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Varietal Response in Alfalfa for Seed Production as Affected by Lygus Infestation and Related Factors

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VARIETAL RESPONSE IN ALFALFA FOR SEED PRODUCTION
AS AFFECTED BY LYGUS INFESTATION AND RELATED FACTORS

by

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Figure 1. High seed yields are produced by healthy plants of alfalfa possessing potentials for high seed production, and provided with a wholesome environment.

INTRODUCTION

Alfalfa is one of the most valuable of our forage crops. A dependable source of seed is therefore a primary essential to the success of our present system of agriculture. More than 70 million pounds of alfalfa seed are required each year in the United States to maintain the present hay and pasture acreage of this crop; and the annual demand for seed would increase to more than 100 million pounds if the acreage were expanded to the extent recommended for soil conservation and a balanced agricultural security.

The office of Agricultural Statistics, Bureau of Agricultural Economics, United States Department of Agriculture, Salt Lake City, Utah, reported an increase in the production of alfalfa seed for Utah that began in 1919 and continued until 1925. The estimated state production during this period varied from 3,540,000 pounds in 1919 to a total of 23,232,000 in 1925. The acreage devoted to this crop increased from 13,000 acres in 1919 to 71,700 in 1925, with acre yields varying from 272 pounds in 1919 to 320 pounds per acre in 1925.

However, since 1925 there has been a steady decrease in yields and total production of alfalfa seed in Utah. By 1932 annual production had declined to an all-time low of 1,320,000 pounds with production during the next 13 years generally well below 5,000,000 pounds. Crop failures for the period were therefore made the subject of considerable study. Research has shown the effects of many factors; namely, soils, soil moisture, climate, harmful and beneficial insects. Interrelationships and complexities occur, such that no condition or factor by itself has been found to be wholly responsible for the success of a seed crop, or the ability of the plant to produce seed. In other words, failure of a seed crop cannot be attributed to any one factor alone. However, some factors have been found to be more important than others.

Predominant among the factors found to affect seed setting and seed production in alfalfa are the harmful insects. This is evident from the conspicuous damage inflicted by lygus bugs, grasshoppers, weevil, spider-mites, and leaf hoppers. Nevertheless, the actual importance of these insects in relation to seed setting and seed production in alfalfa has been found to vary with the genotype of the alfalfa plant itself and its inherent potentials and ability to produce seed.

Lygus bugs especially are recognized as the limiting factor in seed production in Utah; and only after they have been practically eliminated from the fields is it possible to study the effects of other variables related to alfalfa seed production. Hence, the present work has been primarily a study of alfalfa varieties and their response as affected by lygus bugs. Data were taken on flowers per raceme, pods per raceme, seeds per pod, seed yield and other characteristics such as would express more effectively the influence of these insects on alfalfa at various levels of infestation.

Field plots of alfalfa, methods, and techniques for this study were made available to the writer through the facilities of the Utah Agricultural Experiment Station and the United States Department of Agriculture Legume Research Laboratory, located on the college campus at Logan, Utah.

REVIEW OF LITERATURE

Studies Concerning Varietal Potentials and Response in Alfalfa

Only healthy, vigorous plants are capable of flowering profusely and producing high seed yields is the finding of Drake (21). Bohart, et al., (6) states that among conditions favorable for activity of bees on alfalfa are an abundance of healthy flowers produced on healthy plants. This is in accord with work done by Vansell and Todd (47), and Linsley and Mac Swain (29). After years of experimental study with lygus as a factor causing reduction in seed yields of alfalfa, Sorenson (40) indicates that factors other than lygus damage possibly contribute to shriveled seed, indicating that a favorable environment involving many factors is necessary for healthy plant development.

Carlson (10) states that the present tendency in alfalfa improvement is the development of strains for special purposes and conditions. Blinn (5), Tysdal (45) and Whornham (48) are also convinced that through selection and breeding much could be accomplished to increase seed yields of alfalfa. Carlson (15) and Noyes (31) found a close relationship between size of alfalfa plant and seed production, height being positively associated with total number of racemes. Aamodt and Carlson (1) at Wisconsin, concluded that varieties differ widely in their ability to flower abundantly when subjected to moderate lygus infestation. Later, Carlson (12) found a 404 pound per acre yield in favor of the high yielding clones. The difference was attributed to the character of the genotype, since all other factors were as nearly equal as was possible under controlled conditions. Cooper, Brink, and Albrecht (19) related low yields with poor fertilization development due largely to the failure of the pollen tube to reach the ovules, even though the flowers had been tripped. In other words, they found the group of high seeders produced 1.25 seeds per flower compared with 0.07 seeds per flower in the low yielding group. These results are in agreement with those obtained by Carlson (12) and Downs (20). Carlson (14) also found that under natural conditions many flowered racemes produced proportionately more pods than few-flowered racemes. Flowers forming pods increase when plants are grown in a favorable environment as shown by Haws (23). Sorenson (40) found the total number of seeds per pod to be reduced as a result of lygus feeding.

Studies Regarding Structure of the Alfalfa Flower

Piper, Evans, McKee, and Morse (33) in 1914 were principally concerned with the structure of the alfalfa flower and the tripping process. Bohart, Pedersen and others (6) explained and illustrated the flower structure as associated with tripping, pollination and fertilization.

Studies Concerning Pollination and Fertility

Bohart (6) and co-workers stated that the mechanism of the alfalfa flower must be understood before there can be a full understanding of the tripping process and the work of insect pollinators. These workers also found that selfed flowers formed fewer pods than cross-pollinated flowers; and that fertilization subsequent to pollination is a plant response. Haws (23) indicated the need of insect pollinators; and that their protection must be recognized. Seed setting of individual plants of alfalfa seem to be closely associated with their innate response to controlled pollination as advanced by Carlson (15). Fryer and Clark (18) found pollen sterility to merit consideration in alfalfa plants.

Pederson and Todd (32) state that flowers must be tripped before pollination can be effected and that bees are the only agents capable of pollinating alfalfa flowers on a field basis. Piper and Evans (33), Appleton (3), and Armstrong (4) also found tripping to be a necessary function of the plant. Carlson (14) observing flowers allowed to develop naturally, found 10.8 percent which had been tripped, while 37 percent formed pods. This was interpreted to indicate the possibility that alfalfa flowers may form pods rather freely without tripping. However, he found that artificial tripping increased the number of flowers forming pods in a ratio of approximately 1:3 compared with natural development. Fryer and Clark (18) found that although artifically tripped flowers gave an increase in percentage of seed set, only one-half the total flowers tripped set seed. Tysdal (44) found mechanical tripping was not feasible. Jones (25) also worked with mechanical tripping and found the method was successful in tripping 59 percent of the flowers.

Work supporting the idea that flowers must be tripped and cross-pollinated for successful alfalfa seed production has been done by Tysdal (44), (45), Knowles (27), Downs (20), Carlson (11), (12), (15), Vansell and Todd (27). That pollination of alfalfa is dependent upon both the wild bee and the honey bee has been shown by Bohart, et al., (6), Linsley and MacSwain (29), Jones (25), and Bolton (7) also show the importance of cross-fertilization by working with both selfed and cross-fertilized plants.

Studies of Cultural Practices

Blinn (5) working with alfalfa as early as 1913 felt that excessive amounts of soil nitrates may seriously affect seed yield in irrigated regions. Carlson (9), (10) in work completed in 1931 and 1932, respectively found seed yields highest from no manure and lowest at a 15-ton-per-acre application. Whornham(48) found fertilizers to have no apparent effect on seed production.

Grandfield (22) found less vigorous growing alfalfa with high reserves produce more racemes, flowers, pods, and seeds than with low reserves at the same moisture level.

