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WEATHER FACTORS INFLUENCING HONEY PRODUCTION

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WEATHER FACTORS INFLUENCING HONEY PRODUCTION

by

Carl Jens Christian Jorgensen

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THESIS

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HONEY PRODUCTION

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Introduction

Beekeeping as an agricultural pursuit is well recognized as a hazardous business from the standpoint of secure returns on the investment. Many factors of considerable complexity, operating simultaneously, make it difficult to predict a successful or unsuccessful year. This has discouraged many would-be beekeepers and put out of business some who were venturesome enough at least to try to succeed.

At the outset it might be well for all who are in the business of beekeeping to keep in mind the four main factors which combine to make a good honey crop. These have been described by Demuth (4) as being:

1. Overpopulous colonies at time of honey flow,
2. The storing instinct dominant over swarming,
3. Honey plants in optimum condition,
4. Suitable weather for nectar secretion and collection of it by the bees.

Any one of these being limited, the crop will also be correspondingly limited. This obviously points to the necessity of understanding all four factors, yet beekeeping literature of the past has spent perhaps 90 percent of its space to informing and demonstrating successful methods of getting overpopulous colonies, control of swarming, and making the storing instinct dominant, while only 10 percent on factors three and four.

It is not the purpose of the writer to dwell on those factors which can be clearly controlled by the beekeeper, but rather to

concentrate on the effect of weather on honey production, a factor which in the final analysis really determines the size of the crop.

It might be well at this point to consider the value of such knowledge to the beekeeper and to agriculture in general. If it were possible for the beekeeper to know whether the coming honey season would be good or poor it might help him in deciding whether to:

1. Increase by packages or colony division,
2. Purchase additional bee supplies, machinery, sugar etc,
3. Hold or sell crop in view of market conditions,
4. Overwinter the colonies or kill the bees in the fall,
5. Requeen by supercedure or purchase new queens,
6. Get extra supers and equipment in shape for the succeeding crop when labor is available, and time is not at a premium,
7. Choose new or additional desirable apiary sites.

Furthermore it might help the beekeeper during the busy honey flow in such seasonal manipulations as:

1. Swarm control,
2. Amount of supering,
3. Requeening,
4. Removal of the crop.

Finally, such knowledge should reduce the hazards of beekeeping, encourage beekeepers and thus aid agriculture. It is a generally accepted fact that 90 percent of the nectar secreted by flowers goes to waste for lack of bees to gather it. This in itself is of little importance when we consider the great need for bees in the pollination of fruits and seed bearing plants such as the clovers, the cucurbits and special crops raised for seed. It has been suggested that bees are ten times more valuable as pollinators than as honey producers.

Literature Reviewed

Theoretically nectar secretion and honey production should be considered as separate subjects, yet the practical beekeeper is not so much interested in nectar secretion as he is in the amount of nectar gathered by the bees. Lundie (11) believes that while there is an apparent close correlation between the nectar secreted and the nectar gathered by bees, it is not an absolute relationship. It would appear reasonable to expect that the weather factors which are favorable for nectar secretion would also be favorable for honey production, yet much conflicting opinion exists, and further experimentation correlating these two factors would be highly desirable. Both Demuth (4) and Kenoyer (9) have reached some interesting conclusions as to the environmental influences on nectar secretion. Davis (5) states that a rainfall above normal for two years preceding nectar secretion is of prime importance in conditioning plants. McLachlan (12) would add excess sunshine to the above, but he adds that conditions favoring growth during the nectar secreting period reduce the amount of nectar secreted. He also recognizes high temperature days following cool nights as favoring nectar secretion, but finds heavy rains or sudden cold spells unfavorable. Kelty (7) believes that ample moisture during the growing season, with occasional showers and high temperatures during the blooming season, and a fairly wide range in temperature between day and night aid nectar secretion. Kremer (10) states that normal summer temperatures of 65° to 85° F. are favorable for nectar secretion, while temperatures above 90° are adverse. This is not in agreement with Beutler (1) who found that air temperature within biological limits did not affect the flow. She found that lowered light intensity reduced secretion, and that soil moisture had little or no influence on the concentration of sugar in the nectar; while high humidity did dilute the nectar through hygroscopic absorption. This is in agreement with Park (15) who found that sugar concentration in nectar varied inversely with relative humidity. Vansell (16) and Beutler (1) both agree that sugar concentration in nectar varies with species and varieties. Hambleton (6) believes that the factors influencing the secretion of nectar probably do not similarly influence changes in colony weight. It is unfortunate that so little is known concerning nectar secretion of major honey plants. Further investigation will no doubt clear up many controversial issues and make real contributions as far as the beekeeper is concerned.

As to the direct effect of weather factors on honey production, an equally small amount of experimentation has been carried out that supports the great number of statements made by beekeepers and others based partially on observation but more often on reasoning and assumption. While many good beekeepers maintain "scale hives", it is unfortunately true that they are used only to indicate day to day trends and seldom are combined with weather data. Even these rough records are all too few.

The only outstanding work paralleling that here reported, was done by Kenoyer (9) on a 29-year record at the turn of the century in Iowa. The fact that present day beekeeping has made changes in methods as well as kinds of major honey plants, might possibly account for some of the differences found; and point to the need of constant revision of knowledge on the basis of these changes. Work by Hambleton (6) gives mathematical correlations between external factors and net gain on the basis of one season's record. On a similar season's basis Lundie (11) compares weather factors with the flight activities of the honeybee by means of a counting apparatus recording the exit and entrance of bees to the hive. He concludes the survey by this statement: "-of all the external environmental factors which influence the magnitude of the flight occurring on any normal day, a heavy honey flow of nectar is the strongest."

Method of Obtaining Data

The records on which this thesis is based were obtained from Mr. Floyd Markham of Ypsilanti, Michigan, and cover a period of twenty-four consecutive years from 1921 to 1944. Mr. Markham is well known to beemen in Michigan, and recognized as one of the most successful operators in the business. He manages approximately 300 colonies of bees and has been a beekeeper for over fifty years. His scholarly observations and remarks concerning bees are accepted as sound in Michigan and elsewhere. His records include daily observations of a standard ten-frame colony of bees placed on a platform scale for the main honey flow period. The colony weight was recorded each evening after all of the bees were in, and is accurate to the nearest half pound. With the exception of a few years, the same colony was on the scale for the whole recorded season. The exceptions are those where swarms issued, and it was deemed advisable to put the scale under a more normal colony. The scale hive represents an average colony rather than one exceptionally strong or week. The

colony under observation was located in the home apiary which is approximately 4 miles north of Ypsilanti, and 6 miles from the U. S. Weather Bureau cooperative station at the University Observatory in Ann Arbor, from which the official weather data were obtained. The two exceptions to this are the data for barometric pressure and relative humidity which were not recorded at Ann Arbor but had to be obtained from the U. S. Weather Bureau in East Lansing. Upon the advice of that office it is believed that records on these two factors would not be very different from those which might have been obtained at Ypsilanti. It should be here stated that in addition to the net gain or loss for the day Mr. Markham also recorded weather observations in many instances. These correspond in practically all cases with the official weather data and lend credence to the feasibility of using data from Ann Arbor or East Lansing. The official weather data were taken at 7:30 P.M. which closely corresponds to the time Mr. Markham made his recording.

