Life Table of the Diamondback Moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) on Five Cultivated Brassicaceous Host Plants

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ABSTRACT

The development, survival, and reproduction of diamondback moth (DBM), Plutella xylostella (L.), were studied in laboratory at 25±1°C, 65±5% RH and a 14L: 10D hours photoperiodism on five host plants of: cauliflower (Brassica oleracea L. var. botrytis), two varieties of cabbage (B. oleracea L. var. capitata) namely 'Globe Master' and 'Scarlet Ohara', kohlrabi (B. oleracea L. var. gongylodes), and canola (B. napus L.). DBM larvae successfully survived on all host plants, although survival rate was lowest on canola (70.56%). The developmental time of immature stages ranged from 13.76±0.15 d on kohlrabi to 15.06±0.22 d on canola. The reproduction period and adult longevity were longest on cauliflower and common cabbage cultivar 'Globe Master' without any supplemental food while the highest fecundity of P. xylostella being also observed on these two host plants. The highest and lowest net reproductive rates were detected on cabbage cultivars, 'Globe Master' and 'Scarlet Ohara', respectively. Mean generation time was the longest on cabbage cultivar 'Globe Master'. The respective descending order of intrinsic rates of population increase was on cauliflower, cabbage cultivar 'Globe Master', kohlrabi, cabbage cultivar 'Scarlet Ohara' and canola. Cauliflower and cabbage cultivar 'Globe Master' were recognized as the most suitable host plants for DBM.

Keywords: Brassica, Crucifers, Demography, Plant resistance.

INTRODUCTION

The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is the most important pest of cultivated brassicas worldwide, sometimes causing more than 90% crop loss (Talekar and Shelton, 1993; Verkerk and Wright, 1996). *P. xylostella* is regarded as an oligophagous insect, with the larvae feeding specifically on members of the family Brassicaceae which contain mustard oils and glucosides (Gupta and Thorsteinson, 1960). This diverse plant group ranges from cultivated crops to numerous wild plants including weed

species. In general, the vegetables, cauliflower *B. oleracea* L. var. *botrytis*, cabbage *B. oleracea* L. var. *capitata* and kohlrabi *B. oleracea* L. var. are commonly available in various crucifer-growing areas in Tehran region. Canola, *Brassica napus* L. is also annually planted in this region. *P. xylostella* also occurs annually throughout the province wherever brassicaceous crops are grown, causing substantial crop losses.

Insect development, survival, reproduction and life table are parameters affected by kind of host plant (Tsai and Wang, 2001; Morgan *et al.*, 2001; Kim and Lee, 2002; Liu *et al.*, 2004; Yaşar and Güngör, 2005; Kumar et al., 2009). Host plant quality traits

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are the key determinants of the fecundity of herbivorous insects affecting such insect reproductive strategies as: egg size and quality, allocation of resources to eggs, the choice of oviposition sites, and egg or embryo resorption. In some herbivore species, host plant quality during larval growth and development is a key determinant of both fecundity and fertility of adults (Awmack and Leather, 2002).

Life table and population studies showed that rainfall, temperature, natural enemies, as well as host plants influenced the survival and reproduction of DBM (Wakisaka *et al.*, 1992; Haseeb *et al.*, 2001). A development of life tables for DBM on different host plants will help to assess the relative contribution made by the various hosts to the local adult population pool, and to answer other relevant questions associated with DBM.

Plant species differ greatly in suitability as hosts for specific insects when assessed in terms of survival, development and reproductive rate. Shorter developmental time along with greater total reproduction of insects on a host indicate greater suitability of a host plant (van Lenteren and Noldus, 1990). Although developmental rate and reproduction provide important clues concerning the ability of a host to support an insect's complete life cycle, these data should be linked to other parameters (such as mortality) before a definitive conclusion can be drawn concerning host suitability (Liu et al., 2004). Some demographic studies of P. xylostella have been done on different host plants (Wakisaka et al., 1992; Salas et al., 1993; Ramachandran et al., 1998; Sarfraz et al., 2007) showing that development and reproduction of DBM can be affected by host plant as well as by the geographic source of the P. xylostella population (Umeya and Yamada, 1973; Sarnthoy et al., 1989; Shirai, 2000). These differences show that caution must be taken when comparing results among different regions.

