A Study of Allelochemical Insect Control by Three Herbs Grown in a Companion Planting System with Mustard (*Brassica juncea* cv. Florida Broadleaf)

by

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ABSTRACT

Numerous gardening publications report that the companion planting of various herbs among vegetable crops repels insects from the garden, thereby reducing insect damage considerably. An experiment was conducted to test the validity of these claims.

A complete randomized block design with four replications of four treatments was utilized in a field study. Each of three herbs -- sweet marjoram, dill, and shallots -- was planted on both sides of a row of mustard (*Brassica juncea* cv. Florida Broadleaf) on a raised bed; a control with mustard only was used, totalling four treatments. When the plants were ready for harvest, data was collected on the types and degree of damage found on the youngest fully expanded leaf of ten plants chosen at random from each plot. Two raters collected data independently. Ratings were based on a 1 - 3 scale, ranging from none-to-slight damage to severe damage. Three categories of damage were considered -- holes, presence of aphids, and spots.

Totals from each plot were calculated and an analysis of variance run on each rater's data for each of the three categories of damage. In the analysis, no significant differences were found between treatments. Average treatment ratings were compared and showed only slight differences. Records of insects found on the sample plants revealed no patterns in frequency of appearance within the various treatments.

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Most of all, I thank God for holding me in the palm of His hand and for promising me that He has good plans for my life (Jeremiah 29:11-13).

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INTRODUCTION

The Problem

With the increasing use of chemical pesticides, particularly insecticides, there has been a growing concern about pollution of the environment and health hazards effected by these chemicals. Agricultural researchers have experimented with various methods of biological insect control in a search for alternate ways to protect crops from insect damage. Although some progress has been made, experimentation has shown only limited success, and the search continues for non-chemical control methods that are practical for high level crop production.

Although chemical insect control is practical and economical in large-scale operations, non-chemical control offers certain advantages on the small scale (i.e., home gardens and labor-intensive vegetable production in developing countries). One of the most important advantages is cost -- non-chemical insect control is much less expensive than is chemical control. In home settings where small children and pets would likely be in and around the garden, non-chemical insect control methods are safer than are chemical methods. In developing countries, non-chemical controls are more readily available than are chemical controls.

Gardening publications suggest several cultural practices for non-chemical control of insects. Some of those methods listed in Gardening Without Poisons (14) include the alteration of planting dates to avoid peaks in insect populations; rotations to discourage the build-up of

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The style and format of this thesis follows that outlined by the Journal of the American Society for Horticultural Science.

insect populations in a given area; the burning of infested residues to destroy eggs deposited and insects harbored in the plant material; the use of "home-made" insecticides from garlic or peppers (juice is extracted and diluted for use as a spray); and companion planting systems composed of crops that are able to live together and benefit each other (21). The last of these five practices is the target of this experiment.

The Investigation

Allelochemics, a term coined by Feeny and Whittaker (32), concerns the effects of one living organism on another. This phenomenon is one that may be involved in certain companion planting systems.

One companion planting system of particular interest concerns planting herbs among vegetable crops in order to repel insects from the garden. This allelochemical effect is quite commonly reported to occur, but there is little, if any, scientific data to substantiate this information. Should herbs exhibit repellent effects on insect pests, this method of controlling insects would be a valuable tool where chemical insecticides are impractical.

The purpose of this study is to determine whether or not there is an allelochemical effect produced by three herbs -- sweet marjoram, dill, and shallots -- on the insect pests of mustard (*Brassica juncea* cv. Florida Broadleaf) when the plants are grown together in a companion planting system.

LITERATURE REVIEW

Gardening Publications

In numerous gardening books and magazines, it is reported that herbs are helpful in minimizing insect damage on vegetable crops when the two are planted together. Nancy Todd, in The Book of the New Alchemists (30), explains that the strong odors of herbs mask the odors of host plants, making it difficult for insects to find their perferred food source. Many authors claim that herbs will repel any and all garden pests (1, 11, 28). Most authors, however, claim that particular plants repel particular insects. For example, Bacon (1) stated that horseradish protects potatoes from the Colorado potato beetle and that aphids are repelled by coriander and anise. Foster (7) suggests planting parsley with carrots to reduce carrot fly damage on the carrots; she also claims that alliums ward off aphids. Tirrell (29) writes that sage and mint should be planted with the *Brassica* species. It is suggested that the herbs be planted in close proximity to the individual vegetable crops (12,28), or as borders around the perimeter of the garden (1).

None of these statements are backed with scientific evidence. Rather, the authors have made broad remarks based on casual observation, giving no qualifications as to what conditions may enhance or inhibit these alleged repellent effects.

Scientific Publications

Although no information was found specifically dealing with allelochemical effects of herbs on the insect pests of other crops, some experimentation has revealed data that may substantiate the information given in the gardening publications.

Brues (2) observed that the strong scents of the Labiatae and the Umbelliferae repelled lepidopterous pests. Dethier and Schoonhoven (3,4, 24) conducted studies that showed lepidopterous larvae to have keen olfactory senses which were used to distinguish between host and non-host plants. It may be possible, then, that strong-smelling herbs disable insects from finding their hosts. However, Ishikawa et. al. (15) determined that the olfactory sense, in itself, was not an effective way for insects to locate their host plants.

