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TABLE OF CONTENTS

INTRODUCTION

Unprotected potatoes, Solanum tuberosum L., can be defoliated by Colorado potato beetle (CPB), Leptinotarsa decemlineata (Say), but certain congeneric wild species including S. chacoense (Bitt.) and S. demissum (Lindl.) are less susceptible to beetle damage (Hsiao 1974; Pierzchalski 1957; Sinden et al. 1980; Swiniarski et al. 1958). The wild species' resistance to beetle damage has been attributed in part to the presence of steroidal alkaloid glycosides (glycoalkaloids) in their tissues. Most solanaceous plants produce some glycoalkaloids. It is believed that these compounds may have antifeedant or antimetabolic effects on insects (Latheef and Harcourt 1972; Raman et al. 1979; Sinden et al. 1980; Swiniarski et al. 1958; Tingey et al. 1978). CPB tolerate the glycoalkaloids found in S. tuberosum. The resistance observed in the wild Solanum species may be a consequence of high total glycoalkaloid levels and/or the presence of some other compounds, perhaps toxic glycoalkaloids.

The purpose of this study was to compare growth and development of CPB larvae fed S. chacoense and S. demissum with those reared on S. tuberosum.

MATERIALS AND METHODS

S. chacoense (#PI 275138) and S. demissum (#PI 161169) were grown from seed, while S. tuberosum (cv. Katahdin) was propagated vegetatively. All plants were started in a greenhouse with a 16:8 (L:D) photoperiod and were moved outdoors after 4 weeks. Plants were treated with a 200:1 solution of water and Rapidgrow[R] on alternate days to encourage foliar growth.

Adult CPB were collected in Newport, Maine and maintained through one complete generation in the laboratory. Eggs from the laboratory reared adults were incubated in plastic Petri dishes (15 x 90 mm). Newly hatched larvae were weighed and transferred to individual Petri dishes. Each larva was provided with foliage of S. chacoense, S. demissum, or S. tuberosum. Four replicates of 25 larvae were reared on each type of foliage, freshness being maintained by sealing of leaf petioles in water-filled 6 x 50 mm glass culture tubes. Foliage was replaced as needed. Larvae were weighed daily until pupation and the developmental stage noted. After 7 days, each stage 4 larva and its food were transferred to a pupation chamber. These consisted of 40 x 90 mm cylindrical cardboard cartons filled to a depth of 2 cm with a 50:50 mixture of damp peat moss and vermiculite. The containers were closed with clear plastic lids.

Upon emergence, adults were weighed, sexed, and paired. Each pair was placed in a 40 x 90 mm cylindrical cardboard carton covered with a clear plastic lid. Pairs of beetles were provided with the foliage of the same plant species they had been reared upon as larvae. Eggs were collected and counted daily. Eggs from each pair were kept until the larvae eclosed to determine their viability. All larval and adult rearing conditions were at 25^{o}C and a 16:8 photoperiod.

Parameters determined for larvae were percent survival, number of days spent in each stage, weight gained in each stage, total days from eclosion to pupation, final prepupal weight, and weight gained per day. The daily oviposition rate of adults was also determined. Three larval stages were assigned, stage 1/2, stage 3, and stage 4. Stage 1/2 includes instars 1 and 2, while stages 3 and 4 correspond to instars 3 and 4, respectively. Weight gained in stage 1/2 was calculated by subtracting weight at hatching from the first weight of stage 3. Similarly, weight gained in stage 3 was calculated by subtracting the first weight in stage 3 from the first weight in stage 4. Weight gained in stage 4 was calculated by subtracting the first weight in stage 4 from the last weight in stage 4. Weight gained by larvae dying prior to pupation was calculated only for stages completed prior to death. Average weight gained per day was determined by dividing the last prepupal weight by the total days from eclosion to pupation. Upon termination of oviposition assays, ovaries were dissected from all females. Ovariole length, as measured from calyx to the base of the filaments, was recorded for each ovary. Length and diameter of the two largest developing eggs from each ovary were also recorded. Tissue deterioration, however, precluded accurate measurement of the length of some developing eggs. Duncan's New Multiple Range Test was used to determine differences among treatments for the number of days spent in each stage, final prepupal weight, total days from eclosion to pupation, average weight gained per day, ovariole length, and length and diameter of the two largest developing eggs from each ovary.

