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FOOD SUITABILITY OF THREE POTATO CULTIVARS IN RELATION TO SURVIVAL AND DEVELOPMENTAL PARAMETERS OF POTATO TUBER MOTH, *PHTHORIMAEA OPERCULELLA (LEPIDOPTERA: GELECHIIDAE)*

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ABSTRACT

Food suitability of three potato cultivars were estimated when mass rearing of *Phthorimaea operculella* under laboratory conditions was considered. These potato cultivars were Diamond, Kara, and Spunta.

Data of the life table parameters on the three tested potato cultivars revealed that the shortest value of total life span (L) was recorded on Diamond cultivar (56 days), while the longest one was on Kara cultivar (64 days). Total life span value on Spunta cultivar was moderate (59 days). The female fecundity (mx) were 3.75, 3.06, and 3.52 eggs/female on Diamond, Kara, and Spunta cultivars, respectively. The corresponding respective values of net reproductive rate (Ro) were 18.815, 19.633, and 8.697 individual/female. The generation duration (Gt) values were 30.24, 34.10, and 33.51 days on Diamond, Kara, and Spunta cultivars, respectively. The corresponding respective values of intrinsic rate of increase (Rm) were 0.270, 0.250, and 0.113 individual/day. The finite rate of increase (λ) values were 1.31, 1.28, and 1.12 individual/female/day on Diamond, Kara and Spunta varieties, respectively. The corresponding respective values of population doubling time (Dt) were 3.22, 3.48, and 7.69 days. The present result reflects that Spunta cultivar seems to be the least preferendum potato cultivar for *Ph. operculella* compared with the other two tested cultivars.

INTRODUCTION

Potato crop is one of the main vegetable cash crop in Egypt. About 197251 feddans were cultivated in Egypt during 2003 potato growing season. Potato cultivated area at El-Behiera Governorate was 32861 feddans yielded around 9.32 tons/feddan and ranking first in Egypt.

A long list of serious insect pests attack potato crop and cause a considerable damage and loss of potato tubers. Larvae of potato tuber moth (PTM), *Ph. operculella*, is the main dangerous stage in potato growing localities. However, the larvae caused a great quantity and quality damage in potato yield crop. These larvae feed on potato leaves from seedling stage up to harvesting stage. In addition, potato tubers are also attacked during the storage period (Westedt *et al.*, 1998).

This insect in general plays an oligophagous role in its agro-ecosystem. PTM attacks a wide range of variable host-plants such as tobacco, egg-plant, and tomato and is widely distributed in both subtropical and temperate regions (Fenemore,1988 and Sporleder *et al.*, 2004).

MATERIALS AND METHODS

Variable bio-aspects were estimated under laboratory conditions of 27° C and 73 % RH. From stock colony of moths, newly deposited eggs (100 eggs/replicate) were gained and placed in furnished plastic cups provided with filter papers until egg hatching. The incubation period and percent of egg hatching were considered for each replicate. Newly hatched larvae were transferred to four plastic jars, each was provided with fresh slices of each tested potato variety. The plastic jars were kept in an incubator under controlled conditions of 27 ºC and 73 % RH. The potato slices were replaced daily by fresh ones until pupation time. Data obtained were included the larval period, larval mortality, percent of pupation, pupal duration and mortality, and sex ratio of newly adult enclosed.

Newly emerged moths were collected, sexed and confined in groups of couples (one male and one female) at newly clean glass jars. These jars were furnished with cylindrical white paper as an

oviposition site, total number of egg laying, percent of hatching, the mean number of eggs/female and egg fertility were estimated.

From data obtained life table parameters were estimated for *Ph. operculella* reared as larvae on each of the three tested potato cultivars (Diamond, Kara, and Spunta). The following parameters viz total life span (L), female fecundity (mx), net reproductive rate (Ro), generation duration (Gt), intrinsic rate of increase (Rm), finite rate of increase **(λ)**, and population doubling time (Dt) were calculated. The life table parameters were calculated according to the mathematical equations proved by Birch (1948), Abou-Setta *et al.,* (1986), and Draz (1991). All biological data were running through a computer program to study the effect of different potato varieties on PTM survival.