Mr. Markham's average honey production per colony was available for the period 1930 to 1939 and has been incorporated into Figure 1.

The principal sources of nectar available to the bees during this period were white, alsike and sweet clover, basswood and alfalfa.

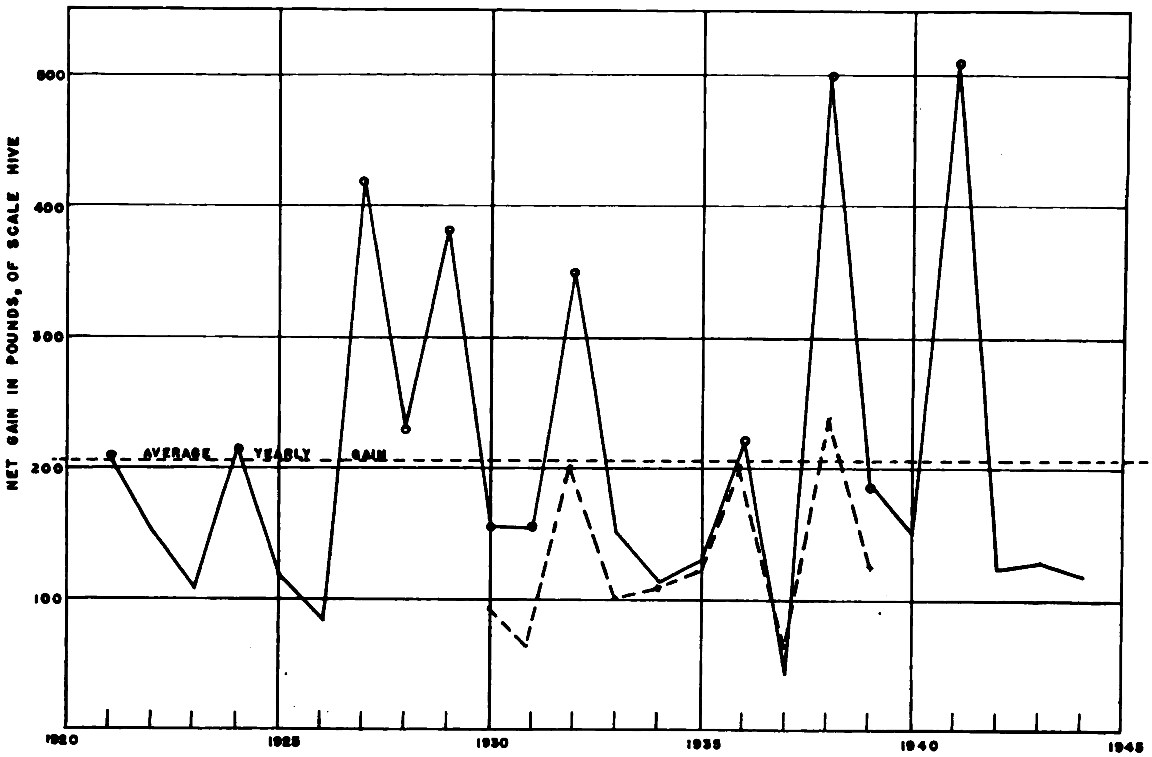

Fig. 1. Yearly gain of scale hive for the 24-year period. Circled years represent the 12 best years. Broken line represents extracted honey average for all colonies for years 1930-1939.

Yearly Variations in Honey Yield

Figure 1 shows the yearly gain of the scale hive for the 24-year period. This yearly net gain represents honey, pollen, and wax increase and is therefore somewhat higher than the amount of honey removed at extracting time. The average gain of 206 lbs. represents the net gain for all years divided by 24, and seems a fair average. A line running through 150 pounds however, would divide the 12 good and poor years evenly and place the poorest of the three good years at or above that level. 1927, 1929, 1932, 1938 and 1941 were very good years; while 1925, 1926, 1934, 1937 and 1944 were the poorest years.

The question might arise as to the value of using one scale hive to represent the total number of colonies in the apiary or locality. For that reason the average honey production per colony for the years 1930 to 1939 has been added in the form of a broken line. The curve is lower than the net gain, since it represents about 75 pounds less than the total net gain. This 75 pounds can be broken down into 50 pounds left on the colony for winter stores and the 25 pounds lost during the average fall and spring. When this wintering-over requirement is properly evaluated, we find a remarkable correlation for this ten-year period. The 1931 figure would no doubt have shown a much better correlation had it not been for the fact that an infection of American Foulbrood in one yard necessitated the destruction of 39 colonies, the making of new nuclei, and rearing of new queens. This reduced the yearly average considerably and accounts for the 1931 dip of all colonies as compared with the scale hive which remained normal. We can conclude then, that the scale hive represents the trend of the average hive in most years, if the colonies are under skilful manipulation. That this is generally true can be also be concluded from Hambleton's (6) experiments of comparing 2 and 3 hives placed side by side. These showed no appreciable differences either hourly or daily for the recorded period.

It is apparent that there was no alternation of good and poor years, as found by Kenoyer (9) in his study. Rather, Figure 1, shows that there is a slight tendency toward a series of good or poor years. The years 1927 through 1932 all fall in the 12 best year series, while the last three years are an example of a series of poor years. This is substantiated by computing the average colony gain preceding the 12 good and poor years. The average yield preceding the 12 good years is 215 pounds, while that of the year preceding the 12 poor years is 206 pounds. Finally, Figure 1 shows that while two bumper crops never followed one another, poor years often came in groups of two or three. Kelty (7) states that two bumper crops seldom occur in succession.

Year	May	June	July	Aug.	Yearly Net Gain
1921		168	38		206
1922		161	-4	-5	152
1923		87	23	-1	109
1924		51	165	-1	215
1925		22	90	7	119
1926		13.5	53.5	21	88
1927		99	214	106	419
1928		33	164	35	232
1929		135.5	242.5	3.5	381.5
1930		28	128	1	157
1931		64.5	83	8	155.5
1932		106	149	94	349
1933		123	30		153
1934		25.5	79	10.5	115
1935		42.5	89.5	-1	131
1936		139	74.5	6.5	220
1937		16.5	28		44.5
1938		228	229	41	498
1939		92	96		188
1940		29	121.5	1	151.5
1941	5	262	226	16	509
1942		84	40		124
1943		37	86	5	128
1944	23	58	24	14	119
Total in Pounds	28.0	2105.0	2469.5	361.5	4964.0
Percent of Total	.7	42.4	49.7	7.2	100.0

Table 1. Net Gains per month and season for each year, the grand totals for each month and the percent of the total for each month.