RESULTS AND DISCUSSION

The survival rate of larvae in each treatment is represented in Figure 1. 94.8% of all mortality in the group fed S. demissum and 91.9% of all mortality in the group fed S. chacoense occurred in stage 1/2, indicating that this stage was the critical stage for CPB larvae fed on these two plant species. Little mortality (14%) occurred in the group fed S. tuberosum and was evenly distributed through the stages.

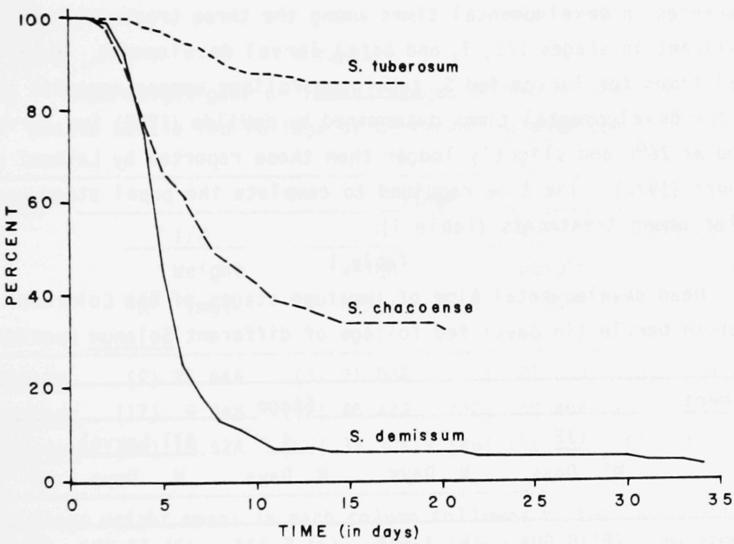

Figure 1. The percentage of Colorado potato beetle larvae surviving each day on the different Solanum species.

No individuals from any group died in the pupal stage. Survival rates for replicates within treatments were consistent for larvae fed S. demissum and S. tuberosum. The survival rate of larvae fed S. chacoense, however, declined in sucessive replicates. All foliage fed to individuals in the first replicate came from plants grown in a greenhouse because of cold weather. Plants were moved outside at the start of the second replicate because of high greenhouse temperatures. The toxicity of S. chacoense apparently increased at this time. It is possible that the filtering effect of greenhouse glass affected the plants' biosynthetic capabilities and that they only developed their full complement of defensive compounds when grown in direct sunlight.

Larvae fed S. tuberosum developed more rapidly than did those fed S. chacoense or S. demissum (Table 1). The group fed S. demissum invariably required the longest time to complete a given stage. Developmental times for the group fed S. chacoense were intermediate. Differences in developmental times among the three treatments are significant in stages 1/2, 3, and total larval development. Developmental times for larvae fed S. tuberosum foliage appear somewhat shorter than the developmental times determined by deWilde (1950) for larvae reared at 26°C and slightly longer than those reported by Latheef and Harcourt (1972). The time required to complete the pupal stage was similar among treatments (Table 1).

Table 1

Mean developmental time of immature stages of the Colorado potato beetle (in Days) fed foliage of different Solanum species[1]

Treatment	Stage 1/2		3		4		All Larval		Pupal	
	N[2]	Days	N	Days	N	Days	N	Days	N	Days
S. demissum	(8)	10.00A	(5)	4.60A	(3)	6.33A	(3)	17.33A	(3)	11.50A
S. chacoense	(43)	5.40B	(35)	3.32B	(32)	5.25A	(32)	13.84B	(32)	11.53A
S. tuberosum	(96)	3.90C	(88)	2.45C	(86)	4.69A	(86)	10.97C	(86)	11.87A

[1]Within columns, length means followed by the same letter are not significantly different DMRT ($P < 0.05$).

