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# Alfalfa Seed Production Studies

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# ALFALFA SEED PRODUCTION STUDIES

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## Alfalfa Culture

From a practical standpoint, the culture to use is the one that gives the greatest net return. The study indicates that planting alfalfa for seed production in 24-inch rows at a rate of 1.5 pounds of seed per acre and thinning in the fall of the year after planting is best. For example, a field planted in the spring of 1963 should be thinned in the fall of 1964. Cutting out approximately every other foot within the row seems advisable. While there appears to be considerable latitude in the extent of thinning, weed problems are encountered if the stand is thinned much more than this.

# ALFALFA SEED PRODUCTION STUDIES

*Part I.* *Alfalfa seed production as influenced by three varieties, six cultural treatments, and four growing seasons, by M. W. Pedersen*

*Part II.* *Additional factors associated with seed yields, by M. W. Pedersen and W. P. Nye*

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## CONTENTS

# ALFALFA SEED PRODUCTION STUDIES[1]

## *Part I. Alfalfa Seed Production as Influenced by Three Varieties, Six Cultural Treatments, and Four Growing Seasons*

By M. W. Pedersen[2]

Many farmers have noticed exceptional seed production by an occasional roadside alfalfa plant or by plants that were missed in plowing an old stand. Border plants or plants at the edges of fields often set seed better than the bulk of the area. The reason for this was investigated before DDT became available and under these conditions the benefit of thin stands for alfalfa seed production was established. For a time after DDT was introduced, workers thought that the effect of stand density had been over-emphasized since good seed yields were obtained on thick as well as thin stands. In some cases, however, growers adopted the best-known practices with thick stands and failed to produce satisfactory yields of seed.

The problem of stand density was investigated at the Utah Agricultural Experiment Station and no simple answer was found (Cir. 135, Bul. 408). Optimum stand density for seed production appeared to be related to the amount of forage growth per plant and the speed of pollination. Changes in soil temperature, relative humidity, and light penetration associated with a thin stand were correlated with seed yield, and it was also found that less pod abscission occurred in thin than in thick stands. Thinning of established stands appeared to result in a stimulated seed yield that could be largely attributed to the change in stand density.

The work reported here was designed to investigate further the question of thinning an established stand. In addition, three varieties were compared and intercropping with winter wheat was studied.

# METHODS

## Culture

The experiment consisted of testing three alfalfa varieties (Ranger, Lahontan, and Uinta) over a four-year period when treated in six different ways. Cultural treatments 1 and 2 were planted in 8 inch rows. Number 1 served as a check; number 2 was thinned in 1958 to 12-inch hills in 24-inch rows, and in 1959 to 34-inch hills. The procedure followed was to remove 2 of each 3 rows and cross thin the remaining 24-inch rows by

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Table 1. Alfalfa seed yields in pounds per acre summarizing the results of four years from a factorial arrangement of three varieties and six cultural treatments

| Cultural treatment | | | | Variety | | | |
|---|---|---|---|---|---|---|---|
| No. | Row space (inches) | Hill space (inches) | Year | Ranger | Lahontan | Uinta | Average |
| 1. | 8 | None | 1957 | 213 | 196 | 449 | 286 |
| | 8 | None | 1958 | 428 | 322 | 1072 | 607 |
| | 8 | None | 1959 | 180 | 116 | 722 | 339 |
| | 8 | None | 1960 | 638 | 471 | 1308 | 805 |
| | | | Avg. | 365 | 276 | 888 | 509 |
| 2. | 8 | None | 1957 | 216 | 198 | 410 | 274 |
| | 24 | 12 | 1958 | 713 | 398 | 1090 | 733 |
| | 24 | 34 | 1959 | 715 | 388 | 1253 | 785 |
| | 24 | 34 | 1960 | 680 | 635 | 1225 | 846 |
| | | | Avg. | 581 | 405 | 994 | 659 |
| 3. | 24 | None | 1957 | 238 | 182 | 470 | 296 |
| | 24 | None | 1958 | 626 | 472 | 1136 | 744 |
| | 24 | None | 1959 | 314 | 340 | 994 | 549 |
| | 24 | None | 1960 | 681 | 502 | 764 | 648 |
| | | | Avg. | 465 | 374 | 841 | 559 |
| 4. | 24 | None | 1957 | 240 | 141 | 497 | 292 |
| | 24 | None | 1958 | 724 | 438 | 1217 | 792 |
| | 24 | 12 | 1959 | 640 | 541 | 721 | 633 |
| | 24 | 34 | 1960 | 746 | 676 | 874 | 765 |
| | | | Avg. | 588 | 449 | 827 | 621 |
| 5. | 24 | None | 1957 | 248 | 177 | 462 | 295 |
| | 24 | 34 | 1958 | 789 | 501 | 1202 | 830 |
| | 24 | 34 | 1959 | 713 | 457 | 808 | 659 |
| | 24 | 34 | 1960 | 690 | 641 | 862 | 730 |
| | | | Avg. | 610 | 444 | 833 | 628 |
| 6. | 24 | None | 1957 | 230 | 143 | 493 | 288 |
| | 24 | None | 1958 | 658 | 449 | 1166 | 757 |
| | 72 | None* | 1959 | 233 | 220 | 372 | 275 |
| | 72 | None* | 1960 | 678 | 511 | 1043 | 743 |
| | | | Avg. | 450 | 331 | 769 | 516 |
| | | | Avg. | 510 | 380 | 859 | 582 |

* Wheat planted between the rows

removing a 12-inch section of the row, while leaving a 10-inch hill. When every other hill was removed, the resultant stand had 34-inch hills and 24-inch rows (figure 1).

Treatments 3, 4, 5, and 6 were planted in 24-inch rows. Treatment 3 served as a check. Treatment 4 was thinned to 12-inch hills in 1959, and to 34-inch hills in 1960. Treatment 5 was thinned to 34-inch hills in 1958. Treatment 6 was thinned to 72-inch rows in 1959, and interplanted with wheat in 1959 and 1960 (figure 1). For further details on methods see appendix I.

# RESULTS

## Seed Yields

The average yield of Uinta over the period of the experiment under all treatments was 859 pounds of clean seed per acre (table 1 and appendix table 1). This was followed by Ranger with 510 and Lahontan with 380 pounds of seed per acre (fig. 2).