Table 1. clearly shows that of the total 24-year period only the 8 years '21, '22, '23, '33, '36, '41, '42, and '44 produced more in June than in July, and of these 8 years only '36 and '41 were in the 12 best years. This would indicate that both June and July determine the good or poor year. This is not the direct contradiction to Kenoyer's (9) findings that might be apparent at first glance. Kenoyer credits June with 59.6 percent of the total, while July produces only 25.7 percent. If we go along with the popular assumption that the principal honey plants have changed since 1920, some light is thrown upon the variation in findings. The principal change is of course the universal acceptance of sweet clover as a valuable forage crop rather than a weed, plus a growing popularity of alfalfa. The increased acreage of sweet clover and alfalfa, with a consequential reduction in acreage of alsike clover has probably lengthened the honey flow. From the 24-year record the writer finds June 15 to 25 to include the beginning date of practically all honey flows. It is rather obvious that the question of management of the apiary should be focused on this all important period. Both spring purchased packages and overwintered colonies must be at their peak by this critical time. Mr. Markham remarks as follows, "We used to figure on June as the best month, but lately with sweet clover and alfalfa, July is the best month or at least as good as June. In the days of comb-honey production, the crop was on the hive by the Fourth of July."

Effects of Specific Weather Factors on Honey Production

Having discussed some general features of the data it now becomes desirable to focus attention on the relationship existing between certain weather factors and colony increase. As previously stated, it would be highly desirable to find correlations on a long time basis, as well as on a daily basis during the honey flow. Insofar as possible both long term and daily effects are shown under the same heading in this thesis. To aid the reader in visualizing daily effects of weather, Table 2. is presented. It was thought preferable by the writer that rather than including all possible days, the ten best and ten poorest days of each season be chosen and their weather effect be shown. These were not all lumped indescriminately, but classified as to 1, 2, 3, or 4 days. Thus a No. 1 good day would be one in which the scale colony produced 15 pounds and up; No. 2, 10 to 15 pounds; No. 3, 5 to 10 pounds, and No. 4, 3 to 5 pounds gain. Similarly with the poor days, the scale colony on a No. 1 day would have a loss of more than 1 pound; a No. 2 day less than 1 pound loss up to zero, a No. 3 day a gain from zero to 1 pound; and a No. 4 day a gain of 1 to 2 pounds.

The data will be presented in the following order: Precipitation, temperature, wind direction and velocity, amount of sunshine, humidity and barometric pressure.

No.	240 Good Days: Range	Total	Precipitation in Inches: T-.10	.11-.24	.25-.49	.50-.99	1.0+	Temperature Maximum: 60-79	70-79	80-89	90+	Minimum: 50-59	60-69	70-79	Range: 0-14	15-19	20-24	25-29	30+	Sunlight Sunrise to Sunset: Clear	P.Cldy	Cldy.
1	15# + Gain	21	4	1	0	0	0	0	5	12	4	9	11	1	0	2	7	11	1	15	3	3
2	10-15# Gain	59	14	0	1	0	0	0	14	39	6	33	26	0	0	7	25	24	3	34	18	7
3	5-10# Gain	119	18	4	1	1	0	0	22	69	28	44	63	12	2	17	54	33	13	62	30	27
4	3-5# Gain	41	7	2	1	2	0	0	8	21	12	12	23	6	1	7	17	13	3	22	13	6
Totals in Days			43	7	3	3	0	0	49	141	50	98	123	19	3	33	103	81	20	133	64	43
240 Poor Days																						
1	1# + Loss	120	27	14	25	13	8	17	58	39	6	55	56	9	41	38	35	6	0	18	26	76
2	0-1# Loss	103	28	9	7	5	1	4	42	42	15	42	53	8	12	31	42	14	4	30	36	37
3	0-1# Gain	16	2	3	1	3	2	0	6	9	1	5	10	1	2	7	4	3	0	4	2	10
4	1-2# Gain	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0
	Totals in Days		57	26	33	20	11	21	106	90	22	102	118	19	56	75	81	23	4	53	64	123

No.	Wind Direction: N	NE	E	SE	S	SW	W	NW	Humidity: 30-39	40-49	50-59	60-69	70-79	80-89	90+	Barometric Pressure: -29.69	.70-.79	.80-.89	.90-29.99	30.00-.09	.10+
1	2	0	1	1	3	6	5	3	2	1	12	4	1	0	1	0	0	1	5	11	4
2	3	1	5	8	7	10	10	15	1	8	14	26	7	3	0	1	4	12	23	13	6
3	15	5	14	17	14	17	19	18	2	10	43	33	17	8	6	2	4	29	39	26	19
4	2	3	4	6	5	9	5	7	0	5	11	13	7	3	2	1	4	5	18	8	5
Totals	22	9	24	32	29	42	39	43	5	24	80	76	32	14	9	4	12	47	85	58	34
No.																					
1	10	10	9	8	2	23	25	33	0	11	13	25	33	24	14	10	23	18	34	14	21
2	15	13	10	7	7	10	19	22	9	11	28	17	18	7	13	6	6	26	23	29	13
3	4	0	2	1	0	2	3	4	0	4	1	3	1	2	5	2	1	2	5	6	0
4	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0
Totals	29	23	21	16	9	35	47	59	9	26	43	44	52	33	32	18	29	46	63	49	34