RESULTS AND DISCUSSION

Certain bio-studies of *Ph. operculella* on the three tested potato cultivars were calculated under controlled conditions based on life table parameters. These parameters were represented in Tables 1, 2, and 3 for the three tested potato cultivars, Diamond, Kara, and Spunta, respectively.

Data presented in Table (1) demonstrate the life table parameters for *Ph. operculella* fed as larvae on the potato cultivar, Diamond. The experiment starts with 400 eggs incubated for four days, to produce 370 newly hatched larvae. After fourteen days (in an average), 248 larvae completed the larval stage and accordingly pupated. So, percentages of survival were 92.5 and 62.0 % for both egg hatching and larval survival rates, respectively. During the adult stage (Moths), adults of both sexes were confined together to record daily birth rate, fecundity of female and average numbers of male and female adults.

Data in Table (2) show the life table parameters of *Ph. operculella* larvae fed on potato tubers variety, Kara. The percentages of survivors were 81.0 and 51.3 % for egg hatching and larval survival rates. The total period of immature stages (eggs , larvae and pupae) was 29 days. To record the female fecundity and daily rate of survival, a number of 79 females were confined with an equal number of males (in couples). The results revealed that approximately one day was needed for mated females to lay their eggs.

Data in Table (3) show that the incubation period of eggs, larval and pupal periods were 4, 16, 8 days, respectively. The daily rates of survival were 1 , 0.78 and 0.393 for egg , larvae and pupae reared, in respect, on potato tubers variety Spunta. Moths (41 couples) from both sexes (male and female adults) were confined to record the rate of survival and daily egg laying/female. However, the data tabulated in these Tables show that the parameters obtained foe the immature stages of *Ph. operculella* differed from one potato variety to another one.

Data of life table parameters of *Ph. operculella* fed as larvae on tubers of three potato varieties were summarized in Table (4). Present results indicated that the total life span (L) of PTM on the three tested potato varieties differed from one variety to another one. However, the shortest L value was recorded on Diamond variety (56 days), while the longest one was on Kara variety (64 days). Total life span of PTM on Spunta variety was moderate (59 days). The lowest value of female fecundity (mx) was 3.06 eggs / female on Kara variety. Such mx value was moderate (3.52 eggs/female) when Spunta tubers were used as larval food. However, El-Saadany *et al*. (1998) found that the average daily specific rate values/female/day was 4.673 at 27 ^{o}C. The author observed that the fecundity was lowered either by increasing or decreasing temperature around 25 ^{o}C. However, it is concluded from the present results that not only the temperature under which the insect was reared affect fecundity of *Ph. operculella* but also the kind of potato variety under which larvae fed.

The lowest net reproductive rate (Ro) value was recorded on Spunta (8.697 individual/female), while highest value was recorded on Kara (19.633 individual/female). It means that net reproductive rates of PTM were 2.26 and 2.16 folds higher on Kara and Diamond varieties than those of Spunta variety. However, the net reproductive rates were found to be; 43.04 individual/female at 27.5 ^{o}C (Bries, 1980), 69.70 (Chi, 1988), 98.95 and 58.14 individual/female for gross and net, respectively, (Chauhan *et al.*,1993), and 13.47 and 69.34 individual/female for the two successive seasons, 1996 and 1997, respectively (Debnath *et al*., 2000).

Results of generation time on the tested potato varieties showed that the shortest generation duration (Gt) was on Diamond (30. 241 days), while the longest one (34.100 days) was on Kara variety.

Intrinsic rate of increase (Rm) were 0.270, 0.250, and 0.113 individual/female/day on Diamond, Kara, and Spunta varieties, respectively. The calculated values of finite rate of increase (λ) for PTM were different among the three tested varieties. Such values were 1.31, 1.28, and 1.12 individual/female/day on Diamond, Kara and Spunta varieties, respectively. However, the finite rate of increase was found to be ranged from 1.01 to 1.08 individuals/female/day (El-Saadany *et al*., 1998) and 1.16 and 1.18 individuals/female/day for two successive generation (1996 and 1997), respectively (Debnath *et al*., 2000).

