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WEATHER FACTORS INFLUENCING HONEY PRODUCTION

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FOREWORD

Beekeepers realize that the performance of their colonies, as measured by honey production, varies greatly from season to season and that this variation is due mainly to climatic and other environmental factors. Information as to the relative importance of these several climatic and environmental factors, however, is limited.

Mr. Floyd Markham, of Ypsilanti, Michigan, has kept accurate records for many years of the daily gain in weight of a representative colony of bees during the honey producing season, together with other pertinent records and observations. These records have been made available to the Michigan Agricultural Experiment Station for study and interpretation.

Mr. Carl Jorgensen, a graduate student at Michigan State College, has studied these records and attempted to interpret them in the light of U. S. Weather Bureau records for the same period covering temperature, precipitation, sunshine, etc. It is believed that the accompanying manuscript will afford an explanation of many of the seasonal variations in honey production that beekeepers have and perhaps offer a few suggestions as to things that may be done to promote heavier production.

V. R. GARDNER,

Director,

Agricultural Experiment Station.

Weather Factors Influencing Honey Production

By CARL JORGENSEN and FLOYD MARKHAM

Beekeeping is generally recognized as a hazardous business. Many factors, 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 to engage in it.

At the outset it would 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 listed 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 its collection by the bees.

Limitation in respect to any one of these will result in the crop being correspondingly reduced. This obviously points to the necessity of understanding all four factors, yet the beekeeping literature of the past has devoted perhaps 90 percent of its space to discussion of methods of getting overpopulous colonies, control of swarming, and making the storing instinct dominant, with only 10 percent devoted to factors three and four.

It is not the purpose here 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, always a factor of major importance in determining the size of the crop.

REVIEW OF LITERATURE

Nectar secretion by plants and honey production by bees are two different things, yet the practical beekeeper is not so much interested in nectar secretion as he is in the amount of nectar gathered by the bees. Nevertheless it would seem reasonable to expect that the weather conditions which are favorable for nectar secretion would also be favorable for honey production, and this idea has been advanced by Lundie

(11) and others. However, there is much conflicting opinion on the subject, and further study of the degree of correlation between these two factors is desirable.

Nectar Secretion

Demuth (4) and Kenoyer (8), based on their long experience, have reported some interesting observations and conclusions as to the environmental influences on nectar secretion. Davis (3) states that in the case of perennials a rainfall above normal for the two years preceding the nectar secretion period is of prime importance in conditioning plants for the process. McLachlan (12) would add excess sunshine to the above. 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 in the North 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 growing season limits did not affect the flow. She found that low light intensity tended to reduce secretion, and that soil moisture had little or no influence on the concentration of sugar in the nectar. High humidity diluted 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) 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 colony weight. Unfortunately data on the factors influencing nectar secretion in the more important nectar-producing plants are comparatively limited.

Honey Production

As to the direct or indirect effect of weather conditions on honey production, exact data are equally limited to support the great number of statements made by beekeepers and others that are based partly on observation and partly on assumption. Many progressive beekeepers maintain "scale hives," but unfortunately they are used mainly to indicate day-to-day trends and seldom are their records combined with weather data. Even these records are all too few.

The most outstanding study paralleling that reported in this article was made by Kenoyer (9) and based on a 29-year record at the turn of the century in Iowa. The fact that present day beekeepers have made changes in methods and that there are differences in major honey plants, may account for some of the differences found in the two studies. Hambleton (6) reports correlations between external factors and net gain on the basis of one season's record. Similarly, on a 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 report is based were obtained at Ypsilanti, Michigan, and cover a period of 24 consecutive years, 1921 to 1944, inclusive. The apiary has consisted of approximately 300 colonies of bees. Records include daily observations of a standard 10-frame colony of bees placed on a platform scale during 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 represented an average colony rather than one exceptionally strong or weak. The colony under observation was located 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. However, the data for barometric pressure and relative humidity, which were not recorded at Ann Arbor, were obtained from the U. S. Weather Bureau in East Lansing. It is believed that records for these two features of the weather were not very different from those which might have been obtained at Ypsilanti. In addition to the net gain or loss for the day weather observations were recorded in many instances. These check closely in practically all cases with the official weather data and lend confidence 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 of the observations at Ypsilanti.

Average honey production per colony was available for the period 1930 to 1939 and have been incorporated into Fig. 1.