Another area of investigation concerns a plant's production of "secondary substances" -- substances believed produced in the co-evolution of plants and insects as a mechanism for insect resistance (8,9,10,20,25, 31). These secondary substances have not been found to be essential to the basic metabolism of the plant (31). Much of the experimental evidence suggests that the secondary substances inhibit feeding on the plants containing them by interfering with herbivore metabolism (26), by inhibiting protein digestion (23), or by making the plant unacceptable for a variety of reasons (5,16). Gordon (13) suggests that a lack of certain amino acids may be a plant's defense against insect feeding. Raizen (20) takes these ideas a step further by claiming that these secondary substances may repel insects from other plants.

Root (22) conducted a test with collards in simple and diverse habitats, from which he concluded that the more diverse the habitat, the smaller the insect populations and the less the damage on the plants. Other studies confirm Root's findings (17,18). Polscer (19) found that herbs and other plants, although they did not offer 100% protection, did offer enough protection to reduce insect damage well below levels considered acceptable by gardeners. Whether or not these decreases in insect populations and damage were thought to result from chemical stimuli given by the other plants was not stated. Tahvanainen and Root (27), however, did determine that chemical stimuli from tomatoes interfered with the host finding and feeding behavior of the flea beetle on collards. Ellenby (6) also discovered that eelworm attack on potatoes was reduced due to root leachates from white mustard grown in close association with the potatoes.

Overall, the experimental evidence remains inconclusive as to whether or not herbs actually have a repellent effect on insect pests.

MATERIALS AND METHODS

A field study was conducted in the fall of 1981 on the horticulture farm at Texas A & M University in College Station, Texas. Mustard (*Brassica juncea* cv. Florida Broadleaf) was chosen as the main crop for data collection because of its short growing season, its growth habit that facilitates data collection, its nutritional value, and its variety of insect pests. Three herbs were selected to be grown with the mustard -- sweet marjoram (*Oreganum Marjorana*), dill (*Anethum graveolens*), and shallots (*Allium cepa* group aggregatum).

Field Design

A complete randomized block design containing four replications of four treatments was utilized (Fig. 1). The four treatments were as follows:

1 - control (mustard only)

2 - sweet marjoram

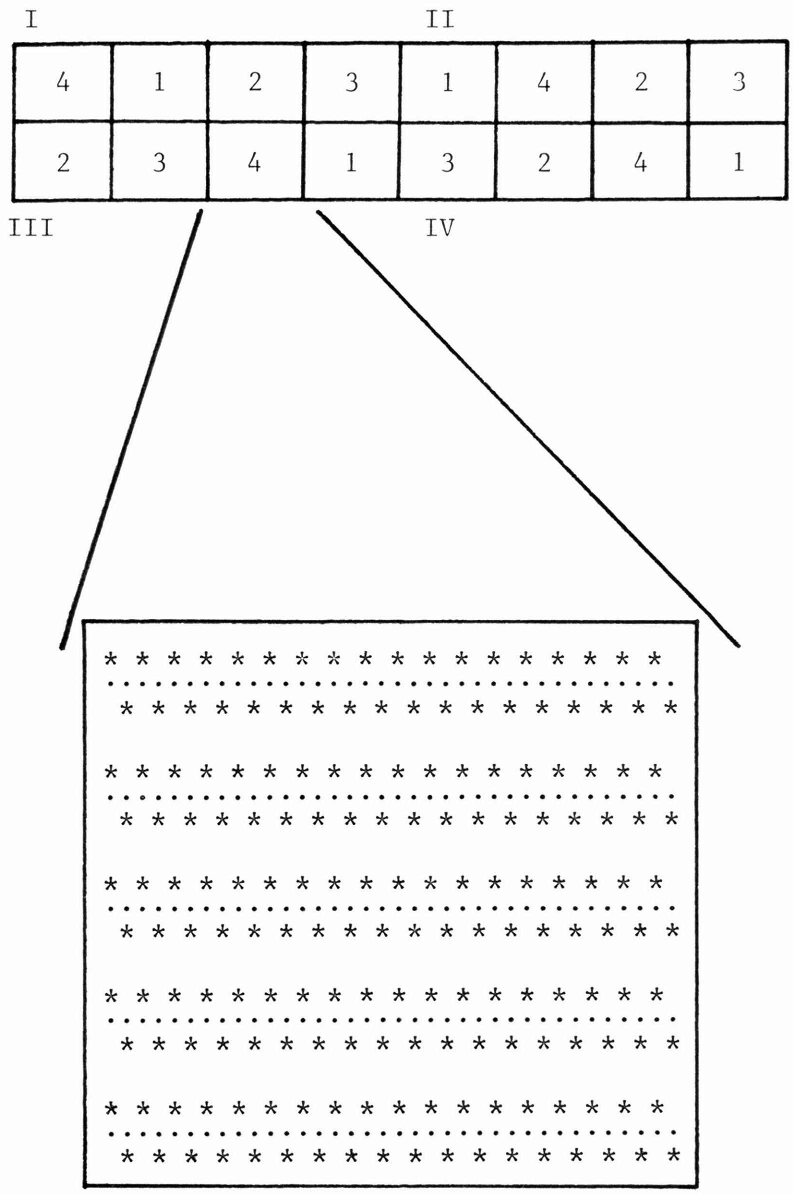
3 - dill

4 - shallots

(Due to the death of most of the marjoram plants shortly after transplanting, the second treatment was considered a second control in the final analysis of the data.)