Data in Table (4) indicated also that the values of population doubling time (Dt) were low on each of Diamond and Kara varieties. Such values were 3.22 and 3.48 days for both varieties, while the highest value was recorded on Spunta variety (7.69 days). However, the results of El-Saadany *et al*. (1998) indicated that the population doubling time for *Ph. operculella* was 3.65 days under laboratory condition. The present result reflects that Spunta variety was more tolerant to *Ph. operculella* infestation than the other two tested varieties. These results agree with Doss (1984) who found that Spunta variety was the only one resistant to *Ph. operculella* infestation. Abdel-Wahab *et al.*(1987) indicated that the intrinsic rate of increase of *Ph. operculella* was about 0.09 Individuals/day during the summer season. Generally, the intrinsic rate of increase of *Ph. operculella* were found to be; 0.136 indivuals/day (Chi,1988), 0.153 (Chauhan *et al*., 1993), 0.079 (Trivedi *et al*., 1994) and 0.190 (El-Saadany *et al*., 1998). However, the calculated biological parameters viz. Ro, Gt, Rm and Dt indicated that potato variety "Diamond" seems to be quite favorable for achieving the highest developmental and multiplication rates of *Ph. operculella* followed by Kara variety, while the variety Spunta was the least one.

Generally , Spunta variety seems to be the least preferendum potato cultivar for *Ph. operculella* than the other selected cultivars. The insect on Spunta cultivar takes much time (7.69 days) for population doubling time compared with 3.47 and 3.21 days on Kara and Diamond potato cultivars, respectively. However, breeding and screening resistance of potato varieties could present a useful strategy in integrated pest management programmes to limit infestation with *Ph. operculella* in field and in stores (Musmeci *et al*., 2000).

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Table (1): Life table parameters of PTM, *Ph. operculella* larvae fed on potato tubers var. " Diamond " .

Stage X	Age (days) X	No. of observation	Survivorship IX	Fecundity mx	Ix.mx	Ix.mx.X
Egg	4	400	1.000			
Larvae	14	370	0.925			
Pupa	7	248	0.620			
Adult female	26	76	0.1900	0.0000	0.0000	0.0000
	27	76	0.1900	21.3290	4.0525	109.4175
	28	74	0.1850	23.1892	4.2900	120.1200
	29	70	0.1750	12.5000	2.1875	63.4375
	30	68	0.1700	9.4706	1.6100	48.3000
	31	68	0.1700	10.1471	1.7250	53.4750
	32	63	0.1575	9.9683	1.5700	50.2400
	33	58	0.1450	4.8448	0.7025	23.1825
	34	55	0.1375	3.3818	0.4650	15.8100
	35	51	0.1275	2.8823	0.3675	12.8625
	36	49	0.1225	1.2653	0.1550	5.58000
	37	45	0.1125	4.6222	0.5200	19.2400
	38	45	0.1125	3.4667	0.3900	14.8200
	39	43	0.1075	2.1395	0.2300	8.9700
	40	42	0.1050	2.0952	0.2200	8.8000
	41	36	0.0900	1.1111	0.1000	4.1000
	42	36	0.0900	0.6111	0.0550	2.3100
	43	25	0.0625	0.3200	0.0200	0.8600
	44	23	0.0575	1.3043	0.0750	3.3000
	45	19	0.0475	0.6842	0.0325	1.4625
	46	19	1.0475	0.8947	0.0425	1.9550
	47	17	0.0425	0.1176	0.0050	0.2350
	48	14	0.0350	0.0000	0.0000	0.0000
	49	12	0.0300	0.0000	0.0000	0.0000
	50	10	0.0250	0.0000	0.0000	0.0000
	51	6	0.0150	0.0000	0.0000	0.0000
	52	3	0.0075	0.0000	0.0000	0.0000
	53	1	0.0025	0.0000	0.0000	0.0000
	54	1	0.0025	0.0000	0.0000	0.0000
	55	1	0.0025	0.0000	0.0000	0.0000
	56	1	0.0025	0.0000	0.0000	0.0000
Total				116.3452	R0=18.815	568.4775
Mean				3.753		Gt=30.241

Rm = 0.270 , λ = 1.310 , Dt = 3.219

Table (2): Life table parameters of PTM, *Ph. operculella* larvae fed on potato tubers var." Kara " .