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

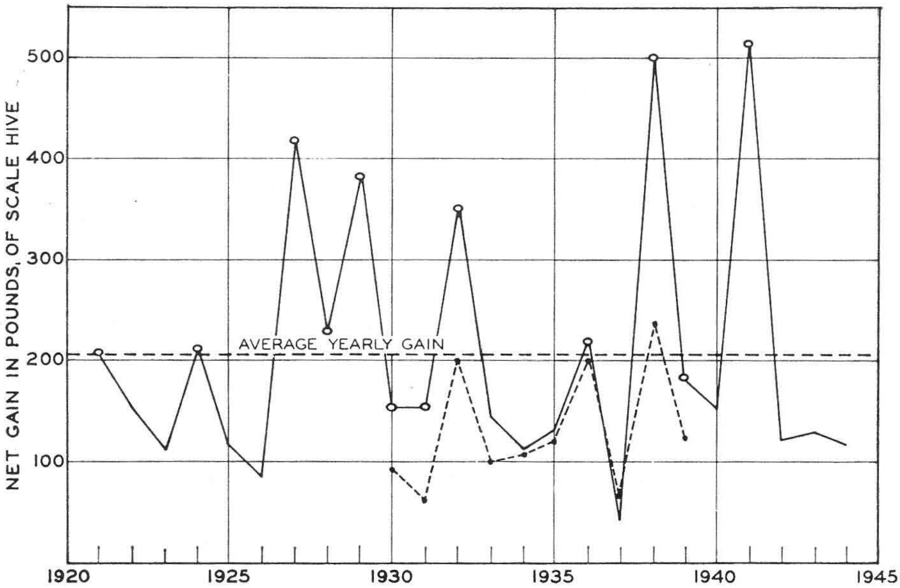

Fig. 1. Yearly gain of scale hive for the 24-year period. Circled years represent the 12 best years. Broken line represents extracted honey average for all colonies for years 1930-39.

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 pounds 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. The years 1927, 1929, 1932, 1938 and 1941 were very good; 1923, 1926, 1934, 1937 and 1944 were the poorest years.

The question might arise as to the reliability of using one scale hive as a measure of average performance of 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. The 75-pound difference between the two can be accounted for on the basis of 50 pounds left with the colony for winter stores and 25 pounds lost during the average fall and spring. When this wintering-over requirement is properly evaluated, we find a remarkably close parallel for the ten-year period. The 1931 figure would no doubt have shown closer agreement had it not been 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 year's average production considerably and accounts for the 1931 dip of all colonies as compared with the scale hive which remained normal. We can conclude then, that in this apiary the scale hive represented the trend of the average hive in most years. That this is probably true is also indicated by Hambleton's (6) experiments in which he compared two and three hives placed side by side. These showed no appreciable differences either hourly or daily for the recorded period.

In the Markham apiary there was no alternation of good and poor years, as found by Kenoyer (9) in his study. Rather, Fig. 1 shows that there was a slight tendency toward a series of good or poor years. The years 1927 through 1932 all fall in the 12 best years series, while the last three years exemplify 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, Fig. 1 shows that while in this study 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.

SEASON OF MAXIMUM HONEY PRODUCTION

Table 1 clearly shows that, at least in the area where these records were obtained, June and July are the important honey-gathering period. During eight of the 24 years—1921, '22, '23, '33, '36, '41, '42, and '44—more honey was gathered in June than in July; in the other 16 years July production exceeded June production.

This would indicate that both June and July determine the good or poor year. In Iowa, Kenoyer (9) credited June with 59.6 percent and July with 25.7 percent of the total season's production. However, the difference in the dominant honey plant population of the two areas and period probably accounts for the difference in findings. The principal change is the more or less 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 substantially lengthened the honey flow. In the study here reported, June 15 to 25 included the beginning date of practically all heavy honey flows.

It is therefore obvious that the question of management of the apiary should be focused on this all-important period. Both spring-purchased packages and overwintered colonies should be at their peak by this critical time. To quote an earlier statement by one of the

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.*

Year	May	June	July	August	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	86
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

authors, "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 is

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

240 good days			Precipitation					Temperature												Sunlight		
No.	Range	Total	in inches					Maximum				Minimum			Range					Sunrise to sunset		
			T-* .10	.11- .24	.25- .49	.50- .99	1.0 +	60- 69	70- 79	80- 89	90 +	50- 59	60- 69	70- 79	0- 14	15- 19	20- 24	25- 29	30 +	Clear	Ptly Cldy.	Cldy.
1	15 lb. + 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 lb. 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 lb. 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 lb. gain	41	7	2	1	2	0	0	8	21	12	12	23	6	1	7	17	13	3	22	13	6
	Total 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 lb. + 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 lb. 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 lb. 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 lb. gain	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0
	Total in days.............		57	26	33	20	11	21	106	90	22	102	118	19	56	75	81	23	4	53	64	123

