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Suitability of Cultivated and Wild Crucifers for the Development of Diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae)

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Abstract: The performance of the Diamondback moth, *Plutella xylostella* L., on Ethiopian cultivated and wild crucifers was studied in the laboratory for two generations. Head cabbage, *Brassica oleracea* var. *capitata* L., was the most suitable host with the shortest developmental period and the highest reproductive potential. Both developmental period and life table statistics showed that the weed *Erucastrum arabicum* Fisch. and Mey was more suitable than some of the cultivated species.

Key words: Diamondback moth, crucifers, Ethiopia, developmental period, life table parameters

Introduction

Diamondback Moth (DBM), *P lutella xylostella* L., feeds on cultivated and wild plants belonging to the family Cruciferae. *Brassica* species in 27 different genera of this family are recorded from different parts of the world as hosts that sustain feeding and reproduction of DBM (Talekar and Shelton, 1993).

The association of DBM to *Crucifer* species is due to the presence of one or more glucosinolates, singrin, sinalbin and glucocheirolin, which act as specific feeding stimulant (Talekar and Shelton, 1993). Gupta and Thorsteinson (1960) suggested that occurrence of feeding inhibitors as well as the absence of essential feeding stimulants exclude some botanical species in crucifers from the food plant range. The existence of effective feeding stimulants other than mustard oil, glucosides and absence of feeding inhibitors, have put some species of Leguminosae in the food range of the pest. For example, field pea, *Pisum sativum* L. was shown to be sufficiently palatable, nutritious and free of toxicants to support successive generations of *Plutella xylostella* larvae in the laboratory (Gupta and Thorsteinson, 1960). Löhr (2001) reported serious damage inflicted by DBM on sugar snap pea in Kenya under field condition. Löhr and Gathu (Lohr and Gathu, 2002) showed that in only a few generations of selection, a DBM strain can be produced that performs comparably well on crucifer and pea.

Cruciferous weeds are able to sustain feeding and reproduction of DBM and play an important role in maintaining DBM population in the absence of cruciferous crops (Harcourt, 1986). This experiment was conducted to compare developmental period and reproduction of DBM in common wild and cultivated crucifers grown in Ethiopia under laboratory condition.

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Materials and Methods

The experiment was conducted at the Melkassa Center of the Ethiopian Agricultural Research Organization (EARO) between October and December, 2002.

Seeds of two cultivated Brassica species, head cabbage (*Brassica oleracea* var. *capitata,* variety Copenhagen Market) and Ethiopian mustard (*Brassica carinata* Braun) were purchased from commercial outlets. *Brassica nigra* Koch. accession number 231212 and *B. nigra* accession number 229938 were obtained from Ethiopian Biodiversity Institute. Seeds of the wild crucifer, *Erucastrum arabicum* Fisch. and Mey, were collected from field in the vicinity of Melkassa Research Center of the EARO. Plants were raised in the green house at Melkassa Center. Seeds were planted in seedling trays and allowed to grow until two to four leaf stage and transplanted to a pot (13 cm diameter and 15 cm height). Compost and sand loam soil in a proportion of 1:1 was used as a growth medium. Leaves were used for testing after the 8-leaf stage. Because of poor germination of *E. arabicum*, not enough plants of this species could be raised. Additional collections of leaves were therefore made from the near by field. The study was conducted in the laboratory in ambient condition (Temperature ranged between 23 and 30°C).

A stock of culture of DBM was established with pupae collected from cabbage fields in the vicinity of Melkassa Research Center. Emerged adults were kept in a plastic container (30x30x30 cm) and allowed to mate. A young cabbage leaf was used for egg laying. The petiole of the leaf was immersed in a beaker (6 cm diameter and 10 cm height) filled with water to avoid quick drying of the leaf. Leaves were changed daily and eggs were incubated on the leaves.