Table 2. **Daily effects of specific weather factors on colony net gain.**

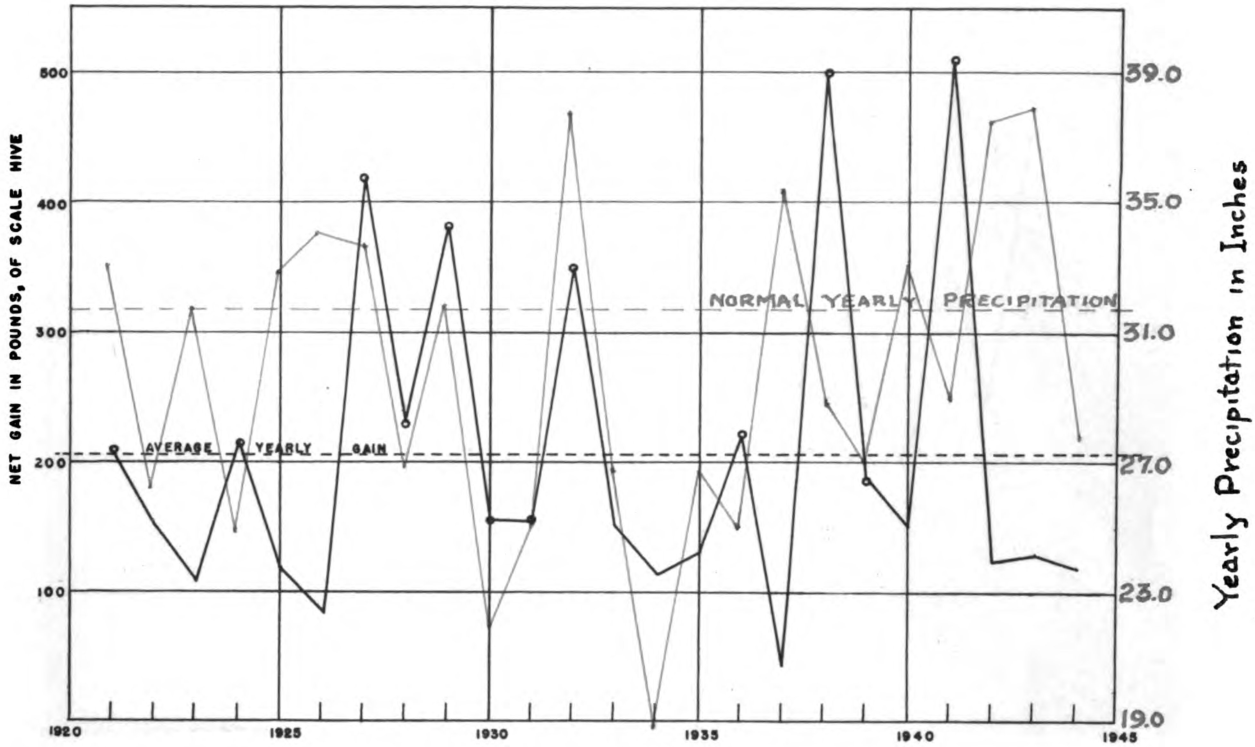

Figure 2. Graph showing the relation of net gain to the annual precipitation for the year of the crop.

Precipitation and Net Gain

1. Crop year precipitation and net gain.

By superimposing the rainfall curve upon that for the net gain in colony weight (Fig. 2.), it can be seen that although some relationship exists, it is variable and has slight significance. There would appear to be a small advantage in a lower than average rainfall during the honey production year. In the years 1927 through 1933 the apparent correlation is probably due to early spring precipitation; while the years of poor correlation, such as the series 1935 to 1941, are years in which the rainfall came too late to affect the honey production for that season. Fig. 2. does however show that in these years, the amount of precipitation

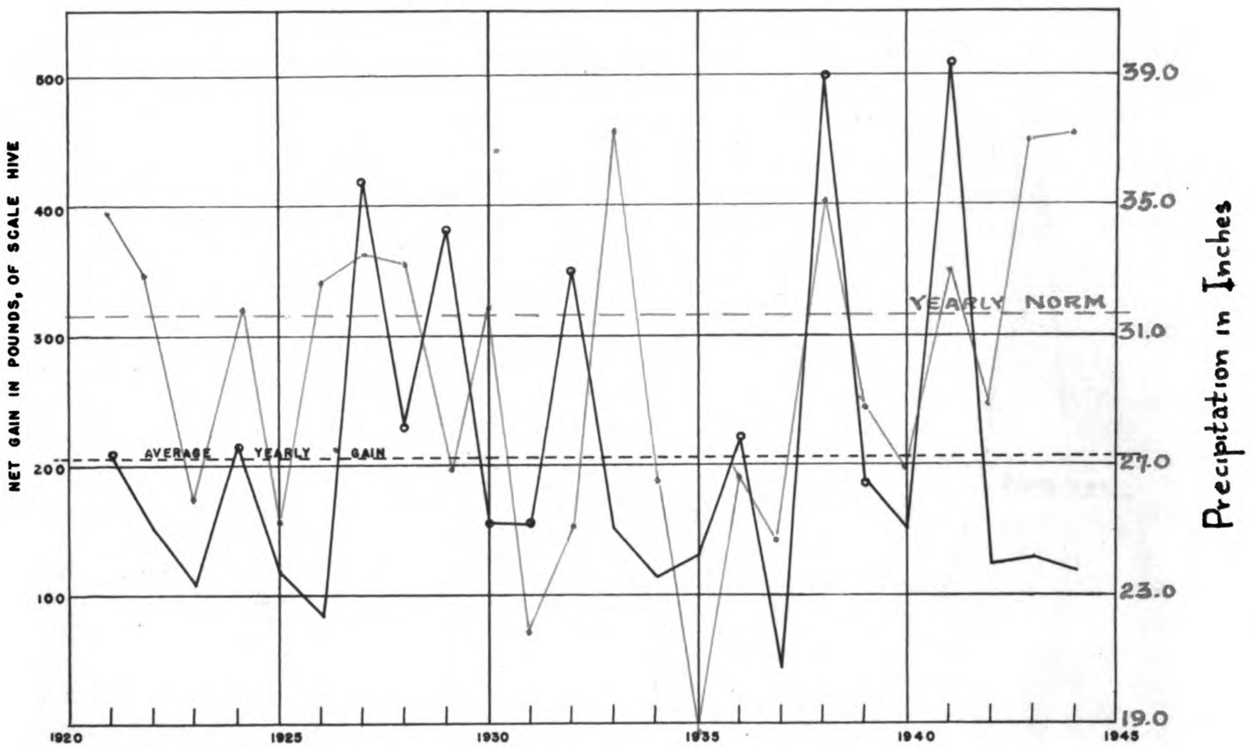

Figure 3. Graph Showing the relation of annual precipitation for the year preceding the crop to the net gain for the crop year.

occurring after the honey flow did have an effect on the net gain for the following year.