## Effects of Thinning

Cultural treatment 2 produced 660 pounds per acre (fig. 2). This was followed closely by treatments 5 with 629 and 4 with 621 pounds of seed per acre. These treatments all involved thinning at some time during the 4 years.

## Effects of Seasons

The largest seed crop was harvested in 1960 when the average yield was 757 pounds per acre (fig. 2). This was followed by 744 pounds of seed per acre in 1958, 540 in 1959, and 289 in 1957. Plots were established in

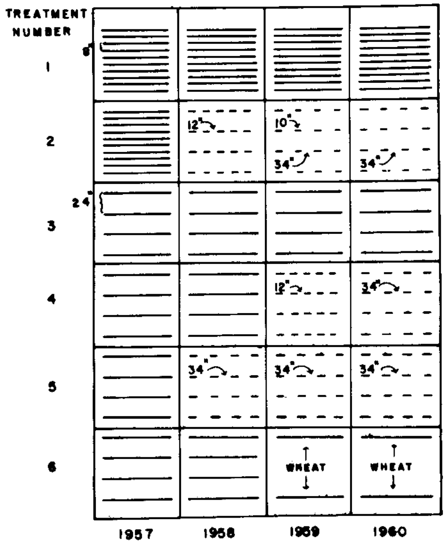


Fig. 1. Diagram illustrating the new spacing and thinning treatments applied during a four-year test of alfalfa seed production

1957 which accounts for the low yield in that year. A combination of over-irrigation and unfavorable weather accounts for the relatively low yield in 1959. Growth was excessive and maturity was delayed in that year. In addition, a period of heavy rainfall occurred during harvest and reduced the yield of seed. The highest yield would be expected the year after establishment, rather than the third year, as occurred here. Improved management and good growing weather, coupled with the fact that yields were determined from hand harvested plots, rather than by combining, are factors contributing to the high yields in 1960.

## Cultural Treatments as Influenced by Years

In 1959 there was a greater reduction of seed yield from the non-thinned or check treatments, and

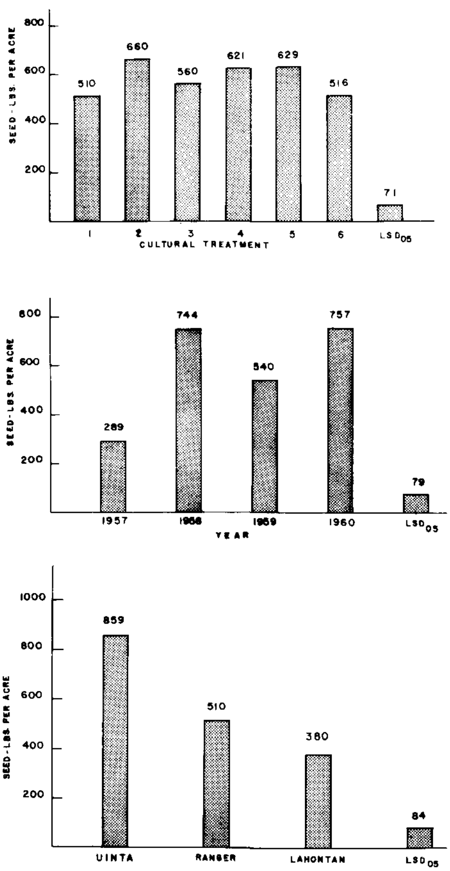


Fig. 2. **Bar graph illustrating alfalfa seed yields from three varieties and six cultural treatments of four years**

the intercropped plots, than from the other treatments (fig. 3). Thus, the cultural treatments had more effect in the unfavorable year of 1959 than in the other years.

## Varieties as Influenced by Years

The seed yield of Lahontan was reduced less in 1959 than the yield of the other varieties (fig. 3), but the advantage was not enough to compensate for the otherwise low seed production of Lahontan. It was the low yielder in 1959 as well as in the other years.

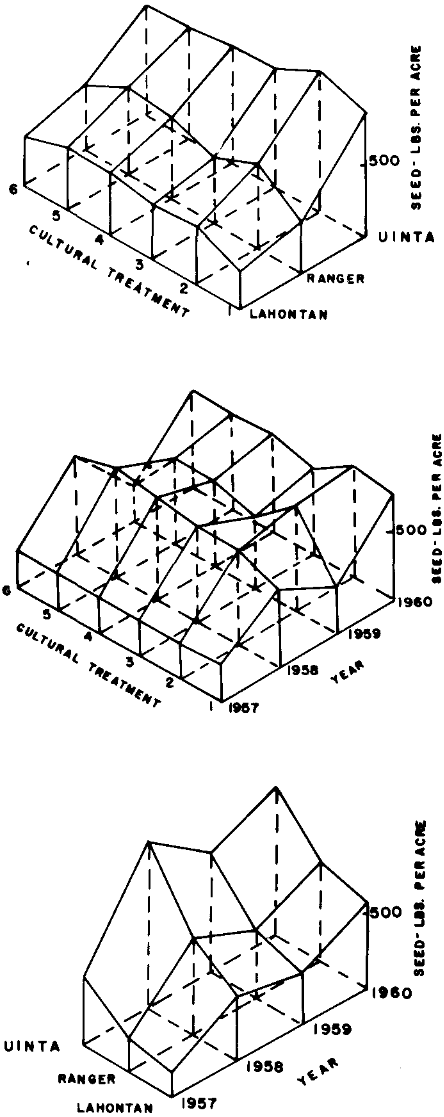


Fig. 3. Three-dimensional charts illustrating the two-way interactions involving the effect of years, varieties, and cultural treatments alfalfa seed yield

## Influence of Cultural Treatments on Varieties

Ranger responded more to the thinning treatments than did Uinta, while Lahontan was intermediate in this respect. This indicates that there was more to be gained by thinning the poorer seed producing varieties (fig. 3). Uinta produced 888 pounds of seed per acre from the hay stand, compared to 994 when a similar stand was thinned, an increase of 12 percent. By comparison, Ranger produced 59 percent, and Lahontan 47 percent more seed after thinning.

## Influence of Culture and Year on Varieties

Ranger responded better to treatment 5 in 1958 than did the other varieties (fig. 4). In 1959, Uinta responded poorly to treatment 4, while treatment 3 resulted in comparatively poor production by Ranger and Lahontan. In 1960 the production of Uinta from treatment 3 was comparatively less and from treatment 6 comparatively more than that from Ranger and Lahontan.