The plots were 6 meters long, 5 meters wide (i.e., 5 rows wide, each row being 1 meter from furrow to furrow) with 1.5-meter alleys between the plots within the replications. All plots were exposed to the border of the field on at least one side, giving insects ready access to

Figure 1. Field and Plot Design



* - treatment plants · - mustard

to all plots. A variety of grasses were growing on the east side of the field; the west side bordered on vegetable crops.

Raised beds were formed with a rolling cultivator and then were levelled off with a roller. Fertilizer (analysis 12 - 12 - 12) was applied at a rate of 170 kilograms per hectare (a rate recommended for leafy vegetables) and was banded down the center of the raised bed at a depth of 15 centimeters. The mustard was drilled with a Planet Junior down the center of the raised bed (2 seeds per centimeter); then herb transplants (or bulbs, in the case of shallots) were planted on top of the raised bed on both sides of the mustard at 25-centimeter intervals (Fig. 2). The two rows of herbs were staggered in relation to each other to provide a more even distribution of the herbs down the row. All transplants and bulbs were treated with starter solution to insure quick establishment. Should the herbs repel insects, having the herbs actively growing as the mustard emerged and developed was desired.

Maintenance of the field before data collection included thinning the mustard to a stand of 12 plants per meter, irrigation as needed, hoeing weeds (herbicides, although not injurious to insects, were not used to avoid any possible damage to the mustard), and side dressing once with ammonium nitrate.

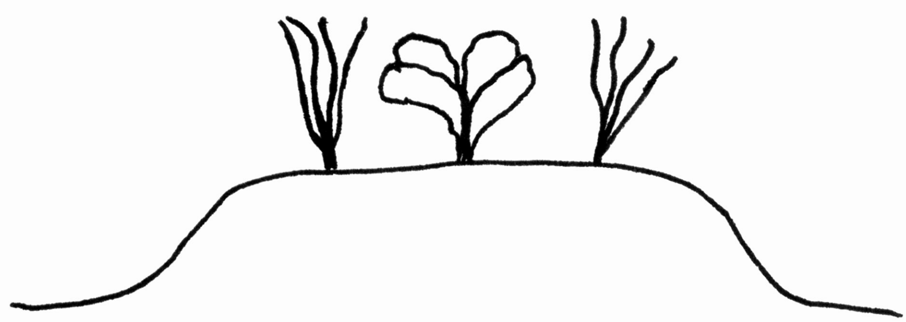


Figure 2. Plant arrangement on raised bed -- cross section.

Data Collection and Analysis

After seven weeks of growth, the mustard plants were of sufficient size for harvest, and data collection procedures were begun. The youngest fully expanded leaf of several plants chosen at random throughout the field was picked and examined to aid in developing a rating scale. Three categories of damage were rated, as well as the degree of damage within each category. The devised rating scale follows:

Category 1 -- Holes (Fig. 3)

- 1 -- none-to-slight -- $<$ 6 small holes and/or $<$ 2 large holes
- 2 -- moderate -- 6-20 small holes and/or 2-4 large holes
- 3 -- severe -- $>$ 20 small holes and/or $<$ 4 large holes

Category 2 -- Presence of aphids (Fig. 4)

- 1 -- none-to-slight -- $<$ 4 patches and scattered
- 2 -- moderate -- 4-8 patches and scattered
- 3 -- severe -- $>$ 8 patches and scattered

Category 3 -- Spots (Fig. 5)

- 1 -- none-to-slight -- one area of concentration and/or scattered
- 2 -- moderate -- 2-4 areas of concentration and scattered
- 3 -- severe -- $>$ 4 areas of concentration and scattered

Two raters worked independently and harvested the youngest fully expanded leaf of each of ten plants chosen at random from each plot. Numerical ratings were assigned each leaf sample for each category of damage. Note was also taken of any insects found in the selected plants. Data was collected once.

Rating totals for each plot were entered into an analysis of variance.