2. Net gain and preceding year's precipitation.

In Figure 3, we see a better correlation than in Figure 2, yet certain deviations exist. In 1929 and 1932 we find that while the preceding year was dry it was dry in the early part of the year and normal in the fall months when honey plants are becoming established for the succeeding year's blossoming period. The early months of 1929 and 1932 were above normal. If we keep in mind that 1931 and 1939 were among the poorest of our best years, the deviations for these two years become explained. The above average rainfall of August 1935 gives us the clue to the apparent discrepancy for 1936. In addition, 1936 was not an exceptional year,

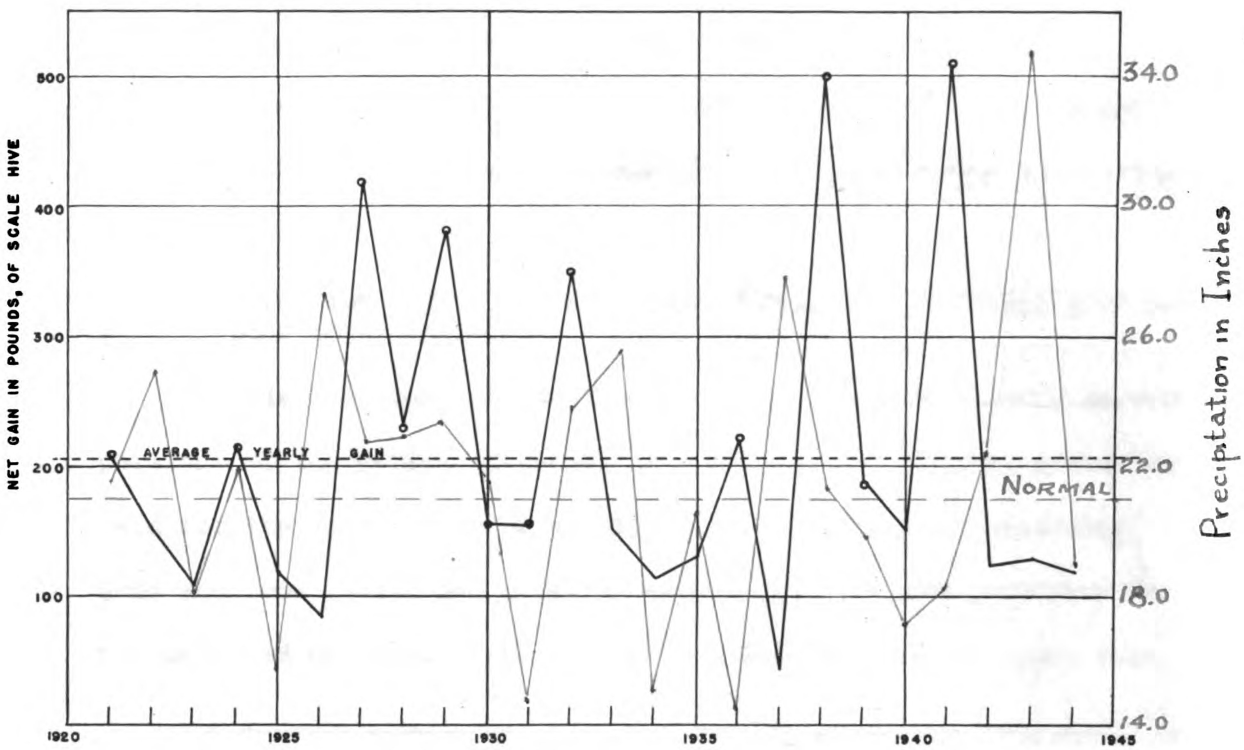

Figure 4. Graph showing the relation of the yearly crop to the precipitation for the 9-month period preceding the honey flow.

being only 14 pounds above average.

In this region, the main honey production is from biennial and perennial plants. The size, vigor and nectar secretion in any one year depends largely on the start they get in August, September and October of the preceding year. We would therefore expect to find the correlation shown above.

3. Net gain and the precipitation for the 9 months preceding.

It would seem that we could assume from the above discussion that the relationship of the preceding 9-month's precipitationto the net gain would be positive in practically all cases. However, from Figure 4, we again see some glaring variations, and we come to the realization that other factors being equal, one good rain at the right time may change the year from poor to good. In 1936 and 1941 wet preceding Augusts and nice rains in June helped to overcome the deficiency in moisture during the winter and spring months.

4. Precipitation for selected periods preceding and during good and poor honey years.

In order to study the influence of precipitation during certain portions of the period preceding and during honey flow on colony net gain for the year, a series of tables were constructed comparing good and poor annual net gains of the scale hive with precipitation for selected periods. Tables 3 and 4 summarize some of these data.

	Normal	12 good	12 poor
Annual precip. for year of crop	30.84	28.64	30.50
Annual precip. for year preceding	30.84	30.21	29.58
Precip. for Sept. thru Dec. preceding	9.94	9.36	9.89
Precip. for Jan. thru May preceding	12.05	11.21	12.42
Precip. for 9 months preceding	21.99	20.57	22.31
Precip. for June of crop year	3.35	3.25	3.25
Precip. for July of crop year	2.82	2.58	2.65

Table 3. Averages of precipitation in inches for selected periods preceding and during honey flow, comparing good and poor honey years.

From Table 3 we note that while it is apparently desirable to have copious precipitation for the year preceding the crop, below normal precipitation is found in the good crop year totals. This when broken down into shorter periods preceding the honey flow would appear to favor below normal precipitation for fall, winter and spring and for the 9 months preceding the crop. Table 3 averages do, however, fail to show the great variations in good and poor years for these selected periods. These variations might be interpreted

as a lack of relationship between the honey yield and precipitation for any of the several periods studied. The averages are in themselves so close in some cases as to prevent definite conclusions to be drawn. Kenoyer's (9) findings agree only insofar as favoring higher rainfall for the preceding year in the 10 best years of his data. Kelty (7) believes that larger honey crops accompany a slightly dry blooming period; while very little honey is produced during a cool, wet blooming period.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Sept.-Dec.	Jan.-May	Preceding 9 Months
Normal in inches	1.87	1.85	2.20	2.69	3.44	3.35	2.82	9.94	12.05	21.99
No. of Good Years above	5	4	3	4	3	4	4	5	4	5
No. of Good Years below	7	8	9	7	9	8	8	7	8	7
No. of Good Years normal				1						
No. of Poor Years above	3	1	8	6	3	5	5	6	6	6
No. of Poor Years below	9	7	3	4	7	7	7	6	6	6
No. of Poor Years normal		4	1	2	2					

Table 4. Comparison of precipitation of good and poor honey years by months and periods, with normals for the month or period.

It becomes immediately apparent from Table 4 that for both good and poor years a great share had below normal precipitation. The very droughthy mid-thirties plus a few other years of exceedingly dry springs tends to bring this about. In general the result for this period of January through July are inconclusive. However, March and April show significantly that below normal precipitation for these two months is favorable while the other months tend to corroborate the findings in Table 3 that slightly drier months are favorable. When viewing the preceding nine-month period September through May, we again find precipitation below normal apparently slightly favorable.

5. Preceding winter's snowfall and net gain.

A great many successful beekeepers feel that heavy snowfall and more specifically snowcover is advantageous and is followed by larger honey crops the succeeding summer. This belief no doubt stems from the assumption that snowcover protects honey plants and prevents heaving due to alternate freezing and thawing. Kenoyer (9) says that according to his findings, winters of heavy snowfall were followed by a larger honey yield in a majority of cases. The present writer has attempted to analyze snowfall by two methods: amount of snowfall by months and season, and the number of days of snowcover by months and season. The results are shown in Table 5.