Good seed producing varieties respond less to improved cultural practices than low producing varieties. This response will be most pronounced in years when conditions are less favorable for seed production. Satisfactory seed yields can be obtained from Uinta without any particular attention to stand density, indicating that this variety produces both high seed and high hay yields from the same stand. In the case of Ranger and Lahontan, however, the response to row culture and thinning is sufficient to justify their use.

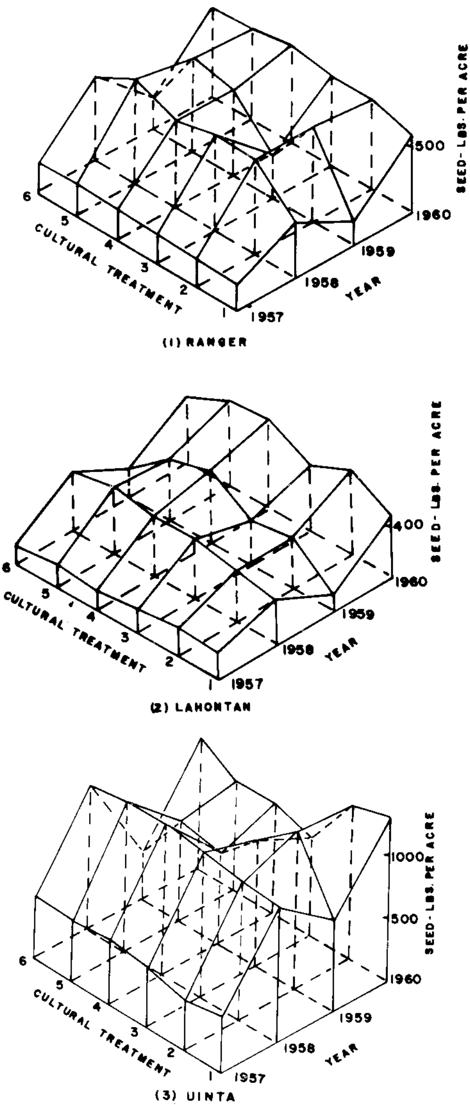


Fig. 4. A three-way interaction involving the effect of varieties, years, and cultural treatments on alfalfa seed yield, illustrated with three charts

The average gross return from the six cultural treatments for 1959 and 1960 when wheat was intercropped was $131 for treatment 1, $191 for treatment 2, $140 for treatment 3, $163 for treatment 4, $163 for treatment 5, and $155 for treatment 6. The values include the calculated returns from the wheat from which the average yield was 36.2 bushels per acre in 1959, and 16.6 in 1960.

## DISCUSSION

To obtain the best seed yields from a given alfalfa variety, its seed-producing potential must be evaluated and the characteristics of the area where it is to be planted must be known.

The alfalfa varieties grown for seed in Utah at the present time do not approach the seed production potential of Uinta. Therefore, it can be assumed that the varieties now grown for seed will respond to thin stands and thinning practices where conditions resemble those of the experimental area.

The possibility of intercropping with wheat has not been fully explored. In these tests it was not possible to irrigate the wheat plots adequately. A differential irrigation treatment is necessary where crops are grown in this manner. As the nursery was not planned for this, the wheat plots received less than the optimum irrigation for maximum yields. Apparently thinning from 24-inch to 72-inch rows for wheat, in 1959, was excessive for the best seed yield from the alfalfa the year following thinning (figure 1 and table 1). The alfalfa plants seemed to have recovered from this operation by the second year, however.

## SUMMARY AND CONCLUSION

1. Three alfalfa varieties (Ranger, Lahontan, and Uinta) were studied in an experiment involving 6 cultural treatments over a 4-year period (1957-1960) at Logan, Utah.

2. Differences among varieties, cultural treatments, and interactions were highly significant.

3. Uinta alfalfa yielded 859 pounds of seed per acre, averaged over the 4 years, followed by Ranger with 510 pounds, and Lahontan with 380 pounds.

4. Satisfactory management practices for growing alfalfa seed under conditions similar to those of the experiment are to plant in 24-inch rows at a rate of about 1.5 pounds of seed per acre. After the second year, the stand should be thinned by cutting out about every other foot in the row.

5. Additional thinning after the third year appeared to stimulate seed yield, but thinning to this extent may create a weed problem.

6. Ranger and Lahonton alfalfa varieties responded more to thinning and row stands than Uinta.

7. The seed yield of Lahonton was affected less by the unfavorable conditions in 1959 than either Ranger or Uinta.

8. Ranger and Lahonton alfalfa varieties responded more to different cultural treatments than did Uinta, but the response varied from year to year among the 3 varieties and was greatest in 1959 when seed production was relatively poor.

9. Satisfactory seed yields were produced by Uinta alfalfa from either hay or seed stands.

10. Additional work with intercropping will be necessary to reach definite conclusions about the practical use of this treatment.

# ALFALFA SEED PRODUCTION STUDIES

*Part II. Additional Factors Associated with Seed Yields*

By M. W. Pedersen and W. P. Nye[2]

In the case of alfalfa seed production an insect, a plant, the environment, and the interactions among these factors are involved. Genetic variations are inherent in both the pollinating insects and the alfalfa plants. Insect-pollinator studies have been largely devoted to comparisons among species. The variation within species has not been explored to any extent. Plant studies are far from complete and the interactions between plants and insects have only been studied in a preliminary way. The following report is a continuation of part I and is devoted primarily to genetic variations among varieties of alfalfa and includes data on environmental factors and honey bee pollinators.

Methods used in these studies are discussed in appendix 2.

