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George E. Bohart
Utah State University

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STUDIES ON POLLINATION OF DIPLOID AND TETRAPLOID RED CLOVER VARIETIES IN UTAH

George E. Bohart, Entomology Research Division
ARS, USDA, in cooperation with the Utah Agricultural Experiment Station.

The decision to undertake pollination studies on red clover in Utah was based on observations in Europe to the effect that tetraploid red clover presents peculiar difficulties with regard to pollination. It was decided to study eight tetraploid and eight diploid varieties to give opportunity for comparisons.

MATERIAL AND METHODS

Although four localities were used for the plantings, only two developed well enough to allow pollination studies. The third location, a field plot, was greatly weakened and thinned by mites, mildew, and other disease factors. In the fourth location (a greenhouse), conditions were not suitable for flowering.

At the first two locations pollinators were those naturally found in the area. One of them, at Barker's Hollow, was located several miles from any honeybee colonies, and here bumble bees were expected to predominate. At the other, near Newton, several small groups of honeybee colonies were nearby, and honeybees were expected to be more significant.

The project was carried on co-operatively with Dr. John H. Carlson of the Crops Research Division (now retired). He planted and cared for the plots and made seed yield and forage measurements.

At Barker's Hollow there were eight tetraploid varieties but no diploids. There were two adjacent series of plants, each composed of two subplots of each of the eight varieties. In each subplot there were ten plants (all of one variety). Within each series all subplots were randomized. The tetraploid varieties were those listed in Table 1.

The plot at Barker's Hollow was not irrigated, and

Table 1. Bee visitors*, corolla tube lengths, and no. seeds per head, for eight tetraploid red clover varieties grown at Barker's Hollow, Utah, 1961

Variety	Sv 034	TP A1	Ul VA	A066	Ötofte	Lot 6586A SV065	RT1	RTE5	Average
Origin	Sweden	Finland	Sweden	Sweden	Denmark	Sweden	Norway	Norway	
Honeybees (nectar)	0	0	0	0	0	11	1	0	1.50
Honeybees (pollen)	0	0	0	0	0	0	0	1	0.12
Bombus	236	82	51	81	123	[illegible]	[illegible]	98	120.0
Osmia	8	2	1	5	15	[illegible]	[illegible]	1	[illegible]
All others	0	0	0	1	1	[illegible]	0	1	[illegible]
Total	244	84	52	87	140	274	55	100	128.30
Corolla length (mm.)	8.96	9.07	7.76	8.75	8.43	7.89	8.53	7.99	8.42
No. seeds per head	384 06	26.34	19.24	25.55	23.53	32.82	27.44	27.12	27.01

*Divide by 600 to obtain the number of pollinators per plant per observation.

Table 2. Bee visitors*, corolla tube length, and no. seeds per head of eight tetraploid red clover varieties grown at Newton, Utah, 1961

Variety	Sv 034	TPA1	ULVA	A066	Ötofte	Lot 586 A SV065	RT1	RTE5	Average
Origin	Sweden	Finland	Sweden	Sweden	Denmark	Sweden	Norway	Norway	
Honeybees (nectar)	8	13	10	21	27	41	6	26	19.0
Honeybees (pollen)	30	36	30	18	69	10	28	68	48.1
Bombus	29	22	19	30	28		10		29.3
Osmia	0	0	0	1	1		1	1	0.6
All others	1	3	1	1	3	2	1	0	1.5
Total	68	80	60	70	127	214	45	121	98.1
Corolla length(mm.)	9.22	9.12	9.20	9.24	8.92	8.14	8.37	8.81	8.88
No. seeds per head	22.23	28.75	30.57	30.57	28.66	28.20	38.83	27.52	28.77

*Divide by 600 to obtain the number of pollinators per plant per observation

Table 3. Bee visitors*, corolla tube length, and no. seeds per head of eight diploid red clover varieties grown at Newton, Utah, 1961

Variety	Kenland	Alta-swede	Dollard	Penn-Scott	LaSalle	Chesapeake Red	Lakeland (Wisconsin)	Tammisto (Finland)	Average
Honeybees (nectar)	20	38	36	23	32	21	26	39	[illegible]
Honeybees (pollen)	40	52	58	41	76	28	48	83	[illegible]
Bombus	26	53	36	18	46	18	30	37	38.0
Osmia	7	2	7	7	3	3	2	1	4.0
All others	1	3	2	7	2	1	1	0	2.1
Total	93	148	140	96	150	71	106	161	120.6
Corolla length(mm.)	8.96	7.53	6.68	8.20	7.81	9.52	9.16	8.174	12[illegible]
No. seeds per head	51.51	43.60	50.65	46.35	43.36	46.31	43.66	46.83	46.53

*Divide by 600 to obtain the number of pollinators per plant per observation

since both 1960 (the year of planting) and 1961 were drought years in Utah, a number of plants were lost, and growth was stunted. By July 1 (1961) it became evident that the natural moisture would no longer sustain the plants, so water was thenceforth added from a tank at biweekly intervals. Although the plants remained stunted, bloom was fairly strong. However, it only lasted from July 1 to July 23 in any significant amount. In 1961, the surrounding wild flowers disappeared early, and the population of native bees had already dwindled considerably by the time the clover came into bloom.

Four observers counted all bees on each subplot on July 7, 10, 11, 14, 19 and 21. Two counts were made on July 11. Thus, there were twenty-four counts on each subplot. Since a number of plants were missing, corrections were made to account for these. Because of the stunted growth, each missing plant left a conspicuous gap in the stand.