Despite extensive literature documenting the effects of host plant quality traits on performance of DBM, few publications have reflected directly on its life table and population growth parameters. The main purpose of this study is to determine the impact of some important *Brassica* crops annually cultivated in Tehran region on the performance and life table parameters of DBM. A knowledge of life table parameters of DBM and the resistance-susceptibility characteristics of *Brassica* crops will enable growers to employ the most appropriate control tactics towards integrated crop management (ICM) of a particular *Brassica* crop.

MATERIALS AND METHODS

Rearing Methods and Experimental Conditions

The initial population of DBM was collected from *Brassica* fields of the Horticultural Investigation Center of Tehran University in Karaj, a suburb of Tehran, Iran during October 2005. The stock culture of *P. xylostella* was initiated on different potted host plants and maintained at $25\pm1^{\circ}$ C, $65\pm5\%$ RH and a photoperiodism of 14:10 (L: D) hours in a growth chamber.

Host plants, namely cauliflower, B. oleracea L. var. botrytis (cultivar 'Niagara'); two cultivars of cabbage, B. oleracea L. var. capitata (cultivar 'Globe Master' and 'Scarlet Ohara'), kohlrabi, B. oleracea L. var. gongylodes (cultivar 'Royal Sluis') and canola, Brassica napus L. (cultivar 'PF') were planted in pots in a greenhouse. Host plant seeds were sown in suitable soil and compost mixtures in seedling flats. After five weeks (plants having six to eight leaves) each seedling was transplanted in a 20 cm diameter plastic pot. Ammonium nitrate (3 g 1⁻¹) was applied once a week following transplanting. When host plants bore 10-12 leaves (about six weeks after transplant), they were taken for experimental use.

Experiments began following the rearing of two generations of *P. xylostella* under laboratory conditions on each host plant used in the study. In order to obtain the same aged eggs of DBM, leaves of host plants were put inside an oviposition cage containing 150 pairs of both sexes of the moths reared on the corresponding host plants. After 5-10 hours, the host plant leaf was taken from the cage and the eggs picked up for experiments. The oviposition cage was a clear cubic Plexiglass container $(35 \times 35 \times 35 \text{ cm})$, the top and sides of which were cut off and replaced with fine mesh gauze coverings. One side of the cage was modified so that it could be opened for either insertion or removal of plant leaves, moths as well as feed. One end of a 10 cm long cotton wick the other end of which was soaked into a 10% honey solution in a 100 ml flask was taken out of the flask to be placed in the oviposition chamber for feeding the adults.

Development and Mortality

Experiments were carried out in a growth chamber set at 25±1°C, 65±5% RH and a photoperiodism of 14:10 (L: D) hours. Developmental time of P. xylostella was determined on each host plant. Ten P. xylostella eggs were taken from a surface of the host plant leaf using a small brush and placed on a leaf disk in each of 20 Petri dishes (8.0 cm diameter), for a total of 200 eggs for each host plant. The leaf disk in each Petri dish was inserted in water soaked cotton to be fresh for a time (depending on temperature treatment). Lids of Petri dishes were cut off and replaced with fine mesh gauze for the needed ventilation. The Petri dishes were placed in a growth chamber, the eggs being checked daily, and the number of daily emerged larvae recorded. This regular checking of eggs either was continued until all eggs either hatched or collapsed.

Development of larvae and pupae was observed in the growth chamber at similar conditions provided for eggs. To evaluate the development on host plants, neonate larvae from the previous experiments were placed individually on the leaf disks of host

plants in 8.0 cm diameter Petri dishes. The base of each leaf disk was inserted in water soaked cotton to maintain its freshness. Fifty larvae were monitored on each host plant. All larvae were checked daily for their developmental stages recorded. Fresh foliage was provided every 1-2 days, until pupation stage. Survival rate and developmental time were recorded for all immature stages while the sex of emerged adults being also determined.

Reproduction and Population Growth Parameters

Fifteen pairs of male and female moths (each pair for one replicate) reared on each host plant were taken for the reproduction experiment. Each moth pair was placed in a cage (15×8×5 cm) for subsequent mating and egg laying. The top of the cage was cutoff and replaced with a covering of fine mesh gauze. Host plant leaves were replaced with fresh ones and the fecundity recorded daily. For this purpose, the male and female moths were placed in a new cage with fresh plant foliages, while all deposited eggs being recorded. Daily monitoring continued until death of adults. To obtain the sex ratio on each host plant, 200-250 deposited eggs on each host plant were placed on each corresponding host plant foliage and maintained until adult moth emergence. Such different parameters as pre-oviposition period, oviposition period, post-oviposition period, adult longevity and age-specific fecundity were also determined. The intrinsic rate of increase (r_m), mean generation time (T), finite rate of increase (λ) , doubling time (DT) and net reproduction rate (R_0) were assessed, using Carey's formulae (Carey, 1993).