TABLE 2—*Continued.*

No.	Wind direction								Humidity							Barometric pressure					
	N	NE	E	SE	S	SW	W	NW	30-39	40-49	50-59	60-69	70-79	80-89	90+	−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

*"T" = trace.

desirable to determine the degree of correlation, both on a daily and a long-term basis, between certain weather conditions and the honey flow. Insofar as possible both long-term and daily relationship are shown under the same heading in this bulletin. To aid the reader in visualizing daily effects of weather, Table 2 is presented, showing weather conditions characterizing the ten best and ten poorest days of each season from the viewpoint of honey production. The days themselves are grouped in four classes according to gain or loss in weight of the colony. Thus a No. 1 "good" day would be one in which the scale colony gained 15 or more pounds; No. 2, 10 to 15 pounds; No. 3, 5 to 10 pounds, and No. 4, 3 to 5 pounds gain. Similarly the scale colony on a No. 1 "poor" day would lose 1 pound or more in weight; on a No. 2 day it would lose, but less than 1 pound; on a No. 3 day it would gain, but less than 1 pound; on a No. 4 day it would gain from 1 to 2 pounds.

Discussion of the data will be presented under the following headings: precipitation, temperature, wind direction and velocity, amount of sunshine, humidity and barometric pressure.

PRECIPITATION AND NET GAIN

1. NET GAIN ONE CROP YEAR AND PRECIPITATION FOR THAT CROP YEAR, THE PRECEDING YEAR, OR PRECEDING 9 MONTHS.

By superimposing the rainfall curve upon that for the net gain in colony weight (Fig. 2), it can be seen that, although there is some

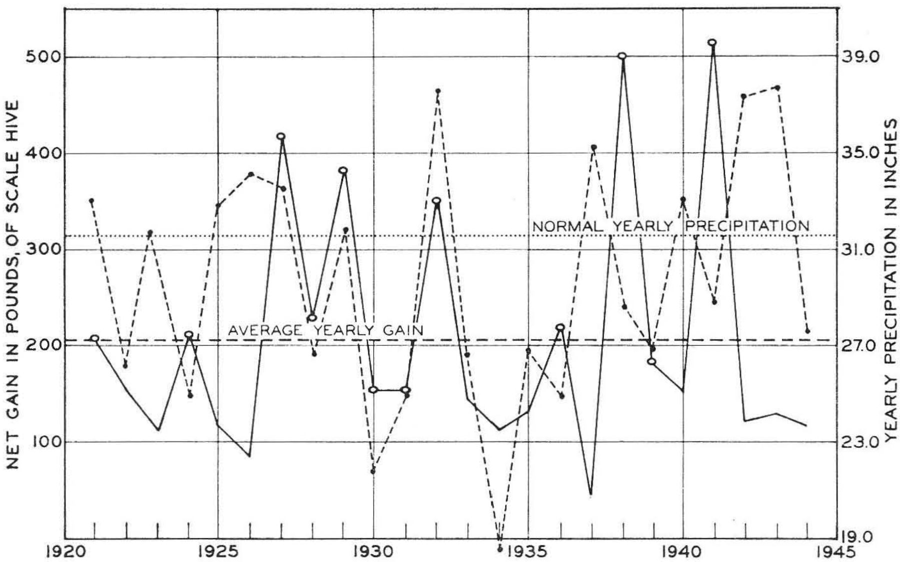

Fig. 2. Graph showing the relation of net gain in colony weight to the annual precipitation for the year of the crop.

relationship between the two, it is far from constant and probably of slight significance. There would seem to be a small advantage in a less than average rainfall during the honey production year. In the years 1927 through 1933 the apparent correlation is probably due more to early spring than to total precipitation. The years in which there is little or no correlation, such as the series 1935 to 1941, are years in which the rainfall came too late to affect the honey production for the seasons in question. However, Fig. 2 does suggest that the amount of precipitation occurring after the honey flow may influence net gain the following year. This is brought out more clearly in Fig. 3. In southern Michigan the main honey production is from biennial and perennial plants and their size, vigor and nectar secretion in any one year might be expected to depend largely on the reserves they stored in August, September, and October of the preceding year.

If the conclusion just reached is correct, it might be assumed that there would be a close relationship between net gain any one season and the preceding 9 months' precipitation. In general, such is the case (Fig. 4). However, the figures show some marked deviations from what would be expected and we come to the realization that, other factors being comparable, one good rain at the right time may change the year from poor to good. Thus, in 1936 and 1941 wet preceding Augusts and abundant rains in June helped to overcome the deficiency in moisture during the winter and spring months.