Aicher (2), from studies in Idaho in 1917, found moisture to be an important factor in seed production. Carlson (9), Grandfield (22), and Whornham (48) found that a limited water supply which allows slow and even growth is desirable in alfalfa seed production. Carlson (11) gave significance to the fact that the highest acre yields of alfalfa seed on record was produced during a period when the precipitation was normal or above under the arid conditions prevailing in Utah. Blinn (5) found that moisture should be regulated to produce a minimum amount of forage, but still meet the requirements sufficient to mature the seed properly. Vansell and Todd (47) in studies around Logan found that nectar-collecting honey bees to be abundant on irrigated alfalfa, but no pollen collectors were observed. Martin (30) referred to a condition in the seed development as "blasting" caused by the arrested development of the embryo due to lack of proper nourishment or to some pathological condition due to improper moisture balance. Downs (20) did similar work and found moisture related to pollen germination. Armstrong (4) found that alfalfa strains differed in the degree of water resistance of the pollen and the need of sufficient water metabolism to prevent ovule abortion.

That cultivation of alfalfa did not result in better seed yields, and is recommended only for weed and insect control is the finding of Carlson (9) and Whornham (48).

Carlson (10) in 1932 explains that it has not been determined definitely whether first or second crop should be left for seed and that this must be determined by the area and season the crop is to be grown. That staggering the cutting of first crop alfalfa does provide greater pollinating efficiency by the bees is suggested by Drake (21). Pasturing-off the first crop alfalfa in late spring, preferably not later than May 15, has resulted in good seed yields as shown by Blinn (5), Carlson (9), and Whornham (48); but these yields do not exceed those obtained with no clipping or pasturing-off the alfalfa.

Low seed yields were found to be associated with thick stands and lodged plants by Carlson (10) and Tysdal (45). Higher seed yields from alfalfa grown in hills and rows were obtained by Carlson (11) and Whornham (48).

Studies of Climatological Data

Both Carlson (11) and Grandfield (22) feel that alfalfa seed production is best where the air humidity is low and the soil moisture is below optimum. Working in Idaho, Aicher (2) related climate, moisture and insects as principal factors affecting seed production in that region. Appleton (3) found no direct relationship between sunshine, temperature or precipitation and tripping frequency. From results by Knowles (27) temperature was thought to be an important weather factor influencing tripping of alfalfa flowers. This was in general agreement with Fryer and Clark (18), Downs (20), and Sorenson (38). In addition to temperature, they feel moisture is a most necessary requirement of the alfalfa plant. Armstrong (4) found air humidity to be closely associated with pollen germination. Tysdal (44) states that apparently favorable or unfavorable environmental conditions are associated with rapid changes in insect populations.

Studies of Plant Diseases

Bohart, Pedersen, and co-workers (6) explain that bacterial wilt, *Corynebacterium insidiosum*, causes a thinning of the stand and reduction in yield beginning approximately the third year. They also found bacterial stem blight, Pseudomonas medicaginis, Sackett; and yellow leaf blotch, Pseudopeziza jonseii, Nannf; are important foliar diseases affecting proper plant development and seed production. Tysdal (43), (46) reports on several important alfalfa diseases and states there is need for development of resistant alfalfa varieties.

Studies of Damage to Alfalfa by Lygus

Sorenson (38), (40) found Lygus hesperus and Lygus elisis to be associated with bud blasting, flower drop, shriveled seed and reduction in total number of seeds per pod in Utah. Knowles (27), in work done in Canada, generally supports this evidence. Carlson (12) showed that lygus-damaged plants may possibly be unattractive to bees. Bolton and Peck (8) found a significant positive correlation between the number of lygus bugs in a field and percent of brown and shriveled seed. Sorenson(39) and Carter (17) found that Miridae is the most injurious of all sucking insects to the alfalfa plant. Jeppson (24), Carlson (16) and King (26) suggested that damage done by lygus was possibly due to a toxic substance injected into the plant at time of feeding. These conclusions are based on evidence of disintegration and death of cells surrounding the small feeding perforations. Jeppson (24) found that lygus populations ranging from 6 to 16 bugs per stroke consistently reduce growth rate of alfalfa. Roberts (34) showed that lygus populations not in excess of 2.9 bugs per stroke are not a seriously inhibiting factor in flowering; whereas, Haws (23) considered these levels of infestation as not inhibiting seed production. This conclusion, however, is probably a mistake. Aamodt and Carlson (1) showed that varieties of alfalfa differ widely in their ability to flower abundantly when subjected to moderate lygus infestations. Noyes (31) adds support to these findings showing the effects to be influenced by the genetic makeup of the plant. Stitt (42) shows lygus and several other injurious insects to have a damaging effect on the vegetative growth of alfalfa.

Studies of Other Harmful Insects

Whornham (48) has shown that other insects when numerous may become a serious factor in alfalfa seed production. Bohart, Knowlton, Sorenson and others (6) list alfalfa weevil, Hypera postica Gyll; seed chalcid, Bruchophagus gibbus; grasshoppers, Locustidae; yellow-striped army worm, Prodenia ornithogalli; thrips, Frankinella spp.; aphid, Illinoia pisi Kalt.; and some species of leaf hoppers, in addition to lygus and mites as the most injurious pests in alfalfa seed production.

Studies of Lygus Control

Smith (37) is of the opinion that dusting is not necessary until lygus populations have reached or exceeded 10 bugs per stroke. Haws (23) found that lygus must be controlled. Smith (36) has shown dusting of alfalfa in the bloom with DDT to have a detrimental effect on the activity of the honey bee and that it should therefore be done in early morning or late evening. Lieberman (28) has shown wild bees to visit plots of alfalfa in proportion to bloom intensity regardless of dusting treatments. Early spring burning of stubble reduces the lygus population, explained Bolton (8). Experimental results by Sorenson (39), (41), and Lieberman (38) show that DDT (10 percent) applied at the rate of 20 pounds per acre gives almost complete lygus control. Bohart, Lieberman, et al. (6), give caution that only toxaphene should be used on seed alfalfa in the bloom and that among conditions favorable for activity of bees on alfalfa are an abundance of flowers produced on a healthy plant. Vansell and Todd (47) state that bees collect pollen only from those fields in a vigorous state of growth. Linsley and MacSwain (29) found the control of lygus will help provide conditions for better plant growth which will aid in attracting the bees. Drake (21) advised that applying DDT (10 percent) in two treatments greatly enhances the establishment of healthy vigorous plants capable of flowering profusely and producing a good seed yield.

METHODS OF PROCEDURE

Description of Experimental Plots

Location. The plots used in this study during the summers of 1949 and 1950 were located on the Utah Agricultural Experiment Station Forage Crops Farm,[1] three miles directly south of Logan, Utah.

Soil and soil moisture. Soil at this farm is of a clay loam texture, dark in color, of good fertility, and of good depth. Soil moisture was available at the six to eight foot level. Each season the plots received one irrigation which was applied during prebud stage of plant growth.

Flora. Weeds were not generally prevalent in the area surrounding the experiment plots or within them. Prickly lettuce, Lactuca elatior; common mallow, Malva rotundifolia; and green foxtail, Setaria viridis; represented the weeds observed growing along the ditch bordering the experiment on the north and east sides. The advanced alfalfa forage crops nursery approximated the plots on the south while other plantings of alfalfa bordered them to the west. (See figures 2 and 3, p. 12). A field of intermediate wheat grass, Agropyron intermedium, was grown approximately 40 feet to the north. Various other cultivated crops comprised the remaining plantings at the farm.

Fauna. Records of sweepings with an insect net indicated the most prevalent injurious insect species to be two species of lygus, Lygus elisus, Van Duzee; and Lygus hesperus, Knight; alfalfa weevil, Hypera postica, Gyll; pea aphids, Illinoia pisi; thrips, Frankiniella spp.; and a few grasshoppers. During the summer of 1949 several colonies of honey bees were placed near the plots. Leaf cutting bees, Megachille spp., and bumble bees, Bombus spp.,

1. Will be referred to hereafter in this paper as the South Farm.

Figure 2. Alfalfa forage crops nursery bordered experimental plots to the south.

Figure 3. Other forage alfalfa bordered experimental area to the west.

were also observed working the flowers during most of July; but were not active in great numbers after that time. Relatively light bee activity was observed during August. Although no colonies of honey bees were placed at the South Farm during the 1950 season, bees were present in sufficient numbers to effect a good percentage of flowers forming pods.