For the experiments, newly hatched larvae from the stock culture were introduced individually into a plastic vial (2.5 cm in diameter and 6 cm in height) and supplied with a piece of leaf size 5 cm long and 2.5 cm wide as food for each Brassica plant and wild hosts. Twenty larvae were observed. To keep the food fresh, a piece of wet filter paper was placed in the vial. Food was changed every other day. Larvae were kept in the vial through pupation. The developmental period of immature stages was determined from daily observation. Pupal weight was measured on two days old pupae which were returned to the respective vial until adult emergence. Weight recorded in mg was rounded off to the nearest whole number.

For the investigation of the effect of the food plant on reproductive potential, individual pairs from each tested crucifer species were placed into a plastic cage measuring 30x30x30 cm. They were supplied with a piece of leaf of the test plants from where they were reared and 5% sugar solution to estimate the fecundity, fertility and incubation period. The larvae hatched were reared again in a similar fashion until adult emergence. Pupal weight from each brassica plant was recorded to examine its relation with fecundity. Suitability of the test brassica plants was compared in generation one and two using survival rate, fecundity, fertility and longevity of the different stages; egg larva, pupa and adult and life table statistics (Maia *et al*., 2000).

Data were subjected to ANOVA using PROC GLM of the SAS software (Anonymous, 1999). Fertility data w ere arcsine transformed before analysis. Means were separated using Student-Newman-Keuls (SNK) test. Relationship of fecundity to pupal weight was examined using simple linear regression.

Population growth statistics, the net reproductive rate (Ro), the intrinsic rate of increase (r_m); the mean generation time (T), the finite rate of increase (λ) and the doubling time (Dt) were calculated and compared using the method of Maia *et al.* (2000) for both generations.

Results

Developmental Period and Pupal Weight

Egg, larval period, pupal period and pupal weight ranged between 2.8 to 3.5, 7.8 to 9.63, 5.15 to 5.58 days and 6.1 to 6.7 mg, respectively. In the first generation, significant variation was observed only for larval period where it was significantly longer in *B. nigra* acc. No. 229938 and *B. nigra* acc. No 231212 than the rest of the cultivated species and the wild crucifer. Although differences were not significant, developmental period was shorter in cabbage for all stages than the rest of the test plants. Egg and larval period in the wild crucifer was intermediate between the cultivated crops (Table 1).

In the second generation, developmental period, egg, larval period, pupal period and pupal weight ranged between 2.6 to 4.0, 9.2 to 10.7, 5.7 to 6.8 days and 6.5 to 8.2 mg, respectively. Egg period was significantly longer in the wild crucifer than on cabbage and Ethiopian mustard. Larval period was significantly shorter in cabbage and significantly longer in the wild crucifer than the rest (Table 2).

Pupal period was significantly longer in *B. nigra* acc. No. 229938 and shorter in cabbage than the rest of the test plants. Pupal weight was significantly higher in cabbage and Ethiopian mustard than the rest.

Fecundity, Fertility and Adult Longevity

The developmental period in the first generation, variation in fecundity, fertility and adult longevity was not significant. Fecundity ranged between 140 to 293 eggs per female and fertility (Arcsine transformed) ranged between 0.36 and 0.99. Fecundity of females reared on cabbage and Ethiopian mustard was about twice as high as of those raised on the wild crucifer and *B. nigra* acc. 229938. Similarly, fertility of cabbage and Ethiopian mustard reared females was twice higher than of those on the wild crucifer. Adult longevity did not show high variability; it ranged between 10.8 and 12.4 days for females and between 9.5 and 11.4 days for males (Table 3).

Table 1: Performance of the first generation of diamondback moth on common cultivated and wild crucifers

	Developmental period (days)				
Crucifer species	Egg	Larval	Pupal	Pupal weight (mg)	Survival (%)
Cabbage	2.8±0.16a	7.85±0.11c	5.25±0.10a	6.55±0.27a	83.4±2.7a
Ethiopian mustard	3.0±0.00a	7.80±0.22c	5.58±0.12a	6.10±0.16a	79.3±3.9a
Brassica nigra[1]	3.4±0.24a	9.10±0.10b	5.23±0.14a	6.20±0.27a	28.1±13.0b
Brassica nigra[2]	3.5±0.29a	9.63±0.16a	5.13±0.17a	6.10±0.17a	25.8±12.1b
E. arabicum	3.2±0.25a	8.05±0.13c	5.40±0.15a	6.70±0.23a	53.0±14.2ab