[2]N is the number of individuals.

Among individuals surviving to adulthood, the amount of weight gained in each stage (Table 2) was comparable among treatments, with the exception that larvae fed S. chacoense gained significantly less weight in stage 1/2. The weight of larvae on the day prior to pupation (Table 2) was comparable among treatments, although the individuals fed S. tuberosum outweighed those fed S. chacoense which outweighed those fed S. demissum. No attempt was made to quantify the amount of food consumed, but it was observed that larvae feeding on S. tuberosum needed their foliage replenished more frequently than larvae in the other two treatments. The supposition that larvae fed S. tuberosum consumed more foliage per day than larvae in the other two treatments is suggested by the greater average daily weight gained throughout the larval period by larvae fed S. tuberosum (Table 3).

Table 2

Mean weight gain of larval stages of the Colorado potato beetle fed foliage of different Solanum species[1]

Treatment	Stage 1/2		Stage 3		Stage 4		All Larval	
	N[2]	Weight (mg)	N	Weight (mg)	N	Weight (mg)	N	Weight (mg)
S. demissum	(2)	21.84A	(3)	21.00A	(3)	81.06A	(3)	119.70A
S. chacoense	(17)	9.94B	(32)	45.42A	(32)	88.46A	(32)	145.28A
S. tuberosum	(65)	13.52A	(86)	39.30A	(86)	101.35A	(86)	153.98A

[1]Within stage weight means in each column followed by the same letter are not significantly different DMRT ($P < 0.05$).

[2]N is the number of individuals.

Table 3
Average daily weight gain of beetles fed foliage of different *Solanum* species during the larval period[1]

Treatment	N[2]	Weight (mg)
S. demissum	(3)	7.53B
S. chacoense	(32)	10.99B
S. tuberosum	(86)	14.44A

[1]Weight means followed by the same letter are not significantly different DMRT ($P < 0.05$).
[2]N is the number of individuals.

All pairs of adults (22) reared from eclosion on *S. tuberosum* foliage laid viable eggs. In 60 days of observation, the number of eggs deposited per female ranged from 113 to 1438 (average 696/female). One female reared on *S. chacoense* laid a single mass of 13 eggs, but these failed to hatch. Ovarioles in females reared on *S. tuberosum* were significantly longer than those from females reared on *S. chacoense* or *S. demissum* (Table 4). Developing eggs in the ovarioles of individuals fed *S. tuberosum* were also larger in length and diameter than those from females in the other two treatments (Table 4). This was assumed to be an indication of more complete ovarian development in the individuals reared on *S. tuberosum*.

Table 4
Size of ovarioles and developing eggs from female Colorado potato beetles fed foliage of different *Solanum* species from eclosion until death[1]

Treatment	Ovariole		Egg			
	N[2]	Length (in mm)	N	Length (in mm)	N	Diameter (in mm)
S. demissum	(2)	0.29B	(4)	0.060AB	(4)	0.014B
S. chacoense	(14)	0.29B	(26)	0.058B	(28)	0.014B
S. tuberosum	(42)	0.43A	(65)	0.069A	(84)	0.024A

[1]Within columns, means followed by the same letter are not significantly different DMRT ($P < 0.05$).
[2]N is the number of individuals.

These results indicate that *S. chacoense* and *S. demissum* are not optimal hosts for the Colorado potato beetle. CPB larvae reared on these *Solanum* species suffer protracted developmental times, high mortality, and tend to be smaller than larvae reared on *S. tuberosum*. In addition, adults which developed from larvae reared on *S. chacoense* and *S. demissum* have smaller ovaries and developing eggs, and are unable to reproduce. Although it has been suggested that these effects are due to glycoalkaloids which act as feeding deterrents, other factors should be considered. These include the possible toxic effects of the glycoalkaloids and other compounds in the plants which may act as feeding deterrents or influence digestibility and nutrient uptake.

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