## RESULTS

### Seasonal Influence

A depressing effect on seed yield, nectar secretion, and honey bee populations in the 1959 season as a result of high soil moisture, low temperature, and high precipitation is shown in figures 5 and 6. The total precipitation for June, July, August, and September 1959 was 5.84 inches, which is more than the long time average. By contrast, the rainfall was

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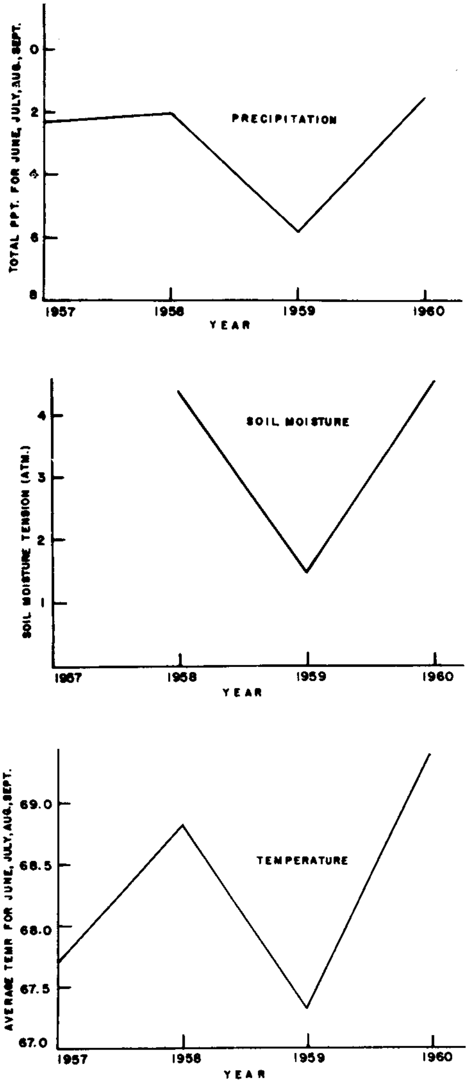


Fig. 5. Charts illustrating the total precipitation and average temperature for June, July, August, and September and the average soil moisture tension in the experimental plots during a 4-month period of an alfalfa seed production test

below average during the other years of the experiment. The average temperature in 1959 was 3.3 degrees lower than normal, whereas the other years were above normal. Soil moisture was greater in 1959 than in 1958 or 1960. This was caused primarily by an excessive irrigation.

## Environmental Influence

Soil moisture tension was affected by cultural management. The solid stand and the wheat intercrop received more water than the other treatments. This seems contradictory, but occurs because water penetration is probably greater than for the other treatments. Where the entire plot is covered with vegetation, the water is retarded and spreads in a sheet over the whole plot, in contrast to rows where the water runs freely in furrows 2 feet apart (appendix table 2).

Light penetration in the row stand was nearly 10 times as great as in the hay stand.

Relative humidity was higher in the hay stand, being 33.5 percent compared to 30.2 percent in the (check) row stand, and soil temperature was lower, being 76.3 F compared to 78.5 in the row stand.

## Diseases and Insects

The three alfalfa varieties were distinctly different in susceptibility to yellow leaf blotch (**Pseudopeziza jonesii** Nannf.). Uinta was the most resistant; Lahontan was the most susceptible, and Ranger was immediate. Cultural treatments 1 and 6 had less yellowleaf blotch infection than the other treatments.

The varieties were similiar in leaf spot (**Pseudopeziza medicaginis** (Lib.) Sacc.) susceptibility, but the infestation on the solid stand was greater than on the row stand.

Uinta was more resistant to downy mildew (**Peronospora trifoliorum** D. By.) than Ranger and Lahontan and infestation on the solid stand was greater than in rows (appendix table 3).

Chalcid infestation was not affected significantly by treatments. The loss was relatively low, averaging only 3.5 percent in 1957.

## Yields

During 1959 and 1960 the average chaff production from Uinta alfalfa was 2.85 tons per acre. This was followed by Ranger with 2.51, and Lahontan with 2.44 tons per acre. Comparing the cultural treatments, the hay stand had 3.27 tons of chaff per acre, compared to 2.53 tons on the 24-inch row check (appendix table 4).

Varieties did not differ significantly in number of stems per acre; however, the unthinned check stands (hay and 24-inch row) had more than an average number of stems while the 72-inch rows had less.

The number of racemes per stem, like the number of stems per acre, was not affected by variety. The cultural treatments affect this character opposite to the way they affect stems per acre, and the net result is compensatory, so that the number of racemes per acre is not significantly affected by different treatments.

On the average, there were 7.15 pods per raceme on Uinta, followed by 6.60 on Ranger, and 6.04 on Lahontan. The cultural treatments had only slight effects on this character.

There were 3.83 seeds per pod in Uinta, 3.46 in Ranger, and 3.01 in Lahontan. Age of stand or season also affected seeds per pod. In 1957 the average number of seeds per pod was 4.9; in 1958 it was 3.7; and in 1960 it was 3.1 (fig. 3). Cultural treatments did not significantly affect this character.

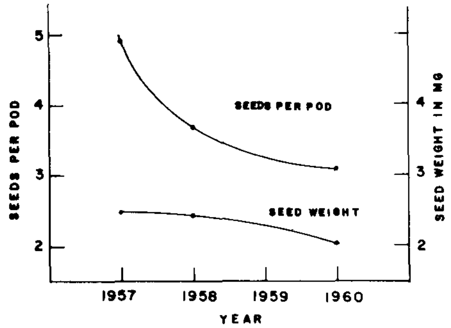


Fig. 6. Changes in alfalfa seed weight, and seeds per pod associated with the age of stand illustrated by curves

Varietal differences in seed weight were opposite to those of seed number per pod, resulting in a compensating effect. Thus, the average seed weight of Uinta was 2.19 milligrams compared to 2.27 milligrams for Lahontan. Similar to "seeds per pod" weight became less as the stand became older. The average seed weight was 2.48 milligrams in 1957, 2.42 in 1958, and 2.03 in 1960.

Uinta had smaller pods than Ranger. The cultural treatments did not significantly affect this character.

Percentage of dry matter was not affected by the treatments. It was expected that a difference in maturity might show up in such a measurement.

## Biological Factors

Ranger alfalfa flowers a little earlier than Lahontan and a little later than Uinta. In all cases hay stands were slower to bloom than row stands. Thinning speeded flowering consistently (appendix table 5.)

The number of flowers per raceme was 19.2 on Ranger, 16.0 on Lahontan, and 16.6 on Uinta. Only 14.7 flowers per raceme were found on the hay stand. This was followed by 15.8 on the 72-inch rows. The range among the other treatments was less; however, there were 19.8 flowers per raceme on treatment 4 (the only treatment thinned in the fall of 1959).

On the average there were 302.8 million flowers per acre, with no significant effects from various treatments.

Ranger had the highest nectar sugar concentration, followed by Lahontan and Uinta. The hay stand was consistently lower than the row stand in this value. The nectar concentration averaged 39.18 percent.