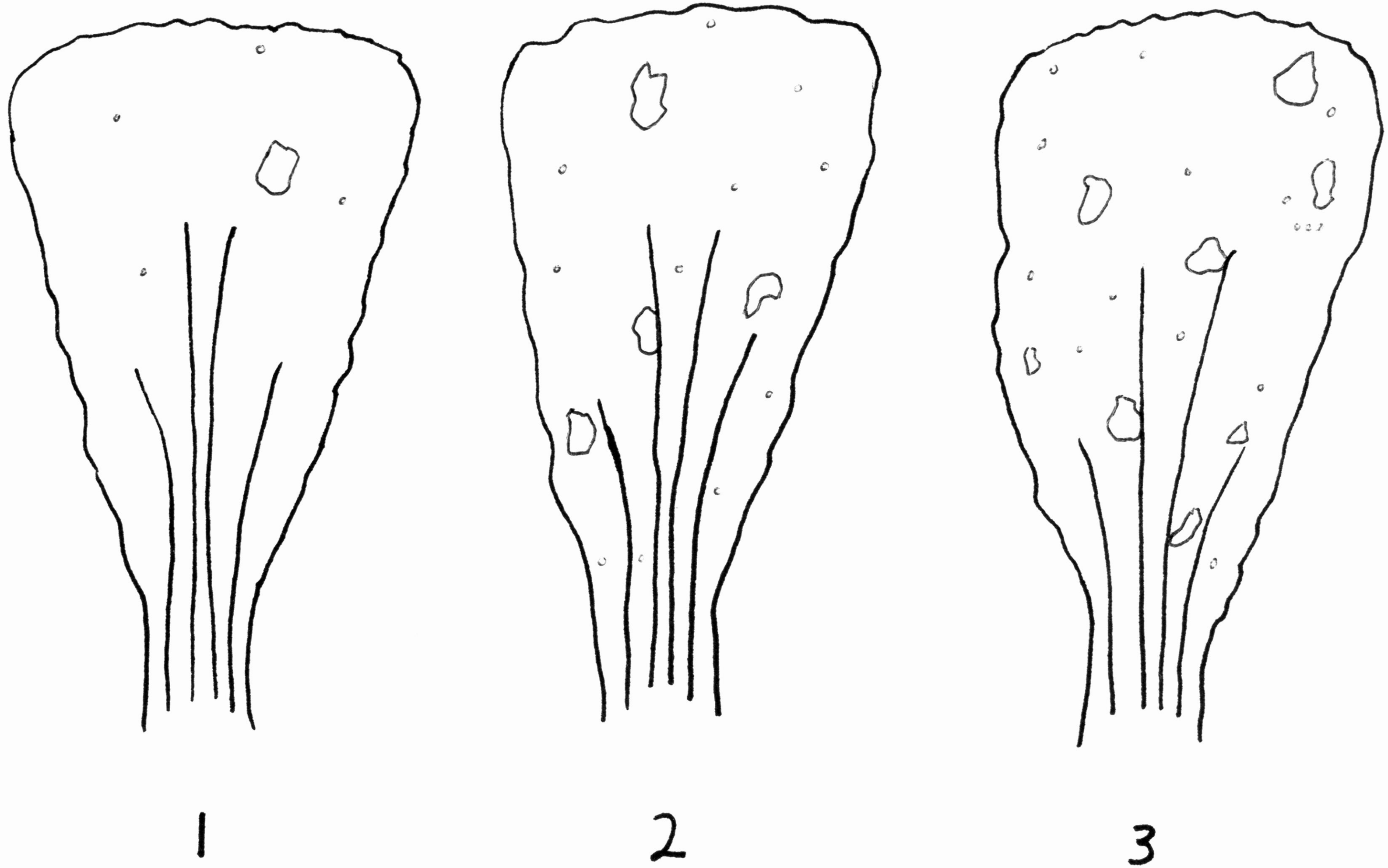


Figure 3. Sketches representing rating levels for holes.