Size of plots. The experimental area consisted of 64 plots in each of four 40 foot by 58 foot blocks. Each plot consisted of three rows of alfalfa six inches apart and 12 feet long. The plots were separated by 18 inch alleyways and by a 24-inch margin at the end of each plot. Guard rows were placed 18 inches beyond the margin of the outside plots. (Refer to table 2, p. 21).

Methods of Planting and Stands

Planting. Plantings were made from seed sown in rows in the field April 24, 1949, at the rate of two grams per plot. Rapid growth favored by a good season made it possible to begin the experiment the same year.

Materials. Sixty-four varieties and strains of alfalfa, principally obtained from the alfalfa breeding stations at Nebraska, Wisconsin, Kansas and Utah were used. These included also seven standard varieties, namely: Ranger, Buffalo, Grimm, Narragansett, Ladak, Williamsburg, and Atlantic.

Treatments

1949 infestation levels. The experiment was designed to establish and maintain lygus populations at four levels, namely: 0 lygus, 1 lygus, 3 lygus, and 6 or more lygus per sweep of the insect net. The plan provided that these four levels of infestation would be established and then controlled by varying the strength of the DDT dust used; namely, 10 percent, 5 percent and 3 percent, respectively. The check block which received no dusting treatment, was allowed to develop to whatever population would occur naturally.

Sweeping plots. Lygus populations were determined by sweeping the area every two days during each stage in plant growth[2] and morphological development.[3] Particular care was exercised to provide complete protection to the zero lygus block in which the lygus population was maintained at the lowest level, especially during the prebud stage of plant growth. Sweepings were made whenever the records showed the lygus populations to be increasing, even though the prevailing population had not approached or exceeded the desired level. The critical period includes the stage of plant development prior to the formation of buds and until the flowers have begun to form pods. (See figure 4, below). Thereafter the sweeping frequency was gradually

Figure 4. A portion of the experimental area during the flowering stage in plant growth and development

2. Includes stage of the plant until it has fully attained its vegetative growth.
3. Is referred to as the period of flowering and seed setting

reduced to a weekly basis. Standard insect nets were used in accordance with the standard procedure. The desired levels of lygus infestation were found to have become established naturally when the alfalfa was about four inches in height and were thus maintained throughout the remainder of the season. An attempt had been made by Noyes (31) and Haws (23) in a previous experiment to establish similar levels of infestation artificially, which was unsuccessful. It was therefore considered best in this experiment to permit their natural development to the desired levels.

<u>Dusting plots</u>. Sweeping records were kept of all insects of any abundance captured on the plots. Their elimination was also effected when desired by the use of proper insecticides, thus eliminating damage not ascribable to lygus bugs. In order to maintain the zero lygus level of infestation, 10 percent DDT dust was used when the sweeping indicated the bug populations to be in excees of one-half bug per sweep. However, the influx of adult lygus made it impossible to maintain the populations at the zero level. DDT dust at five percent and three percent strengths were used to control the one bug and three bug levels, respectively. Whenever it was evident the lygus numbers were rapidly approaching or exceeding the desired levels, the blocks were dusted immediately. Dust was applied early in the morning before seven a.m. or in the evening shortly before sundown to insure protection to the bees. An attempt was also made to reduce drifting to a minimum, yet some drifting did occur when it became necessary to dust at a time when the bug populations demanded immediate attention.

<u>1950 infestation levels</u>. Infestations for the 1950 growing season were established and maintained as nearly as possible at the same levels as those for 1949. However, toxaphene was used instead of DDT to reduce the populations to the required levels during the blossoming periods. The desired

levels were thus accurately controlled with a minimum injury to bee pollinators.

Harvesting. Harvesting on all plots during both the 1949 and 1950 seasons was begun in September at a stage of maturity when at least two-thirds of the pods were brown or buckskin in color. The material from each plot was placed in a sack and allowed to dry inside a storage building. Threshing was done with a small gravity seed thresher.

Source of Data Collected

Lygus population. During the more critical period of plant growth and development, sweeping records were taken every two days. This was necessary to maintain a check on the migratory adult lygus in order to keep the bug population as near to the prescribed infestation levels as possible. Data taken are expressed as the average number of lygus bugs per sweep of a standard insect net for each block during the growing season.

Pollination efficiency. Data were taken for a measure of seed setting and seed production efficiency as follows: 1. florets per raceme; 2. pods per raceme; 3. seeds per pod; and 4. seed yields. Twenty-five racemes were collected at random from each of the 256 plots at two different flowering periods. The first sample was taken as soon as an adequate number of flowers had developed to permit random sampling. (See figure 4, p. 14.) Approximately two weeks later a second flower sample was taken. For each of the 25 racemes the average number of flowers per raceme was determined.

The percentage of flowers forming pods was also determined by similar methods at two different periods. The first collection was taken approximately 10 days following the initial flower set. However, it was necessary when collecting racemes of pods during the second period to differentiate between the pods developed from the first crop of flowers and those of the second flowering period, respectively.

During the second period only those racemes whose pods still possessed a portion of withered flower parts or were dark green in color were taken. From the available flower and pod data,[4] the percent of flowers forming pods was determined. In this way a method was found whereby seed setting efficiency was obtained.

Twenty-five racemes of pods were again collected just prior to harvesting from which four pods were taken at random for a determination of the average number of seeds per pod.

Seed yield data were also taken for each of the varieties and strains.

Figure 5. Collecting the last flower sample

4. Represent the same period of plant development.

RESULTS

The experiment made possible the collection of a large volume of data, only a part of which are presented in this paper. Some of them will be published by Dr. J. W. Carlson in a Utah Agricultural Experiment Station Bulletin.[5] All data summarized in this report will be discussed under the following topics in order: 1. varietal response; 2. lygus infestation and population trends; 3. pollination and seed setting; and 4. variability and correlation. Special emphasis is given to their agronomic implications, with recognition of entomological work only as it affects the agronomic phases of the study. The writer recognizes various limitations in applying tests of significance owing to the design of the experiment.

Varietal Response

The data provided ample means for analyzing the inherent potentials and response of the various strains and varieties of alfalfa for seed production in this area. The writer wishes to remind the reader that the results are based on the plant performance for only two years which is probably not sufficient to evaluate response adequately from a breeder's viewpoint.

However, it is not the purpose here to discuss breeding in detail but rather to indicate that potentials and response for seed production may be expected to vary with strains and varieties of alfalfa and with the environment under which they are grown.

The alfalfa material used was divided into two groups which will be referred to as high and low seeders. The point of division is 150 pounds per acre, or the mean seed yield for the 1949 seed crop. On this basis, it

5. Bulletin in process of preparation.

happens that an equal number of varieties and strains are represented in each group. Furthermore, the same strains and varieties which were among the high seeders for 1949 were also the high seeders for 1950. This indicates, possibly, that varietal response to seed production might be of hereditary origin.

The mean total yields for 1950 are greater for both the high and low seeders than in 1949. Data are given in table 1. This is as may be expected since the yields for 1950 were obtained from second year plants which were more mature and possessed a greater capacity for production. Table 1 further shows that the DDT 10 percent dusted block produced much higher yields than the check block when comparing high and low seeders in 1949. This was also true during 1950 which demonstrates the importance of a favorable environment characterized particularly by low lygus populations.

Table 1. Seed yields of low and high seeding varieties and strains of alfalfa as affected by the differential contol of lygus bugs

Season and seeding groups	No dusting	Dusted* DDT, 3%	DDT, 5%	DDT, 10%	Means
1949 (1st year plants)					
Low seeders (n-32)	42**	73	151	197	115
High seeders (n-32)	62	123	243	346	193
Means	52	98	197	271	154
1950 (2nd year plants)					
Low seeders	127	85	197	241	165
High seeders	173	126	258	381	235
Means	150	105***	227	311	200

*One prebud, one late bud, and two bloom applications. (Toxaphene used in the bloom in 1950).