The differences in varieties in nectar secretion were not significant. However, nectar secretion on the hay stand was consistently low. There was better secretion in 1958 than in 1957 or 1959.

Uinta consistently had more tripped flowers per raceme than the other varieties, but the effect of the cultural treatments varied. Tripped flowers averaged 1.00 per raceme.

Differences in honey bee populations on the various varieties were not consistent, although Lahontan had the lowest population in three of the four years. Bee populations also tended to be low on the hay and unthinned stands. There were higher honey bee populations in 1958 and 1960 than 1957 and 1959.

About 80 percent of the cross pollinated flowers formed pods. In self-fertility, however, 50.2 percent of the selfed flowers on Ranger formed pods, compared to 43.7 percent on Uinta and 32.2 percent on Lahontan.

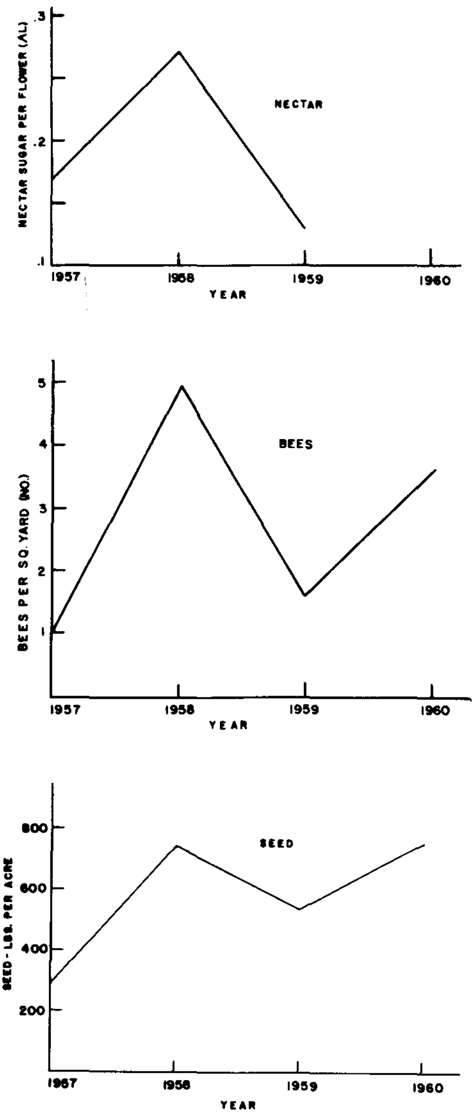


Fig. 7. Nectar secretion, honey bee populations, and seed yield for a 4-year alfalfa seed production experiment illustrated with charts

# DISCUSSION

It was previously shown that the changes in relative humidity, temperature, and light penetration associated with thin stands were beneficial to alfalfa seed production (Pedersen et al. 1959). This experiment confirms the earlier one.

Although population counts of harmful insects were not made, their control was effective. The loss from chalcids in 1959 and 1960 was probably more than in 1957 and 1958, but it was not checked.

Leaf spot and downy mildew were not serious, and they are not considered to have influenced seed yields to any extent. Yellow leaf blotch defoliated Ranger and Lahontan each year, and probably influenced seed yields.

"Many experiments have shown that the fruit growth after pollination depends intimately upon the number of leaves which supply nutrients to the developing fruit" (Bonner and Galston 1955). McAlister and Krober (1958) found that in soybeans 80 percent defoliation cut the seed yield in half, while 40 percent reduced seed yield 21 percent. Kernkamp (1953) observed that blackstem (**Ascochyta imperfecta** Pk.) was harmful to alfalfa seed production.

Yield factors tend to be compensatory. For example, if there are fewer stems per area, the stems have more racemes. Uinta has an advantage in both number of pods-per-raceme and seeds-per-pod. Part of the advantage in number of seeds-per-pod is lost because the seeds are lighter in weight.

The reduction in number of seeds-per-pod and in seed-weight that is associated with season or age of stand is of interest. Generally speaking, seed yield will be the best the year after seeding, drop sharply the next year, and continue at a modest level. Yields followed this pattern except that in 1960 they rose to an even higher level than in 1958. The weather and general culture undoubtedly had an influence. Further study of the fluctuations in seed numbers and weight associated with the age of stand would be worthwhile. Because this work was done in different years, there is a possibility of a measurement error.

Uinta consistently flowered a few days earlier than the other varieties, but the seasonal production of flowers was not significantly affected by either varieties or cultural treatments. Earliness in flowering may have a definite advantage. Before first-crop alfalfa starts to bloom, there is a dearth of flowering vegetation for foraging bees. The first field to bloom would tend to attract the available pollinators in the area. Nectar secretion by the alfalfa plant influenced both bee visitations and seed yields. This varied somewhat from year to year but did not appear to be influenced significantly by the various treatments. There was, however, both a varietal and a cultural effect on nectar sugar concentration. The cultural effect was associated with humidity and temperature. The varietal effect is worthy of further study. Differences between varieties in nectar sugar concentrations could be associated with initial concentration or attractiveness to pollinators, or both.

If the difference is due to a variable attractiveness, the more attractive variety would have the lower sugar concentration. This is true because the variety with the more attractive flowers would be visited more frequently. The nectar would thus be subject to evaporation for a shorter period of time than that from the less attractive variety, and therefore would be less concentrated.

Knowles (1943) concluded that temperature was the most important weather factor influencing tripping of alfalfa flowers and that tripping and temperature were correlated positively. More recent information raises the question of the optimum temperature for seed production. Smith and Pryor (1959) found that temperatures above 100 F the day before bloom reduced percent set and beans per pod in **Phaseolus.** Working with soybeans (Soja) in growth chambers, van Schaik and Probst (1958) showed that high temperature and long photoperiod increased flower and pod shedding.

Bee populations are probably not good measures for comparing the attractiveness of alfalfa varieties. Flower production was similar on all 3 varieties, but flowers on Uinta were tripped at a higher rate. Thus, the available flowers at a given time would be fewer on Uinta than on the other varieties, and the bee-per-flower ratio would be higher on Uinta than the other varieties, even though the bee populations were similar.

## SUMMARY AND CONCLUSIONS

1. Measurements of ecological, disease, insect, biological, and yield factors associated with alfalfa seed yields during a 4-year study are reported.