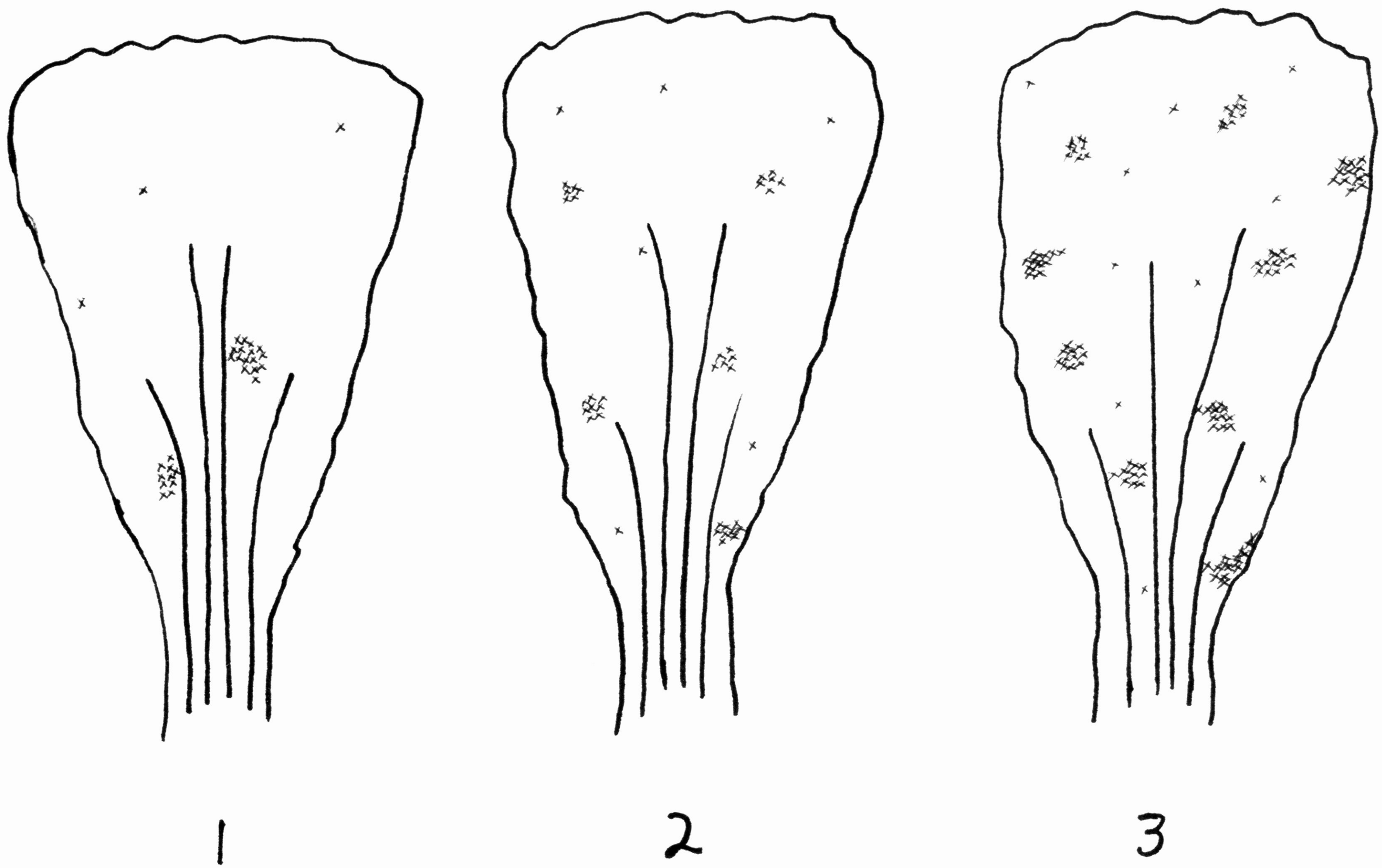


Figure 4. Sketches representing rating levels for aphids.