**Seed yield in pounds per acre.

***Lygus populations, principally the nymphs, were greater on the DDT 3 percent block than on the check block in 1950.

Relatively small differences were found between the average yields of the two years. This can be accounted for by differences in conditions affecting the plots during the two years. Severe infection by bacterial stem blight, Pseudomonas medicaginis, Sackett, and yellow leaf blotch, Pseudopeziza jonesii, Nannf, was also prevalent over the entire planting in 1950 (see figure 6, p. 23). Consequently, it is estimated that the seed yields for 1950 were reduced to approximately one-half.

Yield differences between the DDT 3 percent dusted and the check block in 1950 are not entirely explainable. However, the proximity and management of the forage alfalfa surrounding the plots may provide a partial answer. (See figures 2 and 3, p. 12.) These deviations from normal expectancy bear further evidence of the need to establish healthy plants with high seeding potentials to be maintained by controlling and eliminating unfavorable environmental conditions; and that seed production is affected by the interaction of many factors, including resistance to insects and disease. This suggests that varieties and strains respond differently in their ability to produce seed. Seed yield data as given in tables 2 and 3 suggest this possibility. The varieties and strains receiving complete protection[6] exhibited outstanding results in seed production during the seeding year and were compared for their yield performance in each of their environments.[7] These comparisons were also made for the yield data as obtained in the 1950 season. Almost without exception, as the environment became less favorable the seed yield became progressively lower. Contrary results shown by a few exceptions may be accounted for, partially at least, by their position within the block.

6. Ten percent DDT dusted to establish and maintain lygus number as nearly the 0 level as possible.
7. Lygus differential established approximately at the 0 bug, 1 bug, 3 bugs, and 6 or more bugs per stroke of a standard insect net.

Table 2. Comparative seed yields of 64 varieties and strains of alfalfa randomized 4 times and given differential dusting with DDT for the control of lygus bugs.* 1949.

10% DDT dusted

** 19	20	23	24	22	17	18	21	40	37	33	35	38	34	39	36
***705	420	435	474	297	420	240	270	408	207	303	342	183	240	141	126
55	52	50	54	56	49	53	51	30	32	27	31	25	28	26	29
324	315	339	222	408	297	180	222	312	210	243	180	357	231	222	291
46	47	44	45	41	43	48	42	60	64	63	61	62	59	57	58
336	129	378	390	255	258	204	201	177	465	330	102	336	180	66	147
12	13	9	11	16	10	15	14	5	6	3	2	1	7	8	4
297	294	135	153	420	198	360	252	282	330	153	384	222	192	150	153

No dusting

56	64	40	32	24	48	8	16	1	49	41	57	33	25	17	9
105	195	81	30	48	45	36	36	24	30	27	6	30	21	33	6
53	37	45	21	13	5	29	61	22	30	38	46	6	54	62	14
87	90	150	54	87	60	30	12	6	33	24	21	15	9	12	6
35	27	51	11	43	19	59	3	39	55	63	15	31	7	47	23
66	129	60	24	78	87	48	15	21	36	48	18	9	12	6	27
26	18	2	58	34	10	42	50	44	60	12	4	28	36	20	52
117	126	180	93	102	87	72	42	42	39	75	33	21	195	18	9

5% DDT dusted

3	59	51	11	27	43	35	19	12	4	36	60	44	52	28	20
72	132	132	138	258	357	195	345	297	264	189	126	234	150	258	195
23	31	55	7	15	63	39	47	57	25	33	49	17	41	9	1
171	129	243	132	303	258	135	108	141	300	357	135	225	291	180	117
32	64	24	8	40	56	48	16	34	2	58	50	26	10	42	18
120	417	312	168	264	105	189	342	192	294	219	165	165	171	96	138
29	37	45	13	21	53	5	61	6	14	46	30	54	22	38	62
60	108	216	162	129	105	144	72	288	240	225	162	177	177	165	90

3% DDT dusted

12	13	10	9	16	14	11	15	42	41	45	44	48	47	43	46
126	90	90	78	210	75	60	81	36	60	90	72	66	24	30	30
17	18	24	19	22	20	23	24	60	61	63	57	64	62	59	58
123	270	159	180	165	162	156	240	84	36	21	144	60	120	105	42
5	7	6	3	1	2	4	8	39	37	34	35	40	38	36	33
105	108	267	81	105	162	132	72	69	45	36	84	84	39	15	55
51	54	49	53	52	56	50	55	32	30	25	28	29	31	27	26
186	120	135	90	84	138	141	105	60	60	114	108	39	36	33	54

* The experimental area consists of 4 blocks each 40 X 58 feet. Each block represents 64 individual plots, each of which constitutes a variety or strain consisting of 3 rows, 6 inches apart and 12 feet in length. Plots were separated by 18 inch alley ways and by a 24 inch margin at the end of each plot.

** Top number represents the alfalfa variety or strain.

*** Bottom number represents the seed yield of the associated variety or strain.

Table 3. Comparative seed yields of 64 varieties and strains of alfalfa randomized 4 times and given differential dusting with DDT for the control of lygus bugs.* 1950.

10% DDT dusted

** 19	20	23	24	22	17	18	21	40	37	33	35	38	34	39	36
***630	450	482	512	272	512	481	601	420	422	902	450	513	272	271	212
55	52	50	54	56	49	53	51	30	32	27	31	25	28	26	29
361	270	212	330	181	301	213	270	422	243	272	181	391	301	181	182
46	47	44	45	41	43	48	42	60	64	63	61	62	59	57	58
570	180	450	212	183	272	301	122	182	272	240	93	331	180	181	212
12	13	9	11	16	10	15	14	5	6	3	2	1	7	8	4
600	303	152	210	300	183	242	392	272	271	120	272	183	302	183	152

No dusting

56	64	40	32	24	48	8	16	1	49	41	57	33	22	17	9
332	451	242	151	182	270	212	152	151	150	122	93	180	212	303	92
53	37	45	21	13	5	29	61	22	30	38	46	6	54	62	14
181	181	182	90	62	121	90	91	91	181	120	180	151	180	92	121
35	27	51	11	43	19	59	3	39	55	63	15	31	7	47	23
151	121	62	61	91	212	123	301	60	122	180	181	62	122	60	92
26	18	2	58	34	10	42	50	44	60	12	4	28	36	20	52
181	270	180	213	182	93	152	182	121	92	242	60	91	91	150	61

5% DDT dusted

3	59	51	11	27	43	35	19	12	4	36	60	44	52	28	20
92	331	182	180	152	181	153	273	361	151	151	153	242	150	242	242
23	31	55	7	15	63	39	47	57	25	33	49	17	41	9	1
511	241	331	242	212	270	122	120	120	183	272	212	332	211	122	180
32	64	24	8	40	56	48	16	34	2	58	50	26	10	42	18
210	393	330	270	301	153	211	181	180	181	300	182	150	122	153	182
29	37	45	13	21	53	5	61	6	14	46	30	54	22	38	62
152	240	483	300	242	121	242	120	301	452	212	210	272	242	181	181

3% DDT dusted

12	13	10	9	16	14	11	15	42	41	45	44	48	47	43	46
331	152	91	120	122	121	61	91	120	91	150	32	92	63	92	60
17	18	24	19	22	20	23	21	60	61	63	57	64	62	59	58
301	211	121	180	123	182	122	91	62	62	122	60	62	92	124	30
5	7	6	3	1	2	4	8	39	37	34	35	40	38	36	33
91	92	123	62	121	180	92	120	32	60	60	62	122	61	92	32
51	54	49	53	52	56	50	55	32	30	25	28	29	31	27	26
63	152	150	31	121	151	63	152	120	180	121	92	37	31	91	32

* The experimental area consists of 4 blocks each 40 X 58 feet. Each block represents 64 individual plots, each of which constitutes a variety or strain consisting of 3 rows, 6 inches apart and 12 feet in length. Plots were separated by 18 inch alley ways and by a 24 inch margin at the end of each plot.