2. The 1959 season had higher than average rainfall, lower than average temperatures, and excessive irrigation — conditions that were reflected in low seed yields, low nectar secretion, and low honey bee populations.

3. Soil moisture, light penetration, and relative humidity are discussed in relation to the different cultural practices.

4. The cultural practices are not considered to have affected susceptibility to insect damage.

5. Of the varieties studied, Uinta was the most resistant to yellow leaf blotch and downy mildew.

6. Uinta alfalfa was high in chaff production as well as seed.

7. Cultural practices did not significantly affect the number of racemes or flower per acre. A compensating effect between variations in number of racemes per stem and number of stems per acre causes this.

8. Uinta alfalfa had 8.0 pods per raceme, Ranger had 7.4, and Lahontan had 6.7.

9. Uinta alfalfa had 4.1 seeds per pod, Ranger had 4.0, and Lahontan had 3.6.

10. A reduction in both the number of seeds per pod and in seed weight appeared to be associated with the increasing age of the stand. During the 4-year period, the number of seeds per pod decreased from 4.9 to 3.1 and the seed weight from 2.48 to 2.03 milligrams.

11. Uinta alfalfa flowered a few days earlier than the other varieties. Row stands and thinning also promoted earlier flowering.

12. In the number of flowers per raceme, Ranger was high with 19.2 followed by Uinta with 16.6 and Lahontan with 16.0. The hay stand had the smallest number of flowers per raceme with 14.7.

13. A low value for nectar sugar concentration for Uinta alfalfa is interpreted as indicating greater attractiveness to honey bees.

14. Uinta alfalfa averaged 1.10 tripped flowers per raceme followed by Lahontan with .89 and Ranger with .86.

15. Low bee populations were found on Lahontan alfalfa and on the hay stand of all three varieties.

16. The treatments did not affect cross fertility, but Lahontan showed low self fertility.

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# METHODS

Treatments in this factorial experiment consisted of all combinations of the three alfalfa varieties and the six cultural treatments arranged in four replications of a randomized complete block design.

Seed was planted at the rate of 1.5 pounds per acre in 24-inch rows (seed stands) and 12 pounds per acre in 8-inch rows (hay stands). Planting was done with a tractor mounted drill with four "boxes" spaced at 2-foot intervals and with furrow openers for irrigation between the drills. Planting in the 8-inch rows was completed by hand drill. Drill boxes and planting rates were changed at the end of each plot for the different varieties and rates of seeding. A 5-foot border of bromegrass was planted between the plots and around the nursery. Plots were 45 feet long by 28 feet wide, or 1/34.57th of an acre. The seed crop was produced on the first growth each year.

Considerable hand weeding was done the first year. In later years spring toothing in the spring followed by row cultivations was effective for weed control. Wild lettuce plants were troublesome in both the hay and thinned stands; dodder was a general problem, but was kept under moderately good control.

Water was applied by furrow. During 1957 (the year of establishment) water was applied as needed. In 1958 the nursery was watered June 9 and July 5 for about 9 hours each time. Water was applied June 10, 1959, for a 24-hour period. In 1960 the nursery was watered for 12 hours on June 1. The penetration rate was about 0.6 of an inch per hour, thus, about 10.8 inches of water were applied in 1958, 14.4 inches in 1959, and 7.2 inches in 1960.

The crop was harvested September 27, 1957; August 18-21, 1958; September 28, 1959; and August 15 to September 10, 1960. In 1957 the plots were mowed and the crop left in the swath to cure. After curing, the plant material was collected by hand and fed into a modified small plot harvester. In 1958 the nursery was defoliated with a mixture of one quart of dinitro compound, 10 gallons of diesel oil, and 15 gallons of water per acre, and harvested directly with a combine. The last two years, however, the seed yield was determined from two, 2 x 20 foot samples cut by hand from each plot, in all plots except the intercropped plots, in which the samples were 6 x 20 feet. In other words, a single 20 foot row of alfalfa was harvested per sample from all plots, except the plots with 8-inch rows from which 3 rows were harvested. The small samples were threshed in a special forage crop thresher.

## Insect Control

Lygus bugs were controlled by applying insecticides with a tractor mounted sprayer, and generally recommended procedures were followed. Since re-infestation problems are more severe on small nurseries than on a large acreage, more applications of insecticides were needed than would be required normally for large fields. Two pounds of DDT in the late bug stage, followed by 2.5 pounds of toxaphene about three weeks later was the usual practice. A second application of toxaphene after another three weeks was often necessary. Timing of application and the insecticide to be used were determined by the insects present. On several occasions, one quarter pound of demeton per acre was added to control mites and aphids.

## Bees

Five honey bee colonies per acre were placed at the periphery of the nursery each year as flowering commenced, and several apiaries were within flight range of the plots. During the period of the experiment the population of the leaf cutting bee (**Megachile rotundata**) increased from pratically nothing when the experiment started to a number sufficiently large to be a factor in pollination in 1959 and 1960.

## Analysis of Data

The data were analyzed by standard procedures with the management of cultural treatments across time being visualized as the treatment of interest and not the status of the plot in any one year. The sub-plot error may not be homogeneous, but it is unlikely that this would affect the interpretation. Analysis of variance data are shown in appendix table 1.

Appendix table 1. Analysis of variance for data in table 1

| Source of variation | Degrees of freedom | Mean squares | F |
|---|---|---|---|
| Replications (R) | 3 | 4,395 | 0.24 |
| Treatments (T) | 17 | 786,846 | 42.89** |
| Varieties (V) | (2) | 5,889,468 | 321.06** |
| Culture (C) | (5) | 190,859 | 10.40** |
| V x C | (10) | 64,316 | 3.51** |
| Error a(R x T) | 51 | 18,344 | 0.82 |
| Years (Y) | 3 | 3,468,780 | 154.93** |
| Years x treatments | 51 | 91,214 | 4.07** |
| Y x V | (6) | 190,314 | 8.50** |
| Y x C | (15) | 133,103 | 5.94** |
| Y x V x C | (30) | 50,449 | 2.25** |
| Error b | 162 | 22,390 | |
| Total | 287 | | |

** Exceeds P.01

# METHODS

## Ecological Factors

A bouyoucos soil moisture block was placed in the center of each plot at a depth of 2 feet. The blocks were read at approximately 10-day intervals during May and June. Values for the different readings were averaged for reporting. A dry soil is indicated by a high value.