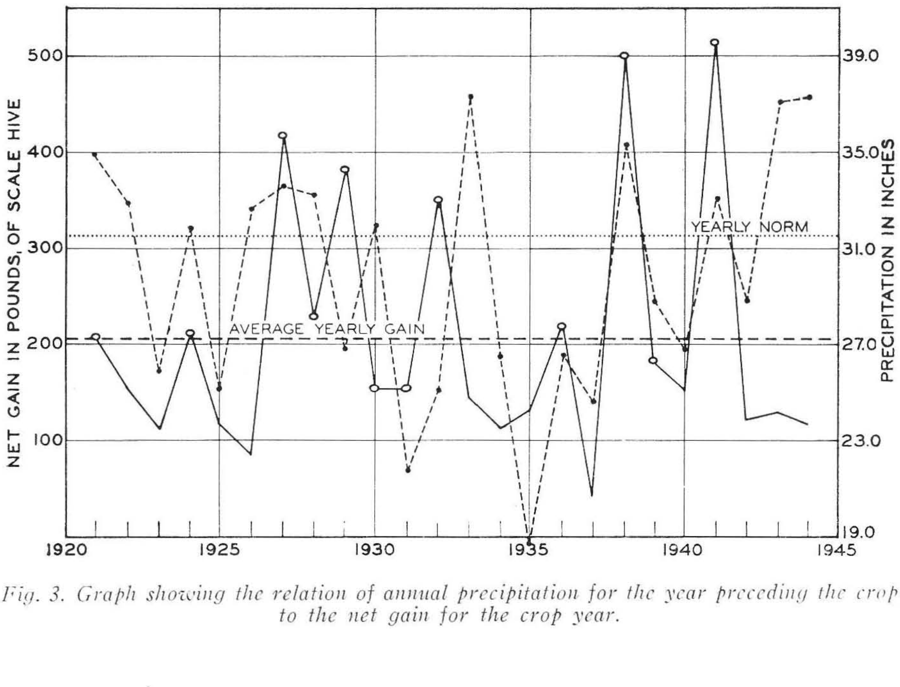

Fig. 3. Graph showing the relation of annual precipitation for the year preceding the crop to the net gain for the crop year.

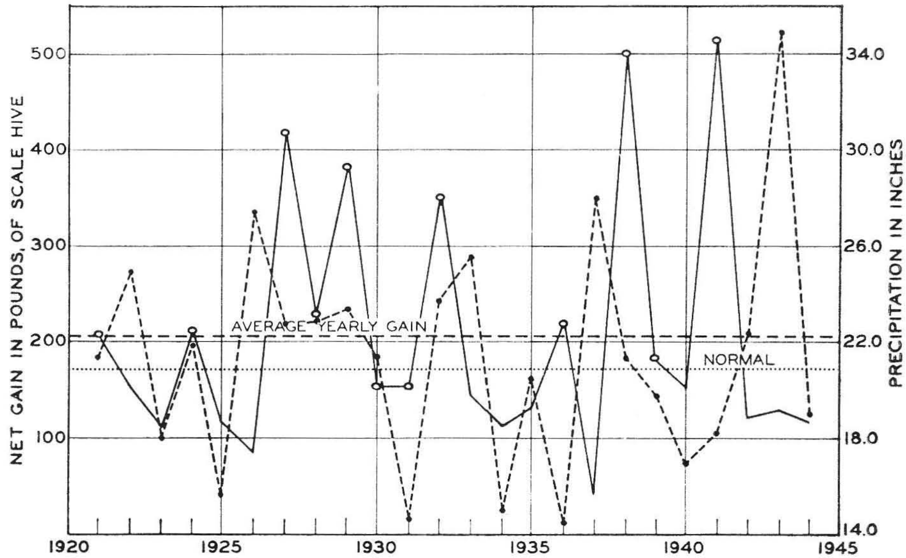

Fig. 4. Graph showing the relation of the yearly crop to the precipitation for the 9-month period preceding the honey flow.

2. Preceding winter's snowfall and net gain

A great many successful beekeepers believe that heavy snowfall—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

Table 3—*Amount of snowfall and days of snowcover by months and season for good and poor years.*

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
Number of good years above	6	6	4	5		6	9	5	7
Number of good years below	6	6	8	7		6	3	7	5
Number of poor years above	6	4	4	6		4	6	5	6
Number of poor years below	6	8	8	6		8	6	7	6

honey yield in a majority of cases. In this study an attempt was made to analyze snowfall by two methods: (1) amount of snowfall by months and season, and (2) the number of days of snowcover by months and season. The results are shown in Table 3.