** Top number represents the alfalfa variety or strain.

*** Bottom number represents the seed yield of the associated variety or strain.

In most cases, either they benefited from the protective dust drifting from the adjacent block or were unduly hampered in their development by the lygus influx from plantings surrounding the experimental area. A few varieties and strains in the check block (six or more lygus per stroke) gave outstanding yields when compared with the other varieties and strains within the block. These same representatives were also among the highest yielders, in most cases, in the other blocks.[8] This appears to be an excellent source of breeder's material in developing lygus-resistant strains.

Figure 6. Shows serious infection by bacterial stem blight on alfalfa

Table 4 shows comparative seed yields of seven high yielding improved strains, a selected group, taken from the general mean yield of the collective group of 64 varieties and strains. Large differences were not apparent between the strains for either season. There was, however, a considerable difference

8. DDT 10 percent, DDT 5 percent, and DDT 3 percent dusted.

in yield between seasons and among treatments. Table 5 presents an unselected group of seven standard varieties included in this experiment, which gave results similar to those of the selected group of high-yielding improved strains referred to above. It was interesting to hote, however, that the yield performance of the seven standard varieties was equal only to, or slightly below the mean yield of all the 64 varieties and strains. Again the check block produced greater yields than the DDT 3 percent block which was due largely to the different lygus numbers occurring within these two blocks during the critical period of plant growth and development.

Table 4. Comparative seed yields of seven high-seeding strains of alfalfa as affected by the differential control of lygus bugs

Season and strain	No dusting	Dusted*			Means
		DDT, 3%	DDT, 5%	DDT, 10%	
1949 (1st year plants)					
1	87**	180	345	705	329
2	195	60	417	465	284
3	180	162	294	384	255
4	36	210	342	420	252
5	15	267	288	330	255
6	150	90	216	390	211
7	81	84	264	408	209
Means	106	150	309	443	256
1950 (2nd year plants)					
1	212	180	273	630	324
2	451	62	393	272	295
3	180	180	181	272	203
4	152	122	181	300	189
5	151	123	301	272	212
6	182	150	483	212	257
7	242	122	201	420	271
Means	244	133	301	339	250

*One prebud, one late bud, and two bloom applications. (Toxaphene used in the bloom in 1950).
**Seed yield in pounds per acre.

Table 5. Comparative seed yields of seven standard varieties of alfalfa as affected by the differential control of lygus bugs

Season and varieties	No dusting	Dusted*			Means
		DDT, 3%	DDT, 5%	DDT, 10%	
1949 (1st year plants)					
Ranger	90**	45	108	207	112
Buffalo	21	69	135	141	91
Atlantic	33	132	264	153	145
Grimm	24	60	138	153	93
Ladak	93	42	219	137	125
Narragansett	9	120	177	222	132
Williamsburg	87	90	171	198	136
Means	51	80	173	173	119
1950 (2nd year plants)					
Ranger	181	60	240	422	226
Buffalo	60	32	122	271	121
Atlantic	60	92	151	152	114
Grimm	61	61	180	210	128
Ladak	213	30	300	212	189
Narragansett	180	152	272	330	236
Williamsburg	93	91	122	183	122
Means	121	74	198	244	162

*One prebud, one late bud, and two bloom applications. (Toxaphene used in the bloom in 1950).
**Seed yield in pounds per acre.

Lygus Infestation and Population Trends

A lygus population differential[9] was successfully established by natural methods on the four experimental blocks by observing the records of sweepings of each block and dusting to control the increased population trend when necessary. Table 6 shows the sequence successfully maintained for the four blocks during the 1949 season. However, some difficulty was encountered in an attempt to duplicate the conditions in 1950. Variation in the lygus populations for the DDT 3 percent and check blocks during the 1950 season was not

9. Four levels established at approximately the 0 bug, 1 bug, 3 bugs, and 6 bugs per sweep of a standard insect net.

entirely accounted for, except that the block was adjacent to more of the surrounding alfalfa which was cut for hay during the season.

Lygus population consisted principally of adults which introduced the problem of migration from adjacent blocks and surrounding area. The average number of lygus in each treatment during 1949 was higher than occurred in respective treatments for 1950. The sweeping records, however, show little difference in the average lygus numbers between the DDT 5 percent and 10 percent blocks. The lygus numbers, particularly during the early growth and development period of the plant, included a rather high number of nymphs in addition to the adult lygus present; whereas, the lygus numbers shown for the DDT 10 percent block was composed principally of adults.

Table 6. Number of harmful insects in alfalfa in relation to dusting with DDT for the control of lygus bugs

Harmful insects**	No dusting	Four applications* DDT,3%	DDT,5%	DDT,10%	Means
Alfalfa weevil					
1949	(negligible infestation in 1st year plants)				
1950	.22	.18	.36	.01	.19
Lygus bugs					
1949	6.60	2.50	1.30	1.20	2.90
1950	.99	1.10	.53	.15	.69

*One prebud, one late bud, and two bloom applications.
**Population values represent the average number of insects per sweep of a standard insect net as determined from 25 sweeps.

As previously indicated, tables 4 and 5 which show differences between the mean yields of plots receiving different dusting treatments, seem to have significant value. This suggests the effect of environmental variability influenced primarily by lygus bugs, that is evident from the comparison of yield data between treatments for each season. Variations in lygus populations seem thus to have a serious effect upon seed production. It will be noted from data given in table 6, that during the two seasons considerable variations in lygus populations existed. It was not possible to eliminate completely the bugs during the two seasons on the block dusted with DDT 10 percent strength. The average population was thus found to be 1.20 lygus per stroke during the initial year. However, at this level good seed yields were obtained which is in accord with the previous findings of Carlson (16) and Sorenson (39). Haws (23) has indicated that lygus do not become economically important in seed production until they exceed approximately 3 bugs per stroke. The finding of these investigators are, therefore, not in complete accord with the results in the present experiment, in which the average number of lygus during the season on the same block dusted with DDT 10 percent was reduced to 0.15 lygus per stroke in 1950, as shown in table 6.

Table 5 shows a considerable increase in seed yields for the seven standard varieties receiving the DDT 10 percent treatment (0.15 bugs level) when compared with the DDT 5 percent treatment at the 0.53 bug level. Also, a similar yield increase was obtained when comparing the DDT 5 percent with the DDT 3 percent treatment (1.1 bug level). These data show little difference for the same treatments between the two seasons. Although lower bug populations were present during 1950, other existing factors did not provide an environment conducive to higher yields. Foremost among these is the serious disease infection, which invaded the plots, and is considered to have seriously affected the seed yields in 1950. If an eradication of the diseases could have been effected, an outstanding increase in yield would have resulted from the dusting, especially for the 10 percent and 5 percent blocks.

Pollination and Seed Setting

The structure of the alfalfa flower is an adaptation for cross-pollination. It is generally assumed, therefore, that a rather low percentage of the flowers became self-pollinated. The majority of the flowers are thus dependent upon bees for pollination. For this purpose several colonies of honey bees were placed at the South Farm during the 1949 season. In addition, a few wild bees such as Megachille and Bombus species were found to be actively working the flowers. However, no bee colonies were placed at the farm in 1950, yet both honey bees and wild bees were present in rather large populations. Differences in pollination efficiency of the alfalfa groups studied appeared important. Thus, the four types of data collected (p. 16) for a measure of seed setting and seed production efficiency were calculated.

Tables 7, 8, and 9 show small or no differences when comparing the average number of flowers per raceme between groups[10] studied in each specific year or between treatments for that season. However, the average number of flowers per raceme does show a marked increase between seasons.

The number of flowers alone does not insure a good seed yield but a high seed yield does require a large number of flowers in addition to all the other conditions and factors present which are favorable and necessary for a healthy plant response.

The average number of pods per raceme, shown for the same groups, in tables 10, 11, and 12, follows a trend in each case similar to the results as indicated for the flowers. Again, only small differences were noted except between seasons. Thus, the average number of flowers and pods per raceme were both influenced by seasonal differences existing during 1949 and 1950. This, too, can be associated with the advantage of second year plants which possess a greater capacity for seed production. This is in accord with Noyes

10. Segregated as high and low seeders, seven selected strains, and seven standard varieties.

(31) who found the size of the plant directly correlated with its capacity to produce.