Statistical Analysis

Statistical analysis was performed using the statistical program SPSS v. 13.0 (SPSS, 2004). Variables were tested for normality using the Kolmogorov-Smirnov test. Effect of host plant on the duration of immature stages, the ovipositon period and adult longevity were analyzed using one-way ANOVA. Means were compared by Tukey multiple range test. Differences in R_0 , T, λ , DT and r_m values were tested through Jackknife procedure (Maia *et al.*, 2000).

RESULTS

Mean incubation period on kohlrabi was found to be the shortest and significantly different from that on cauliflower, canola, cabbage cultivar 'Globe Master' but not on cabbage cultivar 'Scarlet Ohara' (Table 1). No significant difference was observed between the total developmental time of larvae on cabbage cultivar 'Scarlet Ohara' and kohlrabi that had shorter developmental time periods than the other three host plants evaluated (F= 14; df= 4,184; P< 0.05) (Table 1). There was a significant difference observed between the development time of pupae on cabbage cultivar 'Globe Master' and cauliflower that had the shorter developmental time periods than the other three host plants (F= 22; d= 4,184; P< 0.001) (Table 1). The longest total developmental duration was on canola (15.06±0.22 d), and the shortest on kohlrabi (13.76±0.15 d) (F= 8; df= 4,184; P< 0.05) (Table 1).

The lowest and highest survival rates from egg to adult emergence were recorded as 70.56% on canola and 81.42% on cauliflower, the survival rate on canola being considerably lower than that on other

Table 1. Mean developmental time (day±SE) of immature stages of *P. xylostella* on five brassicaceous host plants.

Stage	Host plant						
	Cauliflower	Cabbage cv. 'Globe Master'	Cabbage cv 'Scarlet Ohara'	Kohlrabi	Canola		
Egg	2.86±0.03a	2.87±0.03a	2.74±0.04ab	2.58±0.04b	2.84±0.03a		
Instar I	1.83±0.06b	1.96±0.08ab	1.31±0.07c	1.31±0.07c	2.22±0.09a		
Instar II	2.16±0.06a	2.09±0.05a	1.70±0.08b	1.49±0.08b	1.57±0.09b		
Instar III	1.35±0.08b	1.50±0.08ab	1.60±0.07ab	1.73±0.07a	1.72±0.08a		
Instar IV	2.03±0.03b	2.15±0.06ab	2.12±0.06ab	2.06±0.05ab	2.30±0.07a		
Total larva	7.38±0.144a	7.71±0.15a	6.75±0.11b	6.60±0.11b	7.82±0.20a		
Prepupa	0.51±0.09ab	0.62±0.08a	0.41±0.07ab	0.33±0.07ab	0.30±0.07b		
Pupa	3.35±0.12b	3.31±0.11b	4.22±0.08a	4.24±0.08a	4.10±0.08a		
Total	14.12±0.12bc	14.52±0.18ab	14.13±0.14bc	13.76±0.15c	15.06±0.22a		

Means marked with the same small letter within the same row are not significantly different (P< 0.05; Tukey).

Table 2. Survival rate (%) of various stages and instars of *P. xylostella* on five brassicaceous host plants.

	Host plant					
Stage	Cauliflower	Cabbage cv. 'Globe Master'	Cabbage cv. 'Scarlet Ohara'	Kohlrabi	Canola	
Egg	95	97.14	93.79	92.13	91.25	
Instar I	95.25	92.85	91.66	92	88.67	
Instar II	97.5	100	97.72	97.82	95.74	
Instar III	97.43	94.87	97.67	100	95.55	
Instar IV	100	97.29	100	97.77	97.67	
Total larva	90.48	85.69	87.48	87.98	79.22	
Prepupa	100	97.22	100	100	100	
Pupa	94.73	100	97.61	100	97.61	
Total	81.42	80.95	80.11	81.06	70.56	

hosts (Table 2). This was due to a lower survival at egg as well as at first instar larva stages on canola. The age-specific survival rate (l_x) of *P. xylostella* on five host plants is shown in Figure 1.