[1]= Accession number 231212; [2] = Accession number 229938, Means followed by the same letter(s) in a column are not significantly different, SNK test

Table 2: Performance of the second generation of diamondback moth on common cultivated and wild crucifers

	Developmental period (days)				
Crucifer species	Egg	Larval	Pupal	Pupal weight (mg)	Survival (%)
Cabbage	2.60±0.24b	9.20±0.09c	5.70±0.13c	8.20±0.22a	83.33±3.7a
Ethiopian mustard	2.67±0.21b	10.30±0.15b	5.94±0.12bc	7.75±0.23a	68.24±8.6a
Brassica nigra[1]	3.33±0.33ab	10.15±0.08b	6.35±0.12b	6.50±0.20b	59.14±1.9a
Brassica nigra[2]	3.67±0.33ab	10.50±0.12ab	6.83±0.11a	6.66±0.20b	47.07±6.6a
E. arabicum	4.00±0.32a	10.70±0.13a	6.35±0.16b	6.75±0.33b	53.56±17.0a

[1]= Accession number 231212; [2] = Accession number 229938, Means followed by the same letter(s) in a column are not significantly different, SNK test

Table 3: Reproductive potential and adult longevity of the first generation of diamondback moth on common cultivated and wild crucifers

			Longevity	
Crucifer species	Eggs/female	Fertility*	Female	Male
Cabbage	293.5±23.8a	0.99±0.04a	11.2±0.5a	10.3±0.5a
Ethiopian mustard	257.3±62.4a	0.99±0.08a	11.0±0.6a	10.3±0.3a
Brassica nigra[1]	226.0±54.4a	0.36±0.17a	12.4±0.5a	11.4±0.4a
Brassica nigra[2]	146.2±41.45a	0.37±0.17a	10.8±0.6a	9.5±0.6a
E. arabicum	140.0±51.9a	0.73±0.21a	11.5±1.04a	10.2±0.48a

[1] = Accession number 231212; [2] = Accession number 229938,
* = values are arcsine transformed, Means followed by the same letter(s) in a column are not significantly different , SNK test

Table 4: Reproductive potential and adult longevity of the second generation of diamondback moth on common cultivated and wild crucifers

			Longevity	
Crucifer species	Eggs/female	Fertility*	Female	Male
Cabbage	320.6±38.2a	0.99±0.06a	10.2±0.4a	10.2±0.7a
Ethiopian mustard	85.7±20.2b	0.83±0.12a	10.0±0.4a	10.7±0.4a
Brassica nigra[1]	63.0±4.2b	0.77±0.03a	9.7±0.7a	10.0±0.6a
Brassica nigra[2]	83.3±28.8b	0.55±0.08a	11.3±0.9a	11.0±0.6a
E. arabicum	132.4±41.5b	0.64±0.25a	11.4±0.7a	10.4±1.1a

[1] = Accession number 231212; [2] = Accession number 229938,
* = values are arcsine transformed, Means followed by the same letter(s) are not significantly different , SNK test

Table 5: Life table parameters of the first generation of diamondback moth developed on common cultivated and wild crucifers

	Life table statistics				
Crucifer species	r_m	R_o	λ	T	Dt
Cabbage	0.31a	146a	1.37a	15.8a	2.20a
Ethiopian mustard	0.29ab	91b	1.34a	15.5ab	2.38a
Brassica nigra[1]	0.16c	21c	1.17a	18.9c	4.30a
Brassica nigra[2]	0.18c	26c	1.19a	18.0c	3.81a
Erucastrum arabicum	0.26b	87b	1.30a	17.0b	2.63a

[1] = Accession number 231212; [2] = Accession number 229938,
Means followed by the same letter(s) in a column are not significantly different, Means were separated using student t-test mean comparison (Maia *et al.*, 2000)

In the second generation, fecundity per female, female and male longevity ranged between 63 to 320 eggs, 9.7 to 11.4 and 10.2 to 11.0 days. Fertility ranged between 0.55 and 0.99. Fecundity on cabbage was about four-fold and significantly higher than of all cultivated species. It was also higher in the wild crucifer than the rest of the cultivated species except cabbage though differences were not significant. Variation in fertility was not significant but was higher in cabbage and Ethiopian mustard than the rest as observed in the first generation (Table 4). The relationship of fecundity to weight of pupae was positive and significant ($p<0.05$) in both generations. However, these relationships were weak as only 28% in the first generation and 18% in the second generation of the variation in fecundity was explained by weight of pupae (Fig. 1) .