Incidence of light penetration of the foliage was determined with a photographic light meter.

Relative humidity was measured with an electronic hygrometer.

## Diseases and Insects

Resistance to foliage diseases was determined by rating the plots from 1 to 9 with low values indicating low infection.

Chalcid (**Bruchophagus roddi** Gussakovskii) infestation percentage was obtained by individually opening 100 seed pods and counting the number of infested and non-infested seeds. The seed pods were collected before harvest.

## Plant Factors

In 1959 and 1960 when small plots were used to determine seed yields, the harvested forage was weighed before it was threshed. The seed weight was subtracted from the total forage weight and the remainder labeled "chaff."

The number of stems per acre was calculated from a count of a 6-foot sample of stubble after harvest.

Before harvest a random 20-stem sample was collected from each plot. After all the racemes were removed from the stems and counted, a subsample of 100 racemes was taken. All the pods were removed from the subsample and counted. Bracts were counted on 20 racemes of the 100 in the subsample.

The pods removed from the 100 racemes were threshed and weighed. One hundred seeds were counted and weighed and the total number of seeds calculated from these data.

Percent dry matter was obtained from a single sample per plot of about 3 pounds of forage (green weight).

## Biological Factors

The time of flowering was estimated visually and recorded as percentage bloom June 15 ± 5 days. It was necessary to make the estimate just as flowering commenced because differences cannot be determined after flowering is well under way.

The number of flowers was calculated using the number of bracts on the raceme as an indicator. There is almost a perfect correlation between the two values.

Nectar sugar concentration was determined by checking the honey stomach content of about 12 bees per plot with a hand refractometer.

Nectar volume was measured by centrifuging flower samples collected early in the morning after they had been covered for 3-4 days with a 1-pound kraft bag.

The number of freshly tripped flowers per raceme was determined during peak bloom; 34, 90, and 20 racemes per plot were counted in 1957, 1959, and 1960, respectively.

Honey bee population counts were made each year during the main flowering period (July). Several counts were made, but the specific number varied from year to year. Lath stakes and string were used to outline 2 square yards per plot for ease in counting the bees at a given instant when observed by the technician.

Self-fertility was determined by hand selfing 10 flowers on each of the 20 racemes (per plot) from which all other flowers were removed. After about 10 days the pods were counted and the data reported as the percentage of tripped flowers that formed pods. The same procedure was used for cross fertility except that the flowers were cross pollinated instead of being selfed.

Appendix table 2. Summary of ecological factors for a four-year period

| Factor | Variety* | | | |
|---|---|---|---|---|
| | Ranger | Lahontan | Uinta | Average |
| Soil moisture (atm.) | 5.1 a | 4.8 a | 4.7 a | 4.9 |
| Light (foot candles) | 51.1 a | 55.7 a | 46.9 a | 51.2 |
| Relative humidity (%) | 31.6 a | 30.2 a | 30.4 a | 30.7 |
| Temperature (°F) | 78.6 a | 78.6 a | 78.5 a | 78.5 |

| | Cultural treatment* | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | Average |
| Soil moisture (atm.) | 4.0ab | 5.3bcd | 6.6d | 5.6c | 4.6bc | 3.1a | 4.9 |
| Light (foot candles) | 9.4a | — | 93.0b | — | — | — | 51.2 |
| Relative humidity (%) | 33.5b | 29.8a | 30.2a | — | 29.4a | — | 30.7 |
| Temperature (°F) | 76.3a | 79.2b | 78.5b | — | 80.1b | — | 78.5 |

| | Year* | | | | |
|---|---|---|---|---|---|
| | 1957 | 1958 | 1959 | 1960 | Average |
| Soil moisture (atm.) | — | 5.38b | 3.69a | 5.50b | 4.9 |
| Light (foot candles) | — | 51.2 | — | — | 51.2 |
| Relative humidity (%) | — | 30.8 | — | — | 30.8 |
| Soil temp. (°F) | — | 78.5 | — | — | 78.5 |

* Values followed by the same letter do not differ significantly at P = .05

Appendix table 3. Summary of disease and insect factors

| Factor | Variety* | | | |
|---|---|---|---|---|
| | Ranger | Lahontan | Uinta | Average |
| Yellow leaf blotch (score) † | 6.6 b | 8.0 c | 1.5 a | 5.4 |
| Leaf spot (score) † | 5.6 a | 6.1 a | 5.0 a | 5.6 |
| Downy mildew (score) † | 3.4 b | 5.2 c | 1.2 a | 3.3 |
| Chalcid (%) | 3.2 a | 3.2 a | 4.0 a | 3.5 |

| | Cultural treatment* | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | Avg. |
| Yellow leaf blotch (score) | 5.0a | 5.6b | 5.7b | 5.8b | 5.4ab | 4.8a | 5.4 |
| Leaf spot (score) | 6.9a | — | 4.3b | — | — | — | 5.6 |
| Downy mildew (score) | 3.6a | — | 3.0b | — | — | — | 3.3 |
| Chalcid (%) | 3.6a | 3.8a | 3.2a | 3.4a | 3.2a | 3.3a | 3.5 |

| | Year* | | | | |
|---|---|---|---|---|---|
| | 1957 | 1958 | 1959 | 1960 | Average |
| Yellow leaf blotch (score) | — | 4.9a | 6.2b | 4.9a | 5.4 |
| Leaf spot (score) | 5.6 | — | — | — | 5.6 |
| Downy mildew (score) | 3.3 | — | — | — | 3.3 |
| Chalcid (%) | 3.5 | — | — | — | 3.5 |

* Values followed by the same letter do not differ significantly at P = .05.

† 1 = low infection; 9 = high infection.