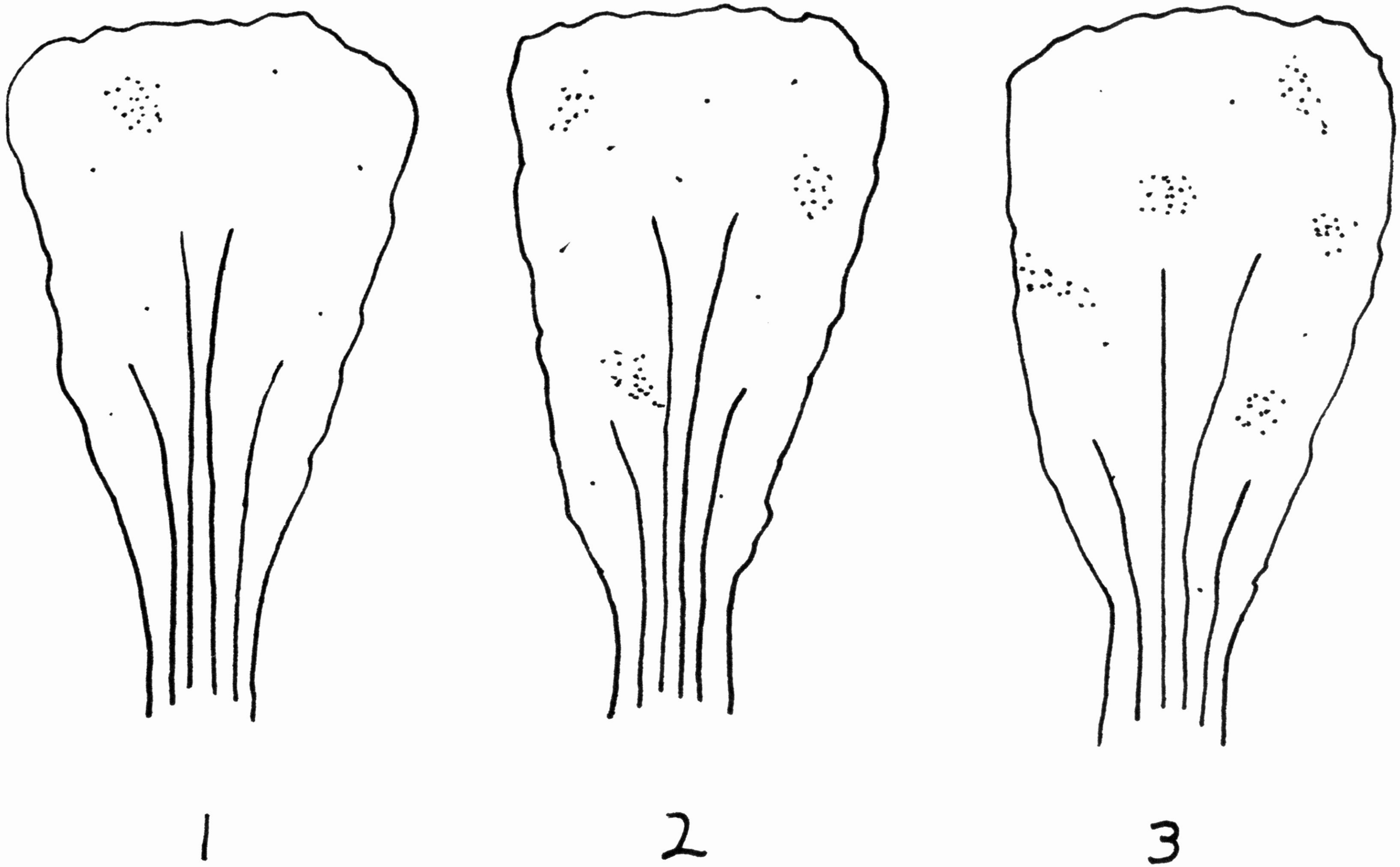


Figure 5. Sketches representing rating levels for spots.

The analysis was conducted with each rater's set of data for each of the three categories of damage, totalling six analyses. Average treatment ratings were calculated and converted to bar graph form for comparison. Records of insects present on the sample plants were studied for any patterns of appearance that may have occurred.

RESULTS AND DISCUSSION

In the analysis of variance, the tabular F value necessary for significance at the 0.050 level was 3.86. For all six analyses, the calculated F values were well below 3.86, indicating no significant differences among treatments (Tables 1 - 6).

In comparing the average treatment ratings (Figures 6, 7, and 8), there was very little difference between ratings. In Fig. 8, there was a slight decrease in the average rating for the third treatment, but this difference was not significant.

In examining the various insects found on the sample plants, the more common insects were cucumber beetles, aphids, flea beetles, and thrips. Very few cabbage loopers and cabbageworms were observed in any of the plots. No correlation was discovered between particular treatments and insect occurrence -- the insects were randomly distributed throughout the field.

Based on the data analysis, it can be concluded that the herbs used in the experiment do not repel insects under the conditions of the experiment. The climatic conditions were typical for mustard production in East Central Texas. The plots within each replication were fertilized, thinned, irrigated, and weeded identically to reduce variation. The complete randomized block design prevented any bias due to varying soil textures within the test plots. That all plots had at least one side open to the border of the field encouraged ready migration of insects into all plots from the perimeters of the field. The herbs were present as the mustard emerged and grew, and should have provided protection from insects if there were, in fact, an allelochemical effect between the herbs and the insect pests of the mustard. The herbs did not, in any way, reduce the vigor of the mustard. The healthy growth of the mustard was indicative of adequate light, moisture, and nutrients.

The numerous reports of the insect repellent effects of herbs need to be investigated further. Although herbs may reduce insect damage in some situations, they do not reduce damage in all situations. Studies that will aid in qualifying such claims are essential if these claims are to be considered reliable.

Modifications in the techniques utilized in this study for future research might help to define conditions that enhance allelochemical insect control by herbs. Using a mixture of herbs, thereby creating a diverse habitat, may reduce insect populations within the plots. Better isolation of plots, perhaps even conducting tests in different locations, may accentuate repellent effects of specific herbs. More treatments involving various combinations of vegetables and herbs may reveal particular combinations of plants that exhibit a significant degree of insect control.

Table 1. Analysis of Variance -- Holes
Rater 1

Source of variation	df	SS	MS	F
Block	3	30.69	10.23	
Treatment	3	5.69	1.90	0.226
Error	9	75.56	8.39	
Total	15	111.94		

F = 3.86 for significance at the 0.050 level.

Table 2. Analysis of Variance -- Holes
Rater 2

Source of variation	df	SS	MS	F
Block	3	42.19	14.06	
Treatment	3	41.19	13.73	1.11
Error	9	112.06	12.45	
Total	15	195.44		

F = 3.86 for significance at the 0.050 level.

Table 3. Analysis of Variance -- Aphids
Rater 1

Source of variation	df	SS	MS	F
Block	3	0.69	0.23	
Treatment	3	0.69	0.23	0.676
Error	9	3.06	0.34	
Total	15	4.44		

F = 3.86 for significance at the 0.050 level.

Table 4. Analysis of Variance -- Aphids
Rater 2

Source of variation	df	SS	MS	F
Block	3	5.25	1.75	
Treatment	3	2.75	0.92	0.652
Error	9	11.75	1.41	
Total	15	19.75		

F = 3.86 for significance at the 0.050 level.

Table 5. Analysis of Variance -- Spots
Rater 1

Source of variation	df	SS	MS	F
Block	3	16.50	5.50	
Treatment	3	18.50	6.17	0.925
Error	9	60.00	6.67	
Total	15	95.00		

F = 3.86 for significance at the 0.050 level.