The percentage of flowers forming pods provides a rather reliable measure for determining the actual seed setting and consequently a general indication of expected seed yields. This relationship of pods to flowers then should follow closely the results obtained separately for these two measures of pollination and seed setting performance.

Table 7. Flowering in low and high seeding varieties and strains of alfalfa as affected by the differential control of lygus bugs

Season and seeding group	No dusting	Dusted* DDT, 3%	DDT, 5%	DDT, 10%	Means
1949 (1st year plants)					
Low seeders (n-32)	11.6**	11.9	14.5	14.3	13.0
High seeders (n-32)	11.5	11.9	15.0	14.9	13.2
Means	11.5	11.9	14.7	14.6	13.1
1950 (2nd year plants)					
Low seeders	16.0	16.2	18.5	19.5	17.5
High seeders	17.6	16.9	18.5	20.0	18.3
Means	16.8	16.5	18.5	19.7	17.9

*One prebud, one late bud, and two bloom applications. (Toxaphene was used in the bloom in 1950).
**Average number of flowers per raceme.

Table 8. Flowering in seven high seeding strains of alfalfa as affected by the differential control of lygus bugs

Season and strains	No dusting	Dusted* DDT. 3%	DDT. 5%	DDT. 10%	Means
1949 (1st year plants)					
1	12.0**	12.5	14.3	15.0	13.4
2	12.6	11.8	17.3	16.8	14.6
3	12.5	12.2	15.5	15.0	13.8
4	12.0	12.7	13.9	17.9	14.1
5	11.1	13.3	16.4	15.0	13.9
6	13.7	9.9	16.8	15.2	13.9
7	14.1	11.4	16.8	19.3	15.4
Means	12.5	11.9	15.7	16.3	14.1
1950 (2nd year plants)					
1	17.3	18.6	18.5	23.5	19.5
2	19.0	19.1	20.7	21.5	20.1
3	19.1	17.5	16.6	18.2	17.9
4	16.8	19.6	13.9	22.4	18.2
5	18.8	18.3	16.7	16.0	17.5
6	17.2	14.1	20.6	23.2	18.8
7	18.1	17.3	21.3	21.4	19.5
Means	18.0	17.7	18.3	20.8	18.7

*One prebud, one late bud, and two floom applications. (Toxaphene used in the bloom in 1950).
**Average number of flowers per raceme.

Table 9. Flowering in seven standard varieties of alfalfa as affected by the differential control of lygus bugs

Season and varieties	No dusting	Dusted* DDT, 3%	DDT, 5%	DDT, 10%	Means
1949 (1st year plants)					
Ranger	12.0**	15.1	15.2	16.0	14.6
Buffalo	10.5	11.7	11.4	12.9	11.6
Atlantic	11.2	12.2	15.0	14.0	13.1
Grimm	11.7	11.2	15.1	15.4	13.3
Ladak	12.2	10.8	16.1	14.8	13.4
Narragansett	11.5	10.2	14.2	14.9	12.7
Williamsburg	11.2	12.6	13.6	12.9	12.6
Means	11.5	12.0	14.4	14.4	13.0
1950 (2nd year plants)					
Ranger	17.3	14.5	21.7	25.4	19.7
Buffalo	15.0	15.2	17.3	18.5	16.5
Atlantic	12.7	15.3	17.2	19.4	16.5
Grimm	15.6	13.6	15.3	18.3	15.7
Ladak	13.2	13.6	20.8	17.5	16.3
Narragansett	12.9	16.7	19.7	19.6	16.2
Williamsburg	17.8	20.0	18.6	17.6	18.5
Means	14.9	15.6	18.7	19.5	17.1

Table 10. Production of seed pods in low and high seeding varieties and strains of alfalfa as affected by the differential control of lygus bugs

Season and seeding groups	No dusting	Dusted* DDT, 3%	DDT, 5%	DDT, 10%	Means
1949 (1st year plants)					
Low seeders (n-32)	3.9***	4.4	5.7	6.0	5.9
High seeders (n-32)	4.4	5.0	6.1	6.3	5.4
Means	4.1	4.7	5.9	6.1	5.6
1950 (2nd year plants)					
Low seeders	9.1	9.9	10.9	12.8	10.7
High seeders	9.7	10.4	11.1	13.3	11.1
Means	9.4	10.1	11.0	13.0	10.9

*One prebud, one late bud, and two bloom applications. (Toxaphene used in the bloom in 1950).

**Average number of flowers per raceme.

***Average number of pods per raceme.

Table 11. Average number pods per raceme in seven high seeding strains of alfalfa as affected by the differential control of lygus bugs

Season and strains	No dusting	Dusted*			Means
		DDT 3%	DDT 5%	DDT 10%	
1949 (1st year plants)					
1	5.3**	5.4	5.5	6.4	5.6
2	5.6	5.1	5.8	6.8	5.8
3	6.3	4.5	7.1	5.9	5.9
4	4.3	4.6	6.5	7.1	5.6
5	3.6	6.4	4.5	5.5	5.0
6	5.9	4.2	5.7	7.7	5.8
7	5.2	4.6	6.1	6.3	5.5
Means	5.1	4.9	5.8	6.5	5.6
1950 (2nd year plants)					
1	9.4	9.9	14.1	15.2	12.2
2	13.3	8.3	10.5	11.3	10.9
3	9.0	15.7	11.3	12.0	12.0
4	9.0	10.8	13.4	15.3	12.1
5	10.3	11.7	14.6	11.2	12.0
6	8.9	8.3	9.9	15.0	10.5
7	10.7	7.3	8.9	13.0	10.0
Means	10.0	10.2	11.8	13.2	11.3

*One prebud, one late bud, and two bloom applications. (Toxaphene used in the bloom in 1950).
**Average number of pods per raceme.

Table 12. Average number of pods per raceme in seven standard varieties of alfalfa as affected by the differential control of lygus bugs

Season and varieties	No dusting	Dusted* DDT.3%	DDT.5%	DDT.10%	Means
1949 (1st year plants)					
Ranger	4.7	4.2	4.3	6.4	4.9
Buffalo	4.0	4.0	5.1	6.2	4.8
Atlantic	3.2	4.0	4.9	6.7	4.7
Grimm	4.6	5.4	5.5	5.1	5.1
Ladak	4.6	3.1	6.6	7.1	5.3
Narragansett	3.0	4.5	5.9	5.7	4.7
Williamsburg	4.5	6.4	5.3	5.7	5.4
Means	4.1	4.5	5.4	6.1	5.0
1950 (2nd year plants)					
Ranger	11.0	7.8	9.5	17.2	11.4
Buffalo	8.0	9.1	9.6	10.8	9.8
Atlantic	7.4	8.5	10.8	13.2	10.0
Grimm	9.9	4.9	13.1	13.6	11.1
Ladak	7.9	9.4	13.8	10.9	10.5
Narragansett	7.6	12.4	10.0	13.1	10.8
Williamsburg	10.0	11.3	9.1	12.0	10.6
Means	8.8	9.4	10.8	12.0	10.6

*One prebud, one late bud, and two bloom applications. (Toxaphene used in the bloom in 1950).
**Average number of pods per raceme.

Table 13 shows that significant differences occurred in the percentage of flowers forming pods when comparing the high and low seeders for the two seasons. These findings were also found to exist for seven high yielding improved strains and seven standard varieties, respectively, shown in tables 14 and 15. Again, little variation between varieties and strains within each season or between treatments is noted. There appears to be merit, however, in providing a better environment for growth and development.

This is likely best demonstrated by the relative percentage values for these same alfalfa groups when comparing plant performance in plots not protected[11] with the DDT 10 percent dusted plots. These data were not taken for 1949. However, the 1950 data alone presents some interesting results. For example, data given in table 16 show the high seeders to yield seeds per pod in greater numbers than the low seeding group when compared for each treatment. Further, it is interesting to note that a comparison of the flower and pod data of these same groups (previously shown in tables 7 and 10 respectively) are consistently in favor of the high seeders.