Appendix table 4. Summary of yield factors

| Factor | Variety* Ranger | Lahontan | Uinta | Average |
|---|---|---|---|---|
| Chaff (ton/acre) | 2.51 a | 2.44 a | 2.85 b | 2.60 |
| Stems per acre (M) | 438.00 a | 425.00 a | 500.00 a | 454.33 |
| Racemes per stem (no.) | 39.30 a | 44.40 a | 43.90 a | 42.53 |
| Pods per raceme (no.) | 6.60 b | 6.04 a | 7.15 c | 6.59 |
| Racemes per acre (M) | 16.10 a | 17.60 a | 19.90 a | 17.87 |
| Seeds per pod (no.) | 3.46 b | 3.01 a | 3.83 c | 3.43 |
| Seed weight (mg./seed) | 2.21 ab | 2.27 b | 2.19 a | 2.22 |
| Pod weight (mg./pod) | 20.55 b | 19.27 ab | 18.59 a | 19.47 |
| Dry matter (%) | 25.90 a | 26.70 a | 26.00 a | 26.20 |
| Seed (lbs./A) | 510.00 b | 380.00 a | 859.00 c | 583.00 |

| | Cultural treatment* 1 | 2 | 3 | 4 | 5 | 6 | Averag |
|---|---|---|---|---|---|---|---|
| Chaff (ton/acre) | 3.27d | 2.71c | 2.53b | 2.32ab | 2.69bc | 2.09a | 2.6 |
| Stems/acre (M) | 578.00a | 396.00b | 602.00a | 421.00b | 437.00b | 292.00c | 454.3 |
| Racemes/stem (no.) | 33.00cd | 44.80b | 25.80d | 42.50bc | 42.70b | 66.30a | 42.5 |
| Pods/raceme (no.) | 6.22a | 6.57a | 6.64a | 6.85a | 6.33a | 6.95a | 6.5 |
| Racemes/acre (M) | 20.60a | 17.40a | 15.10a | 17.80a | 16.20a | 19.90a | 17.8 |
| Seeds/pod (no.) | 3.28a | 3.53a | 3.56a | 3.52a | 3.39a | 3.33a | 3.4 |
| Seed wt. (mg/seed) | 2.23ab | 2.29b | 2.14a | 2.22a | 2.24b | 2.24b | 2.2 |
| Pod wt. (mg/pod) | 19.82a | — | 19.12a | — | — | — | 19.4 |
| Dry matter (%) | 26.50a | 25.70a | 26.70a | 26.70a | 25.60a | 26.00a | 26.2 |
| Seed (lbs./A) | 510.00a | 660.00b | 560.00a | 621.00b | 629.00b | 516.00a | 583.0 |

| | Year* 1957 | 1958 | 1959 | 1960 | Average |
|---|---|---|---|---|---|
| Chaff (ton/acre) | — | — | 2.74a | 2.46b | 2.60 |
| Stems/acre (M) | — | — | — | 454.33 | 454.33 |
| Racemes/stem (no.) | — | — | — | 42.53 | 42.53 |
| Pods/raceme (no.) | — | 9.8a | — | 3.3b | 6.59 |
| Racemes/acre (M) | — | — | — | 17.87 | 17.87 |
| Seeds/pod (no.) | — | 3.7a | — | 3.10b | 3.43 |
| Seed wt. (mg/seed) | — | 2.42a | — | 2.03b | 2.22 |
| Pod wt. (mg/pod) | 19.47 | — | — | — | 19.47 |
| Dry matter (%) | — | 26.2 | — | — | 26.2 |
| Seed yield (lbs./A) | 289.00a | 744.00c | 540.00b | 757.00c | 583.00 |

* Values followed by the same letter do not differ significantly at P = .05.

Appendix table 5. Summary of biological components

| Factor | Variety* | | | |
|---|---|---|---|---|
| | Ranger | Lahontan | Uinta | Average |
| Bloom (%) | 36.00b | 25.00a | 47.00c | 36.00 |
| Flowers per raceme (no.) | 19.20a | 16.00b | 16.60b | 17.28 |
| Flowers per acre ($\overline{M}$) | 306.30a | 275.60a | 326.50a | 302.82 |
| Nectar concentration (%) | 40.53c | 39.34b | 37.69a | 39.18 |
| Nectar per flower ($\mu$l) | .19a | .19a | .20a | .19 |
| Tripped flowers (no./raceme) | .85a | .99b | 1.17c | 1.00 |
| Bees per square yard (no.) | 2.96a | 2.51a | 2.93a | 2.80 |
| Cross fertility † | 82.70a | 80.40a | 76.80a | 79.97 |
| Self fertility ‡ | 50.20c | 32.20a | 43.70b | 42.03 |

| | Cultural treatment* | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | Avg. |
| Bloom (%) | 15.00a | 39.00b | 40.00b | 44.00b | 39.00b | 39.00b | 36.00 |
| Flowers per raceme (no.) | 14.70c | 17.10b | 18.40a | 19.80a | 17.90ab | 15.80bc | 17.28 |
| Flowers per acre ($\overline{M}$) | 302.00a | 294.00a | 263.00a | 354.00a | 290.00a | 314.00a | 302.82 |
| Nectar concentration (%) | 37.36a | 38.43ab | 39.46bc | 39.85c | 40.04c | 39.95c | 39.18 |
| Nectar per flower ($\mu$l) | .17a | .18ab | .20bc | .20bc | .21c | .21c | .19 |
| Tripped flowers (no./raceme) | 1.08bc | .89a | .91ab | .99abc | 1.16c | .98abc | 1.00 |
| Bees/sq. yard (no.) | 2.45a | 2.82b | 2.74b | 2.89bc | 3.04c | 2.86bc | 2.80 |
| Cross fertility † | 80.39a | 81.79a | 77.83a | — | 79.82a | — | 79.97 |
| Self fertility ‡ | 40.70a | — | 43.30a | — | — | — | 42.03 |

| Characteristics | Year* | | | | |
|---|---|---|---|---|---|
| | 1957 | 1958 | 1959 | 1960 | Average |
| Bloom (%) | — | 48.20c | 32.90b | 27.10a | 36.00 |
| Flowers per raceme (no.) | — | — | — | 17.28 | 17.28 |
| Flowers per acre ($\overline{M}$) | — | — | — | 302.82 | 302.82 |
| Nectar concentration (%) | 48.10d | 34.80b | 33.70a | 40.20c | 39.18 |
| Nectar per flower ($\mu$l) | .17b | .27c | .13a | — | .19 |
| Tripped flowers (no./raceme) | .69a | — | .62a | 1.69b | 1.00 |
| Bees/sq. yard (no.) | 1.06a | 4.92d | 1.57b | 3.66c | 2.80 |
| Cross fertility † | — | 79.97 | — | — | 79.97 |
| Self fertility ‡ | 42.03 | — | — | — | 42.03 |

† Percent of cross-pollinated flowers forming pods
‡ Percent of self-pollinated flowers forming pods
* Values followed by the same letter do not differ significantly at P = .05.