Life Table Parameters

Intrinsic rate of increase (r_m), net reproductive rate (R_o) and finite rate of increase (λ) were highest and doubling time was lowest (Dt) in cabbage in both generation one and two than the rest. On the other hand r_m Ro and λ were lowest and Dt was highest in *Brassica nigra* (both accession no. 231212

Table 6: Life table parameters of the second generation of diamondback moth developed on common cultivated and wild crucifers

	Life table statistics				
Crucifer species	r_m	R_o	λ	T	Dt
Cabbage	0.28a	151a	1.32b	17.9a	2.47a
Ethiopian mustard	0.18b	25b	1.20b	18.1b	3.85b
Brassica nigra[1]	0.15bc	22b	1.17b	19.8bc	4.45b
Brassica nigra[2]	0.12c	13b	1.13a	21.4c	5.68b
Erucastrum arabicum	0.17bc	32b	1.18a	20.9b	4.17b

[1]= Accession number 231212; [2] = Accession number 229938,
Means followed by the same letter(s) in a column are not significantly different, Means were separated using student t-test mean comparison (Maia *et al*., 2000)

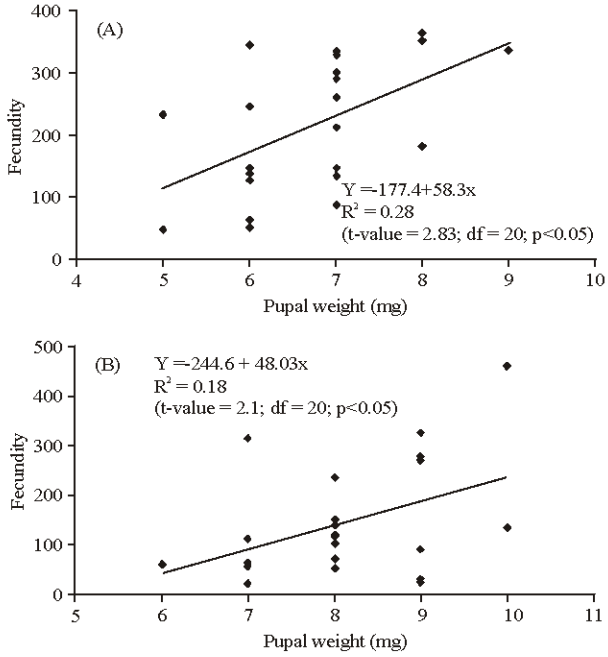

Fig. 1: Relationship of fecundity (Y) to weight of pupa of DBM (x): First generation (A) and second generation (B)

and 229938). Values of these parameters were intermediate for Ethiopian mustard and the wild crucifer, *E. arabicum* (Table 5 and 6).

Discussion

Results showed that cabbage followed by Ethiopian mustard is more suitable for the development of DBM and the wild crucifer is as suitable as the rest of the cultivated brassica crops. Yamada (1983) observed non-significant difference in developmental periods of immatures (Yamada, 1983) in wild and cultivated crucifers. In a similar study with one cultivated species (cabbage) and five wild crucifers, Muhamad *et al.* (1994) reported a shorter developmental period of immatures and highest early fecundity in cabbage. In this study, both in the first and second generations, developmental period of immatures was shorter and fecundity was higher in cabbage. Absence of significant variability in

fecundity of the first generation between the tested brassica plants despite higher differences in the number of eggs laid could be explained by high variability between replicates within treatment.