There was no significant difference observed among the pre-oviposition periods of females reared on all the five host plants (F= 0.54; df= 4,59; P> 0.05) (Table 3). However, the oviposition periods were of great difference and female adult longevities significantly different on different host plants (F= 81; df= 4, 59; P< 0.001). On cabbage and cauliflower, female moths had a longer ovipositon period than on the other three host plants (F= 74; df= 4, 59; P< 0.01). The post-ovipositon period on cauliflower was significantly higher than that on other plants and this was due to the significant difference between longevity on cauliflower



Figure 1. Age-specific survivorship (l_x) and fecundity (m_x) of *P. xylostella* on five host plants, at 25°C.

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and cabbage. Male adult longevity showed a similar trend with its value being significantly higher than on cabbage and cauliflower than on the others (Table 3).

Fecundity was greatly influenced by host plant (F= 68; df= 4, 59; P< 0.001) (Table 3). On all host plants, a distinct peak of m_x (female offspring per female per day) showed a rapid initial increase in relation to the maximum and there being a more clearly defined peak in the early days of adult emergence (Figure 1). Maximum egg production was observed on cauliflower host plant (49.23 female eggs per female per day).

Population growth parameters of *P. xylostella* were significantly affected by host plants. The intrinsic rate of increase (r_m) value was highest on cauliflower and lowest on canola respectively (Table 4). The net reproduction rate (R_0) value on cauliflower

and cabbage cultivar 'Globe Master' was significantly higher than that on other hosts (F= 73; df= 4, 59; P< 0.001) (Table 4). The maximum and minimum values of R_0 were obtained on cabbage cultivars, 'Globe Master' and 'Scarlet Ohara', respectively (Table 4). Mean generation times (T) were longest on the cabbage cultivar 'Globe Master' (18.23±0.37 d) and shortest on the cabbage cultivar 'Scarlet Ohara' (14.72±0.15 d).

DISCUSSION

Host plant availability and quality may play a role in pest population dynamics by affecting immature as well as adult performance. In the case of DBM, few life table studies as regards its various host plants have been published and only a few studies have examined the effect of host plants on the

Table 3. Oviposition period, adult longevity (days \pm SE) and fecundity (eggs per female) of *P. xylostella* on five brassicaceous host plants.

			Host plant		
Stage	Cauliflower	Cabbage cv. 'Globe Master'	Cabbage cv. 'Scarlet Ohara'	Kohlrabi	Canola
Pre-oviposition period	0.40±0.16a	0.50±0.22a	0.21±0.11a	0.26±0.11a	0.40±0.16a
Oviposition period	19.50±0.93a	17.70±0.89a	4.78±0.58b	6.60±0.53b	6.46±0.80b
Post-oviposition period	5.30±1.08a	1.70±0.65b	2.14±0.36b	2.00±0.19b	1.46±0.32b
Female longevity	25.20±1.76a	19.90±1.20b	7.14±0.45c	8.86±0.55c	8.33±0.64c
Male longevity	23.00±2.83a	19.70±0.92a	6.78±0.29b	6.86±0.46b	6.40±0.77b
Fecundity	408.10±28.83a	440.90±17.30a	106.21±16.18b	124.46±14.28b	158.73±18.64b

Means marked with the same small letter within a same row are not significantly different (P < 0.05; Tukey).

Table 4. Population	growth parameters	of P. xylostella	on five	brassicaceous	host plants.
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	Host plant					
Parameter	Cauliflower	Cabbage cv. 'Globe Master'	Cabbage cv. 'Scarlet Ohara'	Kohlrabi	Canola	
Intrinsic rate of	0.293±0.007a	0.285±0.006ab	0.256±0.009bc	0.261±0.006bc	0.244±0.006c	
increase (r _m)						
Net reproduction rate	159.84±11.29a	183.81±7.21a	43.13±6.54b	51.62±6.00b	58.26±6.84b	
(R ₀)						
Mean generation time	17.28±0.31ab	18.22±0.33a	14.71±0.15c	15.10±0.16c	16.64±0.31b	
(T)						
Finite rate of increase	1.34±0.01a	1.33±0.00ab	1.29±0.01bc	1.30±0.00bc	1.27±0.00c	
(λ)						
Doubling time (DT)	2.35±0.06c	2.42±0.05bc	2.69±0.10ab	2.64±0.06abc	2.83±0.07a	

Means marked with the same small letter within a same row are not significantly different (P < 0.05; Tukey).

developmental stages or on the overall performance of this species.