Table 6. Analysis of Variance -- Spots
Rater 2

Source of variation	df	SS	MS	F
Block	3	5.19	1.73	
Treatment	3	24.19	8.06	2.41
Error	9	30.06	3.34	
Total	15	59.44		

F = 3.86 for significance at the 0.050 level.

Figure 6. Comparison of average treatment ratings for holes.

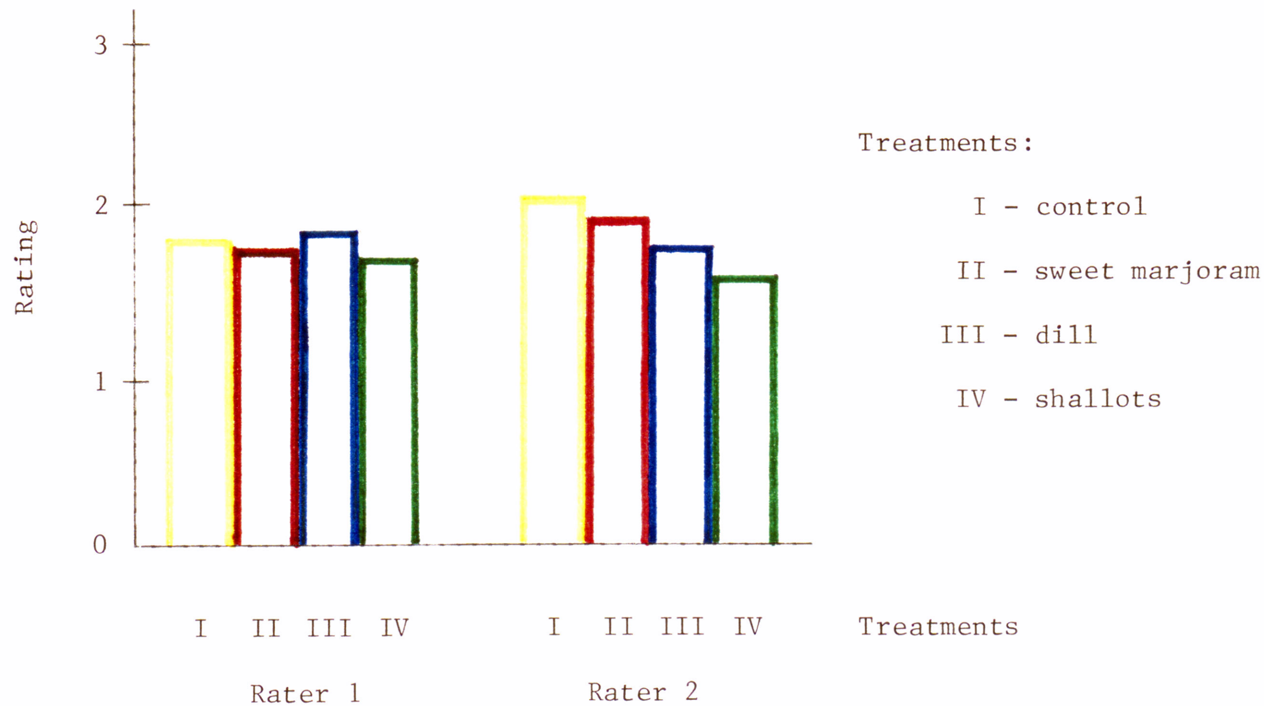


Figure 7. Comparison of average treatment ratings for aphids.

