The width of the females developed on cvs. 'Sukkary', 'Khasab' and 'Sillaj' was greater than those reared on 'Khalas' ($F = 3.88$, $df = 3$, $P = 0.0098$) (Fig. 4). In the present study average width of males and females reared on 4 different cultivars were 9.87 mm and 10.25 mm, respectively. Viado & Bigornia (1949) recorded average body width as 13.40 mm and 14.60 mm for male and female, respectively, of red date palm weevil reared on coconut.

Significantly greater weight ($F = 2.61$, $df = 3$, $P = 0.0254$) was observed for males developed on 'Sukkary' (0.81 g ± 0.022) as compared to those reared on 'Sillage' (0.75g ± 0.018). There was no difference in the weight gained by male adults on 'Khalas' (0.78 g ± 0.019), 'Khasab' (0.76 g ± 0.019) and 'Sillaj'. No significant difference in weight was observed ($F = 1.29$, $df = 3$, $P = 0.2780$) between female reared on the 4 cultivars. The results showed vigorous weevil growth on cv. 'Sukkary' as compared to those developed on other cultivars of date palm. Several other authors have also reported the effect of host plant food quality on different aspects of adults growth and development (Rodrigues & Moreira 2004; Calvo & Molina 2005; Awmack & Leather 2002).

Adult Lifespan

Life span of males and females depends on the date palm cultivar ($F = 6.55, df = 3, P = 0.0006$) and ($F = 19.37$, $df = 3$, $P = 0.0001$), respectively. Both the sexes fed on cv. 'Khasab' presented greatest average adult life span of 176 and 172 d for males and females, respectively. Males reared on 'Sukkary' showed the shortest life span while females have the shortest life when fed on 'Sillaj' (Fig. 5). The average male and female life span ranged from 4-6 and 3.75-5.75 months, respectively. Our results showed much greater longevity of red date palm weevil as compared to previous findings (El-Muhanna et al. 2000; Avand Faghih 1996; Viado & Bigornia 1949; Frohlich & Rodewald 1970). Host plant quality is considered to have significant impact on longevity of adults (Leather 1990; Albert & Bauce 1994; Dodds et al. 1996; Tammaru 1998).

Yield of cocoons per trunk piece was highest in cv. 'Khalas' followed by 'Sillaj', 'Khasab' and 'Sukkary' (Table 1). Highest frequency of adult emergence was noted in cv. 'Khalas' followed by 'Sukkary', 'Sillaj' and 'Khasab'. Male to female ratio was similar in populations reared on all 4 cultivars.

Murphy & Briscoe (1999) have noted wide variation in developmental and other life cycle parameters of red date palm weevil, within and between countries, which exhibit no clear pattern related to climate. They reported a life cycle of 48-82, 60, 60-165, 45-48, and 57-111 d from India, Indonesia, Myanmar, The Philippines, and Iran, respectively.

Influence of host plant food quality on insect growth and development, has been documented by many authors (Price 1997; Speight et al. 1999; Karowe & Martin 1989; Rossi & Strong 1991; Yang & Joern 1994; Stockhoff 1993; Feeny 1970; Mattson 1980; Olmstead et al. 1997; Harborne 1982, 1988; Rosenthal & Berenbaum 1991; Gange 1995; Lambert et al. 1995; Raupp 1985; Stevenson et al. 1993; Eigenbrode et al. 1995). The present study has shown a significant influence of

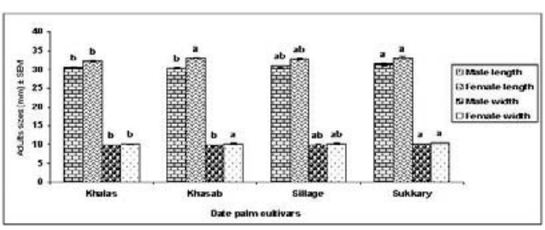

Fig. 4. Size of the adult males and females of red date palm weevil reared on different cultivars of date palm.

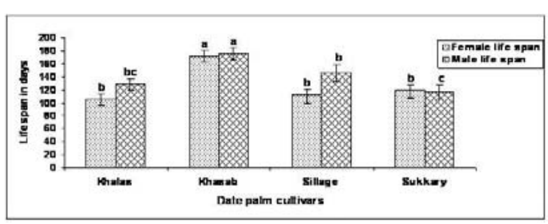

Fig. 5. Average life span of adult red date palm weevil on different cultivars of date palm.

TABLE 1. PUPAL YIELD, ADULT EMERGENCE AND MALE-FEMALE RATIO OF RED PALM WEEVIL ON 4 CULTIVARS OF DATE PALM.

Variety	No. of pupae	Adults emergence %	Male ratio	Female ratio
'Khalas'	92.00	74.10	0.52	0.47
'Sillaj'	73.30	65.30	0.49	0.50
Khasab	66.50	59.06	0.48	0.51
Sukkary	50.16	71.91	0.51	0.48

Adult emergence % = (No. of adults emerged / Total cocoon population)*100.
Male Ratio = Total no. of males / Total adults Population (Male + Female).
Female Ratio = Total no. of females / Total adults Population (Male + Female).

date palm tissue quality not only on food consumption, survival, and development of the larvae as well as weight, size, reproductive ability, and longevity of adults. The results are in agreement with the previous reports (Leather 1990; Albert & Bauce 1994; Dodds et al. 1996; Tammaru 1998). In our experiments, cv. 'Sukkary' proved to be the best overall host for rearing red date palm weevil among the cultivars tested.

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