Host plant has different effects on development and reproduction parameters of P. xylostella (Wakisaka et al., 1992; Salas et al., 1993; Ramachandran et al., 1998; Sarfraz et al., 2007). Life history of DBM can vary considerably depending upon such various factors, as environmental conditions and host plants (Ooi, 1986; Shelton et al., 1991; Muhamad et al., 1994; Syed and Abro, 2003). In the present study, the incubation period on kohlrabi was greatly less than that on the other host plants. This difference was probably a result of different food sources token up by the parents during larval stage. Similar inference has been reported for *Copitarsia* decolora Hampson (Lep., Noctuidae) reared on asparagus and on artificial diet (Gould et al., 2005). The longest and shortest developmental times of individuals from neonate to the end of pupal stage were recorded on canola and kohlrabi (15.06 and 13.76 days), respectively. The survival rate on canola was lowest as compared with that on the other hosts. This difference could be due to the presence of nutritional, phagostimulant factors (such as carbon and nitrogen) as well as defensive metabolites that directly affect potential and achieved herbivore development and fecundity (Awmack and Leather, 2002; Syed and Abro, 2003; Sarfraz et al., 2006). Singh and Singh (1982) studied the influence of various cruciferous host plants on survival and development of P. xylostella. They found that DBM completed its larval and pupal development in the shortest time on cauliflower. In a study conducted by Sved and Abro (2003), the shortest and longest lasting larval periods of DBM were 9.45 and 10.95 days on cauliflower and radish (Raphanus sativa), respectively. They also reported that larval periods on cauliflower, cabbage and rapeseed were 9.45, 9.63 and 10.57 days, respectively, not similar to our findings (Table 1).

Differences between the results of studies could be attributed to differences among nutritional content of host plant cultivars. In addition, variations could be due to differences among geographic populations of *P. xylostella* (Umeya and Yamada, 1973; Sarnthoy *et al.*, 1989, Shirai, 2000). Moreover, plant quality varies considerably depending upon external environmental factors (such as predictable changes between seasons and less predictable changes initiated from environmental stresses) and these could be cited as other reasons for the difference (Awmack and Leather, 2002).

Differences in reproduction period and in longevity of DBM on Brassica host plants in this study indicate that the characteristics of host plants not similar. The longest and shortest female longevities in this study occurred on cauliflower and on the cabbage cultivar 'Scarlet Ohara', respectively. Adult moth showed a prolonged longevity (up to three fold) on these two host plants (cabbage and especially cauliflower) as compared to the other three hosts (Table 3). Adult insects need carbohydrate-rich food as their main source of energy for longevity, fecundity and mobility. This is true for many herbivores including Lepidoptera (Winkler et al., 2005). The sap secreted from the cut leaves of cabbage and cauliflower used up during adult oviposition in oviposition cage could be an additional food source and a basis for longer adult longevity on these host plants as observed in our study.

Total fecundity in the study ranged from 106.21 to 440.90 eggs on cabbage cultivar 'Scarlet Ohara' and 'Globe Master'. respectively (Table 3). Cauliflower and cabbage, in general, appeared to be more appropriate to oviposition than the others. The low number of eggs laid on a plant could have been affected by the more indirect route of reduced fecundity arising from larval feeding on nutritionally poor plants (Verkerk and Wright, 1996; Hamilton et al., 2005). Wakisaka et al. (1992) observed that females fed on Capsella bursa-pastoris L. during the larval stage laid a significantly smaller number of eggs than those reared on broccoli Brassica oleracea variety italica, chinese cabbage Brassica rapa and young cabbage. DBM fecundity figures reported by Syed and

Abro (2003) on cauliflower, cabbage and *B. napus* were 213.3, 190.0 and 82.0 eggs, respectively.

There was a significant difference observed in the intrinsic rates of increase (r_m) with respect to host plants in our study (Table 4). Highest and lowest r_m values were obtained on cauliflower and canola (0.293 and 0.244), respectively. These by contrast were higher than those recorded in Syed and Abro's study (0.239 and 0.160 on cauliflower and canola, respectively). Wakisaka et al. (1992) studied the r_m value of *P. xylostella* on different host plants and found that r_m ranged between 0.2778 and 0.1362 respectively on broccoli and a wild crucifer namely Capsella bursapastoris. Salas et al. (1993) studied life table parameters of P. xylostella on different host plants and found that the highest r_m occurred when the insect fed on cauliflower. The differences between results of various studies could be attributed to cultivar differences as well as to strains of *P. xylostella*. Van Lenteren and Noldus (1990) stated that shorter developmental time and greater total oviposition (fecundity) on a host might be a reflection of the host plant suitability. In our study, mean generation time (T) on cabbage cultivar 'Globe Master' and cauliflower were longer than on cabbage cultivar 'Scarlet Ohara', kohlrabi and canola. The high value of net reproductive rate (R_0) on cabbage cultivar 'Globe Master' and cauliflower is a reflection of high r_m values. Since intrinsic rate of increase (r_m) is a reflective of many factors such as fecundity, survival and generation time and adequately summarizes the physiological qualities of an animal in relation to its capacity to increase, it would be a most appropriate index to evaluate the performance of an insect on different host plants as well as the host plant's resistance (Kocourek et al., 1994; Southwood and Henderson, 2000).