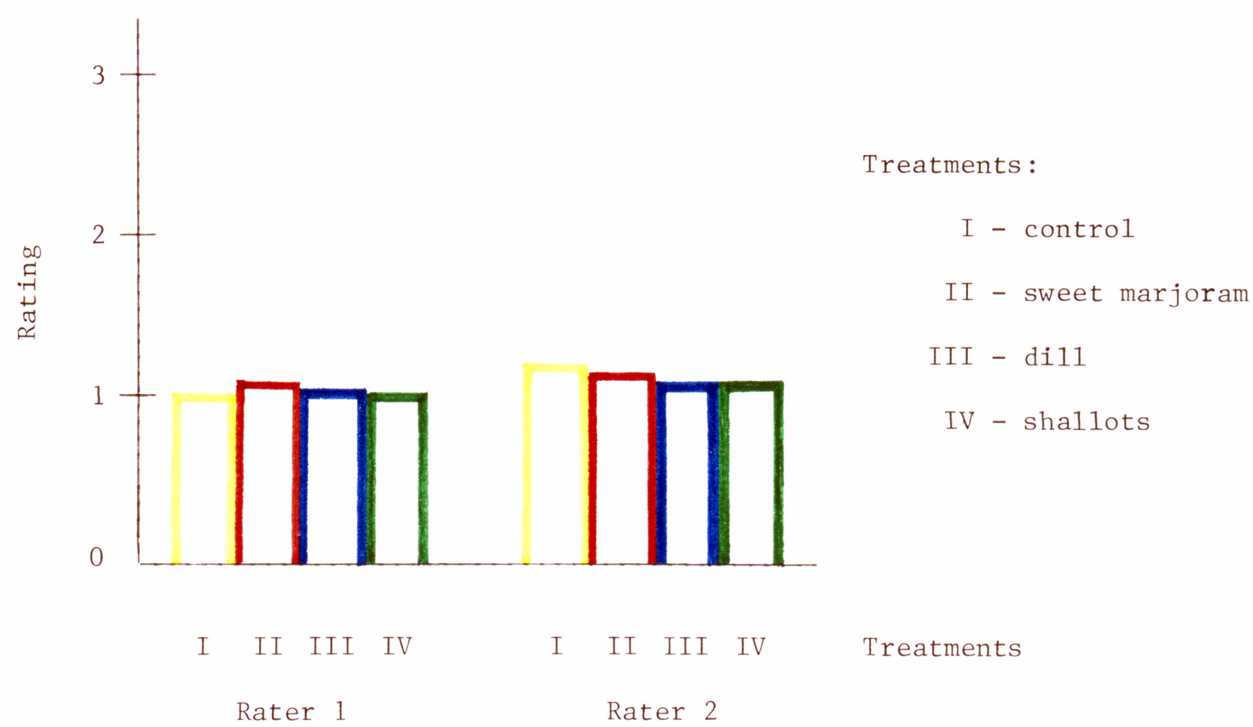
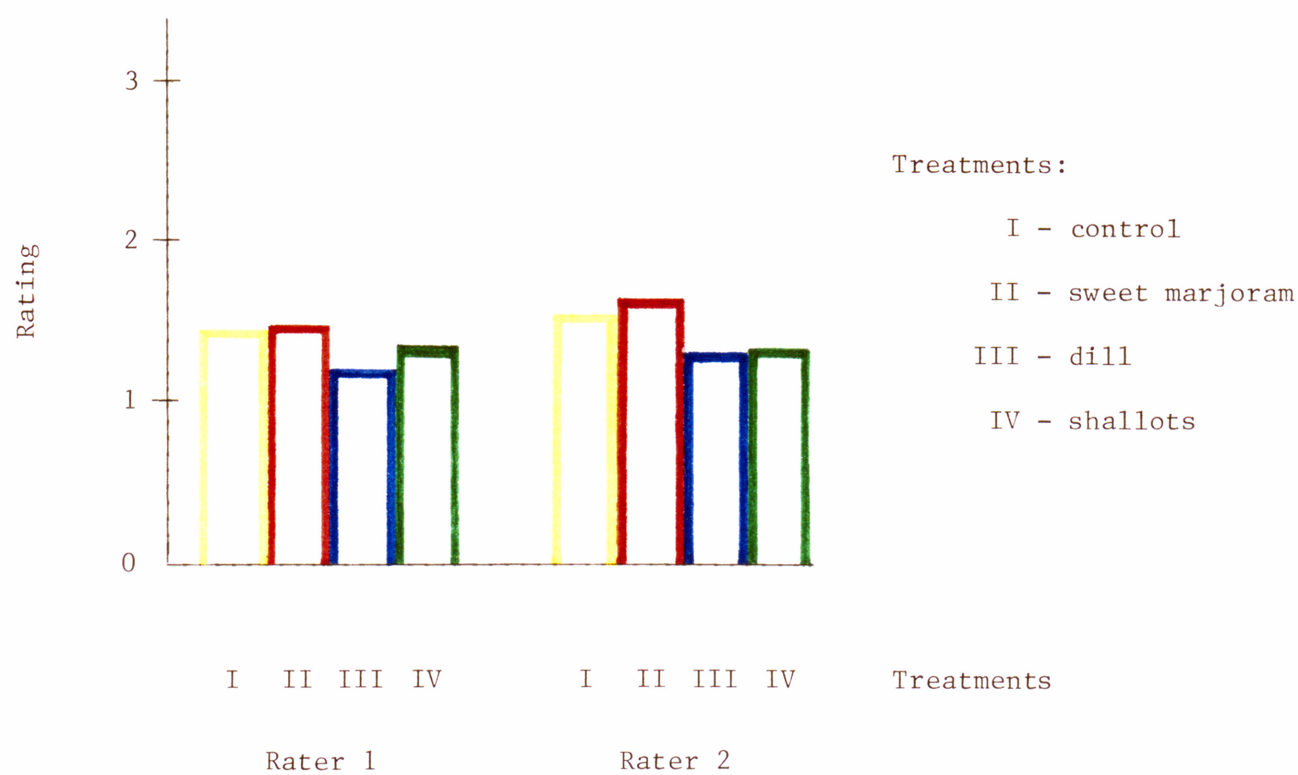


Figure 8. Comparison of average treatment ratings for spots.



CONCLUSION

Three herbs -- sweet marjoram, dill, and shallots -- did not repel insect pests when grown in a companion planting system with mustard. Reports that herbs do protect vegetable crops from insect damage have proved false in this particular study; however, these reports cannot be negated on the basis of one experiment. Other plant combinations could be tested in varying conditions for more substantial information concerning this alleged allelochemical phenomenon. It is clear that reports of successful insect control by herbs in companion planting systems need to be qualified and supported by scientific evidence.

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