Table 13. Percentage of flowers forming pods in low and high seeding strains of alfalfa as affected by the differential control of lygus bugs

Season and seeding groups	No dusting	Dusted*			
		DDT, 3%	DDT, 5%	DDT, 10%	Means
1949 (1st year plants)					
Low seeders (n-32)	33.3**	37.5	40.0	42.3	38.2
High seeders	38.0	42.4	41.0	42.9	41.0
Means	35.6	39.9	40.5	42.6	39.6
1950 (2nd year plants)					
Low seeders	56.4	60.5	60.3	67.9	61.2
High seeders	55.3	62.2	60.7	67.3	61.4
Means	55.8	61.3	60.5	67.6	61.3

*One prebud, one late bud, and two gloom stage applications. (Toxaphene used in the bloom in 1950).
**Percent of flowers forming pods.

11. Did not receive dusting treatment.

Table 14. Comparative efficiency of seed setting in seven high seeding strains of alfalfa as affected by the differential control of lygus bugs

Season and strains	No dusting	Dusted* DDT.3%	DDT.5%	DDT.10%	Means
1949 (1st year plants)					
1	44.1**	43.2	38.4	42.6	42.0
2	44.4	43.2	33.5	40.4	40.3
3	50.4	36.8	45.8	39.2	43.0
4	35.8	36.2	46.7	39.6	39.5
5	32.4	48.1	37.4	36.6	36.1
6	43.0	45.6	37.9	50.6	44.2
7	36.8	40.3	36.3	32.6	36.5
Means	40.9	41.9	38.0	40.2	40.2
1950 (2nd year plants)					
1	54.3	53.2	76.2	64.7	62.1
2	70.0	43.5	50.7	52.6	54.2
3	47.1	89.7	68.1	65.9	67.7
4	45.9	35.1	96.4	68.3	66.4
5	54.8	63.9	87.4	70.0	69.0
6	51.7	58.9	48.1	64.7	55.9
7	54.7	42.2	41.8	60.8	51.0
Means	54.7	58.0	66.9	63.8	60.9

*One prebud, one late bud, and two bloom applications. (Toxaphene used in the bloom in 1950).
**Percent of flowers forming pods.

Table 15. Percent of flowers forming pods in seven standard varieties of alfalfa as affected by the control of lygus bugs

Season and varieties	No dusting	Dusted* DDT.3%	DDT.5%	DDT.10%	Means
1949 (1st year plants					
Ranger	39.1**	27.8	28.2	40.3	33.8
Buffalo	38.0	34.1	49.0	48.0	42.3
Atlantic	28.5	32.7	32.6	47.8	34.4
Grimm	39.3	48.2	36.4	33.1	39.3
Ladak	37.7	28.7	40.9	47.9	38.8
Narragansett	26.0	44.1	41.5	38.2	37.5
Williamsburg	40.1	50.7	33.8	44.1	42.2
Means	35.5	38.0	37.5	42.7	38.5
1950 (2nd year plants)					
Ranger	63.6	63.8	43.8	67.7	57.2
Buffalo	53.3	59.9	55.5	58.4	56.8
Atlantic	58.3	55.6	62.8	68.0	61.2
Grimm	63.5	58.1	85.6	74.3	70.4
Ladak	63.6	69.9	59.1	84.6	69.3
Narragansett	58.9	74.3	50.8	66.8	62.7
Williamsburg	56.2	56.5	48.9	68.2	57.5
Means	59.6	62.3	58.1	69.7	62.2

*One prebud, one late bud, and two bloom applications. (Toxaphene used in bloom stage in 1950).
**Percentage of flowers forming pods.

Table 16. Average number of seeds per pod in low and high seeding strains of alfalfa as affected by the control of lygus bugs

Season and seeding groups	No dusting	Dusted* DDT.3%	DDT.5%	DDT.10%	Means
1950**					
Low seeders	4.9***	4.6	6.6	6.7	5.7
High seeders	5.4	4.6	6.8	6.8	5.9
Means	5.1	4.6	6.7	6.7	5.8

*One prebud, one late bud, and two bloom state applications. (Toxaphene used in the bloom in 1950).
**These data were not taken in 1949.
***Average number of seeds per pod.

Data giving the number of seeds per pod for seven selected high seeding strains are given in table 17. In accord with results as already shown in the tests for the other groups, small differences occur among treatments in the group. Also, differences which continue to appear significant occur between plots receiving no treatment and those receiving complete protection. In fact, it appears that two groups are formed instead of the four treatment groups. To explain this more clearly, plots receiving "no dust" and "DDT 3 percent dust" form one group while the DDT 5 percent and 10 percent form the other. A rather sharp difference is noted in the number of seeds per pod between these two groups, which seems to suggest that 5 percent and 10 percent DDT dusting treatment both give adequate protection to the plants provided the application timing is right.

Table 17. Number of seeds per pod in seven high seeding strains of alfalfa as affected by the control of lygus bugs

Season and strains	No dusting	Dusted*			Means
		DDT,3%	DDT,5%	DDT,10%	
1950** (2nd year plants)					
1	5.7***	5.4	8.3	7.6	6.8
2	5.9	3.8	7.2	6.6	5.9
3	6.1	4.2	6.0	8.7	6.3
4	4.4	4.4	8.2	6.6	5.9
5	5.4	4.5	6.6	7.2	5.9
6	5.6	5.6	6.8	6.0	6.3
7	5.2	4.3	6.7	6.5	5.8
Means	5.4	4.6	7.1	7.1	6.1

*One prebud, one late bud, and two bloom applications. (Toxaphene used in bloom stage in 1950).
**Data not taken in 1949.
***Average number of seeds per pod.

The same kind of data taken for the seven standard varieties, table 18, gave almost identical results. However, the one exception observed was that the standard varieties again only equalled the mean of all the varieties studied. Whereas, the high seeding improved strains have shown unusual performance which has exceeded, with few exceptions, both these groups for all tests studied.

Plants with high seeding potentials seem to exhibit their ability to set seed well under both favorable and unfavorable conditions. Furthermore, those plants possessing that innate quality to set seed well under an unfavorable environment will generally produce considerable yield increases when provided with a favorable environment.

Table 18. Average number of seeds per pod in seven standard varieties of alfalfa as affected by the control of lygus bugs

Season and varieties	No dusting	Dusted*			Means
		DDT.3%	DDT.5%	DDT.10%	
1950** (2nd year plants)					
Ranger	5.3***	4.6	6.8	8.8	6.4
Buffalo	5.4	5.1	7.8	6.7	6.3
Atlantic	5.2	3.9	6.4	5.7	5.3
Grimm	4.4	4.1	8.1	8.3	6.2
Ladak	4.2	3.0	7.1	4.7	4.8
Narragansett	5.3	4.6	6.4	6.8	5.8
Williamsburg	6.0	4.7	5.5	6.3	5.6
Means	5.1	4.3	6.9	6.8	5.8

*One prebud, one late bud, and two bloom applications. (Toxaphene used in bloom stage in 1950).
**Data not taken in 1949.
***Average number of seeds per pod.

Variability and Correlation

Variation is general and the causes are not always known. Without statistical help differences observed hastily may often be misinterpreted. The value of statistical analysis is therefore evident.

Tables 19, 20, and 21 show the correlation coefficient values (r) for flowers x pods; flowers x seed yield; and pods x seed yield as calculated from data taken during the 1949 season for low and high seeding strains of alfalfa. These same data were also collected for the 1950 season; in addition, the correlation coefficient values (r) for seeds per pod x seed yield as shown in table 22 were also calculated. It is difficult to explain the results obtained here. However, referring to table 19, it may be stated that flowering in alfalfa provides no index as to the percent of pods that will later be formed. Relationship of flowers forming pods appears to be a little more consistent with high seeders although their relationship is not marked. The highly significant (r) value for the low seeding group, DDT 10 percent dusted, completely upsets any congruent relationship with the low seeders. All correlations prepared in tables 19, 20, 21, and 22 are similar in that relatively little consistency exists among any of the comparisons. However, data given in table 20, comparing "flowers per raceme x seed yield" show a very definite relationship for high seeders in 1949 but not for 1950. But, low seeders show no important relationship for either season.