Stage X	Age (days) X	No. of observation	Survivorship IX	Fecundity mx	Ix.mx	Ix.mx.X
Egg	4	400	1.000			
Larvae	16	324	0.810			
Pupa	9	205	0.513			
Adult female	30	79	0.1975	0.0000	0.0000	0.0000
	31	79	0.1975	6.7215	1.3275	41.153
	32	79	0.1975	18.8481	3.7225	119.120
	33	78	0.1950	25.9615	5.0625	167.063
	34	74	0.1850	12.6756	2.3450	79.730
	35	70	0.1750	15.7571	2.7575	96.513
	36	68	0.1700	10.4558	1.7775	63.990
	37	66	0.1650	6.4091	1.0575	39.128
	38	66	0.1650	3.7273	0.6150	23.370
	39	65	0.1625	2.5077	0.4075	15.893
	40	61	0.1525	1.0492	0.1600	6.400
	41	57	0.1425	0.8246	0.1175	4.818
	42	56	0.1400	0.6250	0.0875	3.675
	43	56	0.1400	0.6250	0.0875	3.763
	44	55	0.1375	0.3636	0.0500	2.200
	45	52	0.1300	0.1538	0.0200	0.900
	46	51	0.1275	0.0784	0.0100	0.460
	47	43	0.1075	0.2093	0.0225	1.058
	48	42	0.1050	0.0476	0.0050	0.240
	49	40	0.1000	0.0000	0.0000	0.0000
	50	37	0.0925	0.0000	0.0000	0.0000
	51	35	0.0875	0.0000	0.0000	0.0000
	52	33	0.0825	0.0000	0.0000	0.0000
	53	29	0.0725	0.0000	0.0000	0.0000
	54	27	0.0675	0.0000	0.0000	0.0000
	55	24	0.0600	0.0000	0.0000	0.0000
	56	21	0.0525	0.0000	0.0000	0.0000
	57	17	0.0425	0.0000	0.0000	0.0000
	58	10	0.0250	0.0000	0.0000	0.0000
	59	6	0.0150	0.0000	0.0000	0.0000
	60	2	0.0050	0.0000	0.0000	0.0000
	61	2	0.0050	0.0000	0.0000	0.0000
	62	2	0.0050	0.0000	0.0000	0.0000
	63	2	0.0050	0.0000	0.0000	0.0000
	64	1	0.0025	0.0000	0.0000	0.0000
Total				107.0405	R0=19.633	669.470
Mean				3.058		Gt=34.100

Rm = 0.250 , λ = 1.284 , Dt = 3.477

Table (3): Life table parameters of PTM, *Ph. operculella* larvae fed on potato tubers var." Spunta " .

Stage X	Age (days) X	No. of observation	Survivorship IX	Fecundity mx	Ix.mx	Ix.mx.X
Egg	4	400	1.000			
Larvae	16	313	0.783			
Pupa	8	157	0.393			
Adult female	29	41	0.1025	0.0000	0.0000	0.0000
	30	41	0.1025	10.8536	1.1125	33.3750
	31	37	0.0925	15.8378	1.4650	45.4150
	32	33	0.0825	13.4242	1.1075	35.4400
	33	33	0.0825	13.5454	1.1175	36.8775
	34	32	0.0800	15.9062	1.2725	43.2650
	35	31	0.0775	8.32258	0.6450	22.5750
	36	28	0.0700	10.4642	0.7325	26.3700
	37	27	0.0675	5.1111	0.3450	12.7650
	38	25	0.0625	6.6000	0.4125	15.6750
	39	25	0.0625	2.6400	0.1650	6.4350
	40	24	0.0600	1.79166	0.1075	4.3000
	41	20	0.0500	2.8500	0.1425	5.8425
	42	18	0.0450	0.8888	0.0400	1.6800
	43	16	0.0400	0.6250	0.0250	1.0750
	44	15	0.0375	0.2000	0.0075	0.3300
	45	13	0.0325	0.0000	0.0000	0.0000
	46	10	0.0250	0.0000	0.0000	0.0000
	47	8	0.0200	0.0000	0.0000	0.0000
	48	8	0.0200	0.0000	0.0000	0.0000
	49	7	0.0175	0.0000	0.0000	0.0000
	50	5	0.0125	0.0000	0.0000	0.0000
	51	4	0.0100	0.0000	0.0000	0.0000
	52	2	0.0050	0.0000	0.0000	0.0000
	53	2	0.0050	0.0000	0.0000	0.0000
	54	2	0.0050	0.0000	0.0000	0.0000
	55	2	0.0050	0.0000	0.0000	0.0000
	56	2	0.0050	0.0000	0.0000	0.0000
	57	1	0.0025	0.0000	0.0000	0.0000
	58	1	0.0025	0.0000	0.0000	0.0000
	59	1	0.0025	0.0000	0.0000	0.0000
Total				109.061	R0=8.697	291.4200
Mean				3.518		Gt=33.508