In conclusion, the high r_m value on cauliflower and cabbage indicates that DBM has a greater reproductive potential and there are presumably more suitable hosts than the ones evaluated. Canola had the highest antibiosis resistance against *P. xylostella* and

was the least favorable of the hosts evaluated DBM as indicated by the long for developmental time, low survival of immature stages as reflected in a lower value of r_m. Such antibiosis effects could cause reductions in survival fitness of P. xylostella; for example, prolonged developmental time could increase the exposure of the insect to its natural enemies. A knowledge of how Brassica host plant quality influences the life table parameters of DBM can help one to understand the population dynamics and select for the proper measures in management of this insect.

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Plutella xylostella (L.) (Lepidoptera: Plutellidae) جدول زندگی شب پره پشت الماسی Brassica روی پنج میزبان گیاهی از جنس

ع. گلی زادہ، ک. کمالی، ی. فتحی پور و ح. عباسی پور

چکیدہ

رشدونمو، بقا و تولیدمثل شب پره پشت الماسی یا بید کلم (L.) Plutella xylostella در آزمایشگاه در دمای ۱±۵۵ درجه سلسیوس، رطوبت نسبی ۵±۶۵ درصد و دوره نوری ۱۴ ساعت روشنایی و ۱۰ ساعت تاریکی بر روی پنج گیاه میزبان کلم گل Brassica oleracea L. var. botrytis، دو رقم کلم پیچ (معمولی و قرمز) B. oleracea L. var. gongylodes ، کلم قمری Brassica L. var. gongylodes و کلزا B. و قرمز) anapus L. var. capitata ، کلم قمری B. oleracea L. var. optimus و کلزا ا به napus مورد بررسی قرار گرفت. لاروهای شب پره پشت الماسی با موفقیت بر روی همه گیاهان میزبان زنده ماندند، اگرچه که میزان بقا روی کلزا پایینتر از بقیه بود (۲۰۰/۵۶). طول دوره نابالغی شب پره از افراد بالغ بر روی کلم قمری تا ۱۵/۰۶ روز روی کلزا طول کشید. بیشترین طول دوره تولیدمثل و طول عمر روی همین دو گیاه میزبان به دست آمد. بالاترین و پایین ترین نرخ خالص تولیدمثل (R) بترتیب بر روی دو افراد بالغ بر روی کلم گل و کلم پیچ معمولی Globe Master و کلم یود. میانگین طول نسل (T) روی همین دو گیاه میزبان به دست آمد. بالاترین و پایین ترین نرخ خالص تولیدمثل (R) بترتیب بر روی دو افزاد بالغ بر روی کلم گل و کلم پیچ معمولی Globe Master و میزبان از سیر میزبانها بود. میانگین طول نسل (T) روی همین دو گیاه میزبان به دست آمد. بالاترین و پایین ترین نرخ خالص تولیدمثل (R) بترتیب بر روی دو مرقوی همین دو گیاه میزبان به دست آمد. بالاترین و پایین ترین نرخ خالص تولیدمثل (R) بترتیب بر روی دو رقم کلم پیچ معمولی 'Globe Master' و کلم پیچ معمولی Scarlet O fhara' بود. میانگین طول نسل (T) شب پره روی کلم پیچ معمولی 'Globe Master' و کلم پیچ معمولی معمولی مود. ترتیب کاه شی نرخ ذاتی موزایش جمعیت (m) به ترتیب بر روی کلم گل، کلم پیچ معمولی Globe Master ، کلم ییچ فرمز 'Scarlet O fhara' و کلم گل و کلم پیچ معمولی و کلم پیچ معمولی مولی مود ی میزبانها بود. ترتیب کاه شی کلم پیچ

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