Corolla tube lengths were measured from ten heads taken at random from each subplot.

The number of seeds per head was obtained from counts on eighty heads taken at random from each subplot.

RESULTS

Sixteen species of bees were included in the counts. Of these, by far the majority were bumble bees, of which the majority were Bombus fervidus and B. centralis, both long-tongued species. Honeybees were insignificant in number (Table 1). We were interested in observing the activities of Bombus occidentalis, the only corolla-cutting species in our area, but for some reason it was absent in both the localities studied. Pollinator populations at Barker's Hollow were not exceptionally high, in spite of the supposedly favourable location and the small size of the plot. As shown in Table 1, there was a total of about 1 bee per six plants per observation.

Differences in pollinator populations between varieties were highly significant ($F = 8.132$).

Corolla tubes were short, probably because of inadequate soil moisture. Although differences between varieties seem large, they were non-significant because of the great variation between replications of a few varieties. There was no

correlation between varietal attractiveness and corolla tube length (Table 1).

The number of seeds per head ranged from 43.6 to 24.6. The differences were highly significant ($F = 10.42$), and there was a positive correlation between the number of seeds per head and varietal attractiveness ($r = 0.8016$).

At Newton there were two adjacent series of plots, one composed of eight diploid, and the other of eight tetraploid, varieties, and there were 25 plants in each subplot. The 16 subplots in each series were randomly arranged.

The plot at Newton was irrigated only three times because of a water shortage, but the plants did not show evidence of moisture stress. However, powdery mildew, which was prevalent on both series of subplots, reduced the vigour of the plants and almost eliminated bloom on many of them. The diploid varieties began blooming in the middle of June, but the tetraploids did not reach the same stage until July 1. The tetraploids held their bloom about a week longer at the end of the season. Consequently the diploid plants received more visitation from spring insects, such as Osmia and queen bumble bees.

Pollinator counts were made on the same days and in the same manner as at Newton. Procedures for measuring corolla tube lengths and seeds per head were also the same.

Eighteen species of bees were included in the counts at Newton. Honeybees were about three times as abundant as wild pollinators (Tables 2 and 3). Pollen-collecting honeybees were more than twice as abundant as nectar collectors. Among wild bees Bombus fervidus was by far the most abundant. Populations of wild pollinators were much lower than at Barker's Hollow, but the total numbers of honeybees and wild bees were similar at both locations.

When comparing tetraploids with diploids, it can be seen from Tables 2 and 3 that honeybees were slightly more abundant on the diploids, and bumble bees on the tetraploids. The differences are, however, probably not statistically significant.

Analysis of total pollinator populations visiting the varieties of diploids and tetraploids at Newton showed no significant differences within either type. The small number

of replications and the high variation between them probably account for this. Analysis of the numbers of seeds per head showed a significantly higher value in the diploid varieties. Since differences in pollinator populations were not significant, no attempt was made to correlate visitation by pollinators with the number of seeds per head.

When pollinator populations on the various tetraploid varieties at Parker's Hollow were compared with those on the same varieties at Newton, the correlation coefficient was 0.893, which was barely below significance at the 5% level. This indicates a tendency for the same ranking in attractiveness at the two locations, in spite of the differences in growing condition and pollinator species involved.

DISCUSSION

Difficulties encountered in obtaining and maintaining good stands and growing conditions in the experimental plots undoubtedly affected the value of the results. Drought, root diseases and mildew took a heavy toll. Correcting the figures for missing plants was probably only a slight improvement over ignoring them, since it is not clear what effect isolation had on the attractiveness of plants in the plots that were much thinned out.

At Newton the lack of sufficient replications made significant data almost impossible under the erratic growing conditions encountered. Also, at Newton the gap in blooming time between the tetraploid and diploid plots made comparisons between their attractiveness to pollinators relatively meaningless. Finally, the presence of tetraploid and diploid plots side by side seemed to have a harmful effect on yields (because of triploid combinations) and thus obscured the relationships between pollinator visits and yields.

At Parker's Hollow significant differences between tetraploid varieties in terms of the number of seeds per head and attractiveness to pollinators, and correlation between these two factors, show that useful studies of tetraploid varieties are possible. However, this type of work requires better arrangements for land and labour than we had at our disposal.

Work in other areas has indicated that bumble bees are about twice as efficient as pollen-collecting honeybees

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When pollinator populations on the various tetraploid varieties at Barker's Hollow were compared with those on the same varieties at Newton, the correlation coefficient was 0.693, which was barely below significance at the 5% level. This indicates a tendency for the same ranking in attractiveness at the two locations, in spite of the differences in growing conditions and pollinator species involved.

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Difficulties encountered in obtaining and maintaining good stands and growing conditions in the experimental plots undoubtedly affected the value of the results. Drought, root diseases and mildew took a heavy toll. Correcting the figures for missing plants was probably only a slight improvement over ignoring them, since it is not clear what effect isolation had on the attractiveness of plants in the plots that were much thinned out.

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for pollination of red clover, and that pollen-collecting honeybees may be twice as efficient as nectar collectors. On this basis, it would appear that in farm areas of Cache Valley (even where honeybee colonies are kept) bumble bees would prove to be nearly as important as honeybees on small plantings of red clover, but they would probably lose much of their importance on larger areas.

The differences between tetraploids and diploids with regards to attractiveness to honeybees and bumble bees were small under the rather atypical conditions of our plots. Since so little difference in corolla tube length was evident, this is not surprising.