Rm = 0.113 , λ = 1.120, Dt = 7.691

Table (4): Life table parameters of PTM, *Ph. operculella* reared as larvae on different potato varieties.

Life table parameter	Potato variety		
	Diamond	**Kara**	**Spunta**
Total life span (L) (day)	**56.000**	**59.00**	**64.000**
Female Fecundity (mx) (egg/female)	**3.753**	**3.058**	**3.518**
Net Reproductive Rate (Ro) (individual /female)	**18.815**	**19.633**	**8.697**
Generation duration (Gt) (day)	**30.241**	**34.100**	**33.508**
Intrinsic rate of increase (Rm) (individual/female/day)	**0.270**	**0.250**	**0.113**
Finite rate of increase (λ) (individual/female/day)	**1.310**	**1.284**	**1.116**
Population doubling time (Dt) (day)	**3.219**	**3.477**	**7.691**

الملخص العربى

تأثير ثلاثة أصناف من البطاطس على معدلات البقاء والنمو لحشرة فراشة درنات البطاطس *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae)

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تم دراسة تأثير تربية حشرة فراشة درنات البطاطس *Ph. operculella* على ثلاثة أصناف بطاطس مختلفة على مقاييس جداول الحياة وذلك تحت الظروف المعملية.

أظهرت قيم مقاييس جداول الحياة على أصناف البطاطس الثلاثة المختبرة أن اقل قيمة لفترة حياة الحشرة (total life span, L) كانت 56 يوما على الصنف دايموند، بينما كانت أعلى قيمة 64 يوما على الصنف كارا، بينما كانت تلك القيمة 59 يوما على الصنف اسبونتا. بلغت قيم خصوبة الأنثى (female fecundity, mx) 3.75 و 3.06 و 3.52 بيضة/أنثى على أصناف البطاطس دايموند، كارا، واسبونتا، على الترتيب. وبلغت قيم معدل التوالد (net reproductive rate , Ro) لنفس الأصناف على الترتيب 18.815 و 19.633 و 8.697 فرد/أنثى. بلغت قيم زمن الجيل (generation duration, Gt) 30.241 و 34.100 و 33.508 يوما على أصناف البطاطس دايموند، كارا، واسبونتا، على الترتيب. وبلغت قيم معدل الزيادة التى تضاعف المجموع (intrinsic rate of increase, Rm) لنفس الأصناف على الترتيب 0.270 و0.250 و0.113 فرد لكل أنثى لكل يوم. وبلغت قيم معدل التزايد النهائى **(**finite rate of increase, λ**)** لنفس الأصناف على الترتيب 1.31 و1.28و1.12 فرد لكل أنثى لكل يوم. وبلغت قيم زمن تضاعف المجموع 3.22 و3.48 و 7.69 يوم على أصناف البطاطس دايموند، كارا، واسبونتا، على الترتيب. وتخلص الدراسة الى أن الصنف اسبونتا كان اقل الأصناف الثلاثة المختبرة تفضيلا بالنسبة لحشرة فراشة درنات البطاطس.