Amount of Snowfall in Inches					Snowcover in Days				
	Dec.	Jan.	Feb.	Season		Dec.	Jan.	Feb.	Season
Normal in Inches	6.7	8.2	8.5	34.6	Normal in Days	13	19	15	59
No. of Good Years above	6	6	4	5		6	9	5	7
No. of Good Years below	6	6	8	7		6	3	7	5
No. of Poor Years above	6	4	4	6		4	6	5	6
No. of Poor Years below	6	8	8	6		8	6	7	6

Table 5. Amount of snowfall and days of snowcover by months and season for good and poor years.

We see from this table that the amount of snowfall has less to do with the succeeding crop than we might expect. To further show that the amount of snowfall for the season apparently has

little to do with the following crop the writer found that of the five highest net gain years, all had below normal snowfall the preceding winter. Of the 5 poorest honey seasons, 3 had above and 2 below normal snowfall for the preceding winter. As to days of snowcover it is apparent that December favors slightly above normal snowcover and January significantly favors above normal snowcover since 9 of the 12 best years had above normal number of days.

6. Precipitation and daily gain.

Rain as we might expect, has a striking effect on daily gain, since it effects both nectar secretion and bee activity. Munro (14) states that excessive rainfall during the normal nectar flow period was more responsible for a decreased honey yield than any other cause. Kremer (10) states that rainfall makes nectar unacceptable to bees since it dilutes it to an excessive extent, and further that rainy weather usually stops bees completely from gathering nectar. Inspection of Table 2 shows agreement with these statements. Of the 240 best days only 56 had any precipitation and 43 of those days had less than .10 of an inch. On further investigation of daily records the writer found that in a great majority of these days, the precipitation occurred during the night and thus affected bee activity very slightly. As the gain becomes progressively poorer, we see a progressive increase in amount and number of days of precipitation. Of the 240 poor days, 147 had rain. Also of the 120 poorest days, 87 had fairly heavy or continuous rain. In the majority of cases, these occurred during the hours of bee activity.

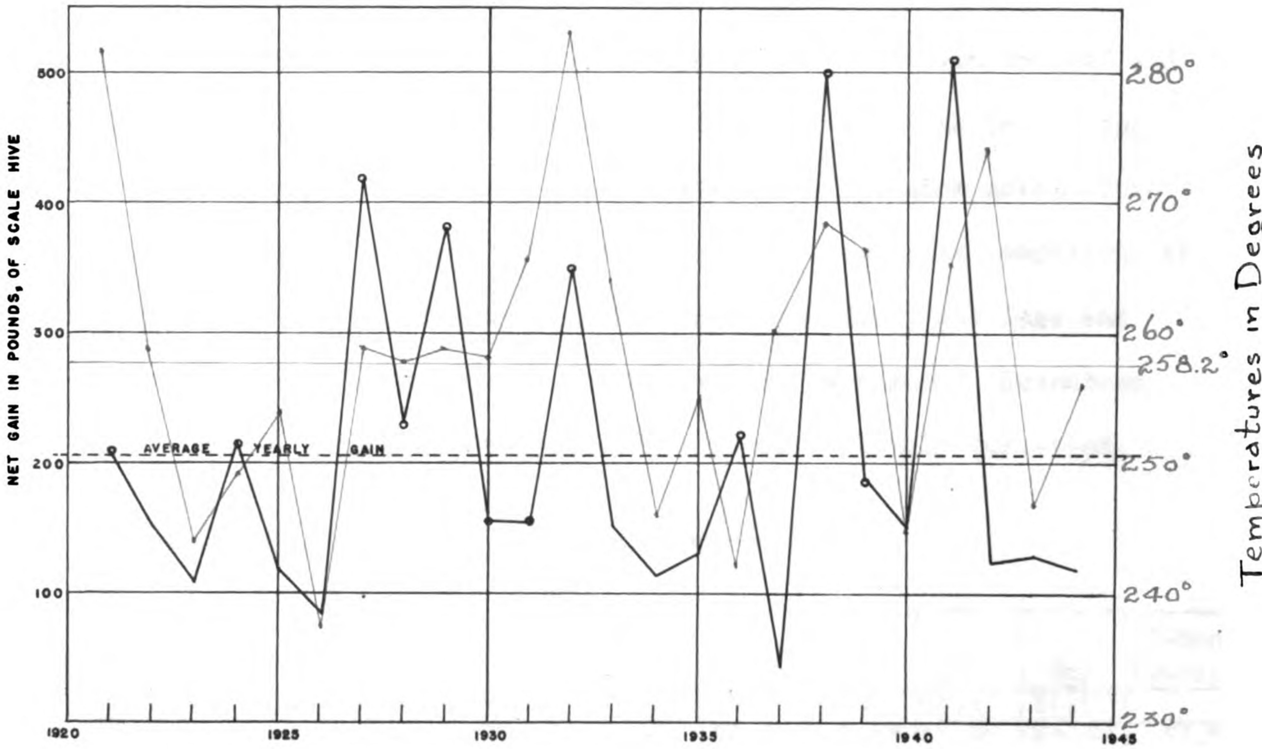

Figure 5. The relation of average temperature totals for the seven-month period November through May preceding the honey flow, to the net gain for the year.

Temperature and Net Gain

1. Preceding temperatures and net gain.

Figure 5 shows a comparatively high degree of correlation between preceding period temperatures and honey flow. Of the 12 best years, 9 had above average temperature for the preceding 7 months, while only 3 had below. Of the 12 poorest years, 8 had below average temperatures for the same period while 4 had above. A further analysis of specific years clears up the majority of the discrepancies. For the years 1931 and 1935 the precipitation for the preceding 9 months was very low. The fair crop of 1936 in spite of low temperatures and precipitation preceding, can be attributed to an exceptionally warm March and May plus a normal June. This made the

June honey increase high. The very hot dry summer of 1936 and the cool wet June of 1937 however, reduced nectar secretion in 1937 and probably accounts for the low yield of that year. The poor crops of 1939 and 1944 are likely due to precipitation below normal for the preceding 9 months. 1942 had apperently favorable conditions of temperature and precipitation up to the honey flow, but June and July of 1942 were two of the wettest months on record. Seventeen thuderstorms occurred, and bee activity was seriously curtailed.

2. Preceding temperature averages and net gain.

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	7-Month Average
Normal in Degrees	38.0	27.4	23.3	23.7	33.2	45.8	57.9	
12 Good Years	39.66	29.32	25.01	27.23	35.63	47.07	58.88	37.54
12 Poor Years	38.39	28.02	25.08	25.04	33.2	45.80	58.32	36.24

Table 6. Preceding temperature averages by months for good and poor years.