In general, no relationship is apparent between pods per raceme x seed yield for either high or low yielding groups during 1949 or 1950 as shown in table 21. Seeds per pod data were taken only during 1950 as shown in table 22. These data taken for the high and low seeders, when associating the seeds per pod x seed yield in 1950, do not provide a significant measure of performance.

Table 19. Correlation coefficient values (r) flowers per raceme x pods per raceme for low and high seeding varieties and strains of alfalfa as affected by the differential control of lygus bugs

Season and seeding group	No dusting	Dusted DDT.3%	DDT.5%	DDT.10%
1949 (1st year plants)				
Low seeders (n-32)	.3424	.2685	-.0161	-.2237
High seeders (n-32)	.5488**	.1905	-.1295	-.0294
1950 (2nd year plants)				
Low seeders	-.0717	.2746	.1338	.5047**
High seeders	.3815*	.4529	-.0256	-.0951

*Indicates significant correlation at a probability of .05 percent.
**Indicates significant correlation at a probability of .01 percent.

Table 20. Correlation coefficient values (r) flowers per raceme x seed yield for low and high seeding varieties and strains of alfalfa as affected by the differential control of lygus bugs

Season and seeding groups	No dusting	Dusted* DDT.3%	DDT.5%	DDT.10%
1949 (1st year plants)				
Low seeders (n-32)	.3428	.0119	.0776	-.1913
High seeders (n-32)	.5817**	.3730*	-.0736	.4305*
1950 (2nd year plants)				
Low seeders	-.0030	.0084	.2803	.3810*
High seeders	-.0158	.4360*	.1000	.1509

*Indicates significant correlation at a probability of .05 percent.
**Indicates significant correlation at a probability of .01 percent.

Table 21. Correlation coefficient values (r) pods per raceme x seed yield for low and high seeding varieties and strains of alfalfa as affected by the differential control of lygus bugs

Season and seeding groups	No dusting	Dusted DDT 3%	Dusted DDT 5%	Dusted DDT 10%
1949 (1st year plants)				
Low seeders	.2846	-.0061	-.0384	-.2925
High seeders	.6191**	.1638	.1020	.2843
1950				
Low seeders	.3327	.2692	.1418	.1248
High seeders	.4056*	.4768**	.5395**	.1008

*Indicates significant correlation at a probability of .05 percent.
**Indicates significant correlation at a probability of .01 percent.

Table 22. Correlation coefficient values (r) seeds per pod x seed yield for low and high seeding varieties and strains of alfalfa as affected by the differential control of lygus bugs

Season and seeding groups	No dusting	Dusted DDT 3%	Dusted DDT 5%	Dusted DDT 10%
1950*				
Low seeders	.2493	.2434	.0336	.2928
High seeders	-.1445	.1365	-.2621	.0137

*Data not taken in 1949.

Correlation coefficient (r) between random variations in flowering between the two seasons is 0.78 (63 df) (table 23), which is significant. Thus flowering appears to be an inherent characteristic. In other words, plants which set an abundance of flowers the first year will also produce in abundance the following year, provided conditions necessary for seed production are favorable.

Table 23 suggests that pod setting is also an inherited characteristic. The correlation coefficient value (r) 0.3229 (63 df), a significant value, explains that plants which set pods well the first year continued to express this characteristic the second year under the existing conditions.

A similar correlation coefficient (r) for percent of flowers forming pods (table 23) was found to be 0.2158 (63 df) which is not statistically significant although this value is approaching significance.

Table 23. Correlation coefficient values (r) for flowers, pods, percent flowers forming pods, seed yield between the years 1949 and 1950 for low and high seeding strains of alfalfa as affected by the differential control of lygus bugs

Flowers	Pods	Percent flowers forming pods	Seed yield
.7885**	.3229*	.2158	.6519**

*Indicates significant correlation at a probability of .01 percent.
**Indicates significant correlation at a probability of .05 percent.

The ultimate measure of a plant's value for seed production is the seed yield. Table 23 shows the correlation coefficient value (r) 0.6519 (63 df) 1949 x 1950 to be highly significant. This significant correlation supports the fact that seed productivity is a heritable character.

This innate response for high seed production receives additional support as shown by the high seeders in 1949 which were among the high seeders in 1950 as well.

As indicated in this experiment, much variability does exist. Local factors are highly variable and fluctuations in conditions are great. Single factor effects appear, therefore, to provide a valid basis for interpretation. It has been suggested by Carlson that:

> ...multiple-order interactions involving three or more facters may afford a better answer to the problem of seed production. However, more work must be done before the current lines of evidence can be fully appreciated and woven into an effective pattern. (unpublished data)

CONCLUSIONS

The present study, based on experimental data taken during two seasons at four levels of lygus infestation, shows that varieties and strains of alfalfa respond differently in their ability to produce seed. Almost without exception, yields showed a steady increase as the lygus populations were reduced. The results thus confirm previous findings bearing on this point. Highest yields were obtained in 1950 at levels somewhat less than one bug per stroke of a standard insect net.

Strains which produced poorly with high levels of lygus bugs gave an increase in yield when fully protected. However, some strains produced well with moderately heavy infestation which suggests that such material might afford an excellent source of resistant varieties and strains.

The data do not show fully the potential value of genetic characters in alfalfa as related to seed production. Further studies are required on this point as a basis of breeding work for the development of lygus resistance.

SUMMARY

1. An investigation during the summers 1949 and 1950 was designed to obtain information concerning the effect of controlled levels of lygus infestations on varieties and strains of alfalfa for seed production.

2. Sixty-four alfalfa varieties and strains, several of which represented the most recent developments in state and federal breeding programs were used in the experimental study at South Logan.

3. Individual varieties and strains, low and high seeding groups, seven standard varieties and seven high seeding improved strains, were studied and compared at each of four lygus levels. The following kinds of data were analyzed: flowers per raceme, pods per raceme, percent of flowers forming pods, seeds per pod, and seed yield.

4. During 1949 the desired levels of lygus infestation at 0, 1, 3, and 6 to 7 bugs per sweep were approximately established and maintained naturally by varying the strengths and frequency of application of the insecticidal dusts. Although the lygus populations which existed during 1950 were lower than occurred in 1949, a population differential was established which proximated the trend of the previous season.

5. It was not possible to eliminate all bugs during the two seasons on the fully protected plot. However, lygus was maintained at a low level during both seasons. The average population was thus found to be 1.20 lygus per stroke of the insect net during 1949 and 0.15 in 1950.

6. Almost without exception, all varieties showed steady increases in seed yields as the zero level of lygus infestation was approached.

7. The varieties and strains responded differently in each lygus

environment. Many of them gave poor yields when subjected to high lygus populations but produced well when adequate protection from infestation was provided. Others produced well in both the protected and unprotected environments.

8. Because of the low lygus levels existing during 1950, high seed yields were anticipated. However, it was estimated that the serious disease infestation which was prevalent over the entire planting reduced the expected yields by approximately one-half.

9. Selected high seeding strains gave consistently higher yields in all tests when compared with the seven standard varieties, Ranger, Buffalo, Atlantic, Grimm, Ladak, Naragansett, and Williamsburg, which were equal to, or slightly below the mean of the 64 varieties and strains.

10. Correlation coefficient values (r) for flowers per raceme x pods per raceme, flowers per raceme x seed yield, pods per raceme x seed yield, and seeds per pod x seed yield for low and high seeding strains of alfalfa show relatively little consistency among any of the comparisons.

11. Correlation coefficient values (r) for flowers, pods, and seed yield 1949 x 1950 were significant. High performance the first year was repeated the following year for that specific character.

12. Local factors are highly variable. Single factor effects are probably of limited importance as a basis for an evaluation of seed production ability. However, interrelated effects involving several factors seem to provide a better interpretation.

13. Healthy alfalfa plants having high innate potentials for seed production provided with an environment conducive to high yields are required for maximum production of seed.

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