Positive relationship of pupal weight to fecundity observed is in agreement with several reports (Muhammad *et al*., 1994; Yamada and Umeya, 1972; Moller, 1988). The life table statistics in both generations clearly shows that cabbage was the most suitable host and *B. nigra* (both accessions) was the least suitable with the other cultivated brassica, Ethiopian mustard and the wild crucifer being intermediate.

This was similar to results of the developmental periods of the different stages as well as fecundity and fertility observed in both generations. However, comparison for life table parameters in the first generation showed significant differences between tested plants. On the other hand differences were not significant when comparison was made for developmental period and reproductive potential in the first generation. This could be due to differences observed in fertility as the life table analysis considers all variables in the estimation of the life table parameters. Although only one wild crucifer which is widely found as weeds in crop fields was compared with cultivated species in this study, the development of DBM on wild crucifer was found to be comparable with some of the cultivated brassica crops, *Brassica nigra*. Sixty-one species of crucifers in 21 genera are reported to occur in Ethiopia (Edwards *et al*., 2000). Their influence in the spatio-temporal dynamics of DBM and their parasitoids is expected to be high as observed in several brassica production regions (Talekar and Shelton, 1993). Future studies in this line should focus on testing of a larger number of wild crucifers for the preference to oviposition and development of both DBM and commonly associated parasitoids. Assessment of the chemical constituent of the crucifer species would help to better understand mechanism of host suitability. Assessing DBM population and parasitism level by the different parasitoids under field condition on commonly found wild crucifers would also help to understand their role in the population dynamics of DBM which in turn is helpful in the development of appropriate management program.

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References

Anonymous, 1999. SAS/STAT. The SAS system for windows, Version 8.0. SAS Institute, Cary, NC.

Edwards, S., M. Tadesse, M. Demesse and I. Hedberg, 2000. Flora of Ethiopia and Eritrea. Addis Ababa, Ethiopia.

Gupta, P.D. and A.J. Thorsteinson, 1960. Food plant relationships of the diamondback moth (*Plutella maculipennis* (CURT.)) I. Gustation and olfaction in relation to botanical specification of the larva. Ent. Exp. Appl., 3: 241- 250.

Harcourt, D.G., 1986. Population Dynamics of the Diamondback Moth in Southern Ontario. In: N.S. Talekar and T.D. Griggs, (Eds.) Proc. 1st Intl. Workshop. Shanhua, Taiwan: Asian Vegetable Research and Development Center, pp: 3-15.

Löhr, B., 2001. Diamondback moth on peas, really. Biocontrol News and Information, 19: 38-39.

Löhr, B. and R. Gathu, 2002. Evidence of adaptation of Diamondback moth, *Plutella xylostella* L., to pea, *Pisum sativum* L. Ins. Sci. Appl., 22 : 161-173.

Maia, A.H., A.J.B. Luiz and C. Campanhola, 2000. Statistical inference on associated fertility life table parameters using jacknife technique: Computational aspects. J. Econ. Entomol., 93: 511-518.

Moller, J., 1988. Investigations on a laboratory culture of the diamondback moth, *Plutella maculipennis* (Curt.) (Lep., Yponomeutidae) I. Life history parameters: Hatching, pupation, emergence, copulation and oviposition. J. Applied Entomol., 105: 360-373.

Muhamad, O., R. Tsukuda, Y. Oki, K. Fujisaki and F. Nakasuji, 1994. Influence of wild crucifers on life history traits and flight ability of the diamondback moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae), Res. Popul. Ecol., 36: 53-62.

Talekar, N.S. and A.M. Shelton, 1993. Biology, ecology and management of the diamondback moth. Ann. Rev. Entomol., 38: 275-301.

Yamada, H. and K. Umeya, 1972. Seasonal changes in wing length and fecundity of the diamondback moth, *Plutella xylostella* (L.). Jpn. J. Applied Entomol. Zool., 16: 180-186.

Yamada, H., 1983. The percentage of pupation and emergence, fecundity of the diamondback moth fed on cruciferous weeds. Proc. Kansai Plant Prot. Soc., 25: 53.