From Table 6 we see that with the exception of January all best years-have an average monthly temperature higher than all poor years for the preceding period November through May.

3. Relationship of monthly temperature to net gain of good and poor years.

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Normal in Degrees	63.2	50.8	38.0	27.4	23.3	23.7	33.2	45.8	57.9
Good Years above	5	7	7	8	8	10	7	6	7
Good Years below	6	5	5	4	4	2	2	4	3
Good Years normal	1						3	2	2
Poor Years above	9	7	6	6	8	9	5	4	6
Poor Years below	2	2	6	4	4	3	6	6	5
Poor Years normal	1	3		2			1	2	1

Table 7. Number of good and poor years above or below normal temperature by months.

Table 7, in addition to the months shown in Table 6, also includes September and October of the preceding fall. It appears that a September below normal is advantageous. The months of October through February are inconclusive, while March, April, and May show very definite advantage in above normal mean temperatures Kenoyer (9) found similar relationships to exist for the months of March, April, and May.

4. Temperature and monthly gain.

While it would be possible to continue Table 7 for the honey flow period, such a computation would not necessarily give a true picture of actual conditions, since good and poor Junes and Julys would not in many cases be synonymous with good and poor years. On this basis Table 8 represents an attempt by the writer to correlate average temperatures with net gain for the 12 best Junes and Julys rather than Junes and Julys of the 12 best years.

	Mean Maximum	Mean Minimum	Mean Monthly	Mean Range
June Normals	78.9	57.6	67.3	21.36
12 best Junes	79.6	57.7	68.5	21.6
12 poorest Junes	78.6	57.5	68.0	21.1
July Normals	84.0	62.2	72.1	21.85
12 best Julys	83.3	61.7	72.5	21.5
12 poorest Julys	84.7	62.5	73.6	22.2

Table 8. Comparison of means with normals of temperature for good and poor Junes and Julys.

An analysis of Table 8 reveals the interesting fact that while averages for mean maximum, minimum, monthly, and range are higher for good Junes, the exact opposites are true for good Julys, when lower averages seem favorable. This parallels Kenoyer's (9) finding only insofar as June is concerned, since he found higher averages to be favorable in July as well. Inasmuch as the averages in many cases are within one degree of each other, it would seem questionable to draw any conclusions.

5. Temperature and daily gain.

Considerable experimental evidence exists indicating the importance of this weather factor on daily gain. In fact Hambleton (6) states, "Temperature is the most important single factor influencing changes in colony weight." His mathematical correlation was .7529.

We see from Table 2 that a maximum temperature of 80 to 90 degrees seems most favorable and includes 141 of the total 240 good days. It also becomes apparent that bee activity is of little use on days when the maximum temperature does not reach 70 degrees. This is in complete agreement with Kenoyer (9) who found that only 1 percent of the total honey crop was gathered when the temperature was below 70 degrees, while 53 percent was gathered between 80 and 90 degrees. Of the poorest days, 75 had a maximum temperature below 80 degrees. Minimum temperatures for both good and poor days seem quite similar and in themselves mean little unless we consider them in relation to maximum temperature. A minimum temperature of 60 to 69 degrees seems favorable when the maximum reaches 80 to 90 degrees. While a minimum below 60 degrees is unfavorable when the maximum fails to reach the 80 to 90 degree range. Even during bright sunny weather, Lundie (11) found that bee activity was reduced as much as 40 to 50 percent on days ushered in by low morning temperature. He further found that flight commenced at temperatures varying from 55 to 80 degrees with a most frequent range of 66 to 77 degrees during the main honey flow. Kremer (10) states that temperatures below 60 degrees retard bees, reduce the number of trips per day, but do not stop them completely.

Concerning diurnal range of temperatures, 20 to 24 degrees seem most favorable, with 204 of the 240 best days above 20 degrees. This is especially significant since of the 120 poorest days 79 had a diurnal range of 19 degrees or less, while only 6 had above 24 degrees as compared to 59 out of 80 good days above 24 degrees. Keeping in mind the limited number of days of very great diurnal range, it would seem safe to assume with Mitchener (15) that the greater the difference between night and day temperatures, the greater the increase in weight of the hive. Lundie (11) did, however, state on some excessively hot days, flight curves remained low.

It might be well for us to conclude our discussion of the effect of temperature on honey production by giving the reader Mr. Markham's comments on this subject. He believes a great diurnal range is good for honey production especially for the alsike clover flow. Incidentally, alsike is about the only major honey plant producing some honey below 70 degree temperatures, according to Mr. Markham; while alfalfa and sweet clover are on the other end of the range, producing nectar even at temperatures above 90 degrees. He also states, "A good honey day is one with a heavy dew in the morning which burns off hot."

Wind and Net Gain

Inasmuch as no official data were available for wind velocity at Ann Arbor, only wind direction could be analyzed for each of the 240 good and poor days. The observation took place at 7:30 p.m. and represents the prevailing wind direction for the day. This might permit a margin of error both on the part of the observer and the writer, but in the majority of cases, the wind direction recorded no doubt is the direction for the period of bee activity. We see from Table 2 that for good days southeast, south and southwest seem most favorable; while northwest, north, and northeast seem least favorable, especially northeast. Kenoyer (9) similarly concluded that a south wind was favorable while an east wind was unfavorable. The great number of both good and bad days when the direction is west or northwest can be attributed to the prevailing westerlies of this region.

On exactly 100 single days for all years, Mr. Markham had recorded under remarks, such notes as windy, high wind, strong winds, etc. From these data the wrtier found the following:

52 days showed an average gain of 4 pounds (9 pounds to 1 pound range)
48 days showed an average loss of 1 1/3 pounds (0 to-6 pound range)

It would appear improbable that a moderate wind in itself has a great bearing on gain, but in combination with other factors it does have an effect. It is Mr. Markham's belief that when high velocities are present, drying up of nectar occurs, especially at high temperatures. Both Markham and Kremer (10) believe that high wind combined with low temperature or precipitation retard bee activity, and consequently reduce net gain. Lundie (11) found a wind velocity of 16 to 21 miles per hour reduced the possible maximum flight 28 percent.

This is in agreement with Markham when he says, "Zero to 10 miles per hour is ideal, 10 to 15 miles per hour makes little appreciable difference; while 16 to 24 miles per hour progressively reduces the yield, with 25 to 30 miles per hour no good." His conclusion as to direction of wind are, "I never got a big yield on days of east wind, but southeast to northwest clockwise is the best half of the wind rose. An east wind would dry up a cow."

Sunshine and Net Gain

Considerable evidence exists as to the positive correlation of sunshine and light to bee activity and honey production. Mitchener (13) and Hambleton (6) agree that the more hours of sunshine, the more nectar the bees bring to the hive. Kenoyer (9) summarizes by stating that clear days are preeminently the days for honey production. Cameron (2) places ultra violet light intensity as the most important single factor influencing bee activity, provided the temperature is above 62 degrees. Lundie (11) noted that on heavily overcast days, with or without occasional precipitation, the low intensity of light seemed to be the strongest factor inducing the bees to stay home. Further he believes that it is the waning light rather than fall in temperature which causes a decrease in flight toward sunset. These findings correspond closely with the writers finding on the relation of amount of sunshine to net gain. At the time of observation the type of day from sunrise to sunset was recorded. These were tabulated in Table 2. Of the 80 best days, only 10 were cloudy, while 49 were clear. Of the total best days, 135 were clear and 43 cloudy. Conversely, of the 120 poorest days, 76 were cloudy and only 18 were clear. Of the total poor days, 123 were cloudy and 53 were clear. It is also apparent that the days become progressively better or poorer depending on the amount of sunshine. It has occurred to the writer that perhaps an even greater effect in favor of sunshine could be shown were it not for the fact that many days which were recorded as cloudy actually had a high amount of light. Such days might be those on which cirrostratus or altostratus clouds existed. These, while partially obscuring the sun, did allow much light to penetrate. Mr. Markham feels his best yield comes on clear days, and that warm and partly cloudy days are fair, while cloudy days are poorest since the temperature is lowered. He feels the hotter the temperature the less is the effect of clouds, particularly on basswood.

Table 9 presents averages of clear, partly cloudy and cloudy days for the 12 good and poor Junes and Julys.

	12 Good Junes	12 Poor Junes	12 Good Julys	12 Poor Julys
No. Clear days	10.5	9.7	13.0	13.7
No. of P. Cldy days	10.5	9.8	10.1	10.9
No. of Cloudy days	9.0	10.5	7.9	6.4

Table 9. Averages of sky cover for good and poor Junes and Julys.

It is quite evident that the amount of sunshine has a much greater effect on daily gain than on monthly totals. Table 9 does point to an advantage for clear days in June, and for more cloudy days in July. This in the writer's opinion is not a condemnation of clear weather for July, but rather a condition brought about by the fact that July is normally a sunnier month than June and also a hotter one.

Cloudy weather would tend to prevent excessively hot days, and thus be favorable.

Humidity and Net Gain

It has long been known to plant physiologists that humidity has a considerable effect on plant behavior. While considerable experimentation and writing has been done on this subject, little is known concerning the effect of relative humidity on honey production. Vansell (16) has noted that honeybees often worked for pollen only, until the concentration of sugar in nectar increased to a point above five percent. Hambleton (6) favors a wide variation of diurnal relative humidity, and also states that a dry atmosphere has a beneficial effect upon changes in colony weight. Table 2 finds relative humidities below 59 percent and above 80 percent very unfavorable with the optimum range for good days between 50 and 69 percent.

Although the range of relative humidity for poor days is more evenly distributed, relative humidites above 70 percent do seem particularly unfavorable. Inasmuch as the observation was made late in the day when the relative humidity may be as much as 20 percent higher, it is no doubt true that the optimum range is well below 50 to 69 percent, and that unfavorable conditions may exist when the humidity is no higher than 60 percent during bees' working hours.

Barometric Pressure and Net Gain

As was stated previously, no official barometric pressures were available for the Ann Arbor Weather Bureau, and East Lansing pressures were used. These pressures in Table 2 are corrected sea level readings and would have to be revised downward to be accurate for Ypsilanti with an elevation of approximately 745 feet above sea level.

Table 10 gives mean barometric pressures for the 12 best and poorest Junes and Julys, with their mean ranges.

	Normal	12 Good Junes	12 Poor Junes	Normal	12 Good Julys	12 Poor Julys
Mean bar. press. in inches	29.01	29.03	28.99	29.05	29.05	29.05
Mean bar. press. range, inches	.72	.71	.724	.61	.60	.63

Table 10. Relation of average mean barometric pressures to normal for good and poor Junes and Julys.

Apparently a mean barometric pressure above normal with a range below normal is favorable for June, while a range below normal is favorable for July.

The daily effect of barometric pressure can be seen from Table 2. Pressures below 29.80 inches appear unfavorable, while extremely high pressures appear neither unfavorable nor favorable. The optimum range seems to be between 29.90 and 30.09 inches. Inasmuch as 29.95 inches is normal sea level pressure, it would seem probable that pressures approximating normal or slightly above are favorable for net gain.

Conclusions

The scale hive represents the trend of the average hive in most years, but only if the scale hive is a normal one.

Good and poor years tend to come in series rather than in alternations of good and poor seasons.

It is June and July which determines the good or poor year. July provides 49.7 percent of the total honey produced while June provides 42.4percent,and August and May negligible amounts.

Long time influences of weather on honey production are much less apparent than daily influences.

It seems that a good honey season is one preceded by a year of above average precipitation in which biennial and perennial honey plants are able to become well established. A fall, winter and spring of below average precipitation seems favorable.

The influence of precipitation on yearly net gain in the months preceding and during the honey flow are inconclusive. March and April however, significantly show below average precipitation to be favorable.

Above average snowfall preceding the honeyflow seems not at all necessary, while a January with above average number of days of snowcover appears favorable.

Rainfall during the honey flow period is very unfavorable. Of 240 best days only 56 had any precipitation, while of 240 poor days, 147 had rain.

A good honey crop is usually preceded by a fall, winter and spring of above normal temperatures, with a very definite advantage for a warmer March, April and May.

A good honey flow seems more likely to be associated with mean temperatures above normal in June and below normal in July, than the reverse.

A maximum temperature range of between 80 to 90 degrees seems most favorable and includes 141 of the 240 best days. A diurnal range of over 20 degrees included 204 of the 240 best days.

Southerly winds seem most favorable while northerly winds seem unfavorable. Northeast winds were particularly unfavorable. Wind does not however prevent colony gain unless other unfavorable factors are combined with wind.

Clear days favor honey production. Of the 80 best yielding days only 10 were cloudy, while of the 120 poorest days only 18 were clear. Clear days seem of more importance in June than in July.

A relative humidity above 70 percent and below 39 percent seems unfavorable. The optimum range of relative humidities is between 50 and 69 percent. These findings were taken from data recorded at 7:30 p.m. when the relative humidity may be as much as 20 percent higher.

A June with slightly higher than normal barometric pressure appears favorable, while a range of pressures below normal seems beneficial during both the months of June and July. The optimum range of barometric pressures is between 29.90 and 30.09 inches, or approximately normal to slightly above.

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