One can see from this table that the amount of snowfall had little influence on the succeeding honey crop. The five highest net gain years were preceded by below normal snowfall. Of the 5 poorest honey seasons, 3 had above and 2 below normal snowfall the preceding winter. It seems that long-continued snowcover, especially in January, is favorable for honey production the following summer.

3. PRECIPITATION AND DAILY GAIN

Rain, as one might expect, has a striking influence on daily gain, since it affects 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 the nectar 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 inch. On further study of daily records it was found that in a great majority of these days, the precipitation occurred during the night and thus affected bee activity very slightly. With each progressive increase in amount and number of days of precipitation the gain becomes progressively poorer. Of the 240 poor days, 147 had rain. Of the 120 poorest days, 87 had fairly heavy or continuous rain. In the majority of these cases precipitation occurred during the hours of bee activity.

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.

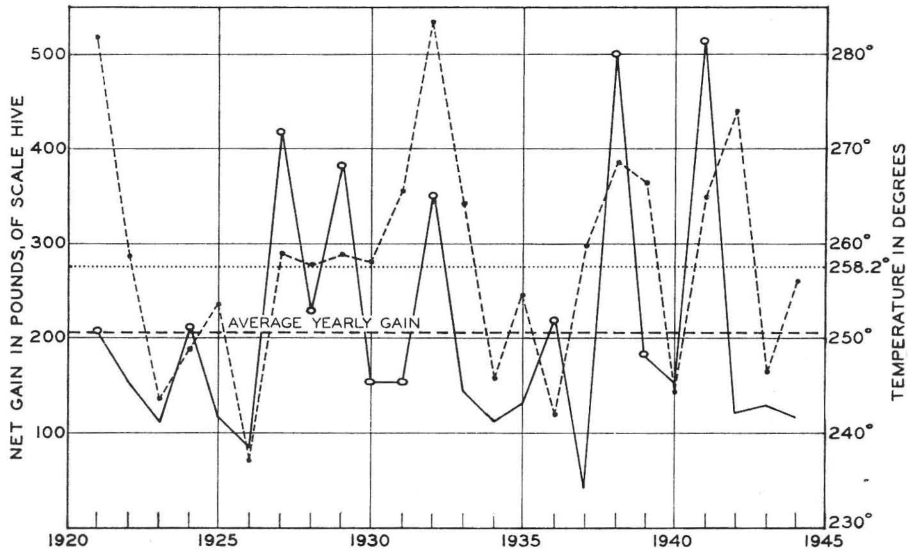

Fig. 5. The relation of average temperature totals for the 7-month period November through May preceding the honey flow, to the net gain for the year.

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 probably were due to precipitation below normal for the preceding 9-month periods. 1942 had apparently 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 thunderstorms occurred, and bee activity was seriously curtailed.

2. TEMPERATURE AND MONTHLY GAIN

Table 4 represents an attempt to correlate average temperatures with net gain for the 12 best and the 12 poorest Junes and Julys.

TABLE 4—*Comparison of means with normals of temperature for good and poor Junes and Julys.*

	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

An analysis of Table 4 reveals that though the averages for the mean, maximum and minimum temperatures are slightly higher for the best than for the poorest Junes and the opposite is true for July, the differences are so small as to be of doubtful significance. Kenoyer (9) reported higher temperatures for both June and July as favoring honey production.

3. TEMPERATURE AND DAILY GAIN

Considerable experimental evidence exists indicating an important influence of temperature on daily gain. In fact, Hambleton (6) states, "Temperature is the most important single factor influencing changes in colony weight." He reported a correlation coefficient of .7529 between the two.

It will be noted in Table 2 that a maximum temperature of 80° to 90° F. was most favorable for honey production during the period and under the conditions covered by this study; 141 of the 240 "good" days registered temperatures within that range. Furthermore there was little bee activity on days when the maximum temperature did not reach 70° F. This is in agreement with Kenoyer (9) who found that only 1 percent of the total honey crop was gathered when the temperature was below 70° F., while 53 percent was gathered between 80° and 90° F. On 75 of the poorest days, the maximum temperature was below 80° F. Minimum temperatures were essentially the same for both good and poor days. In themselves they probably mean little, unless one considers them in relation to maximum temperature. Thus a minimum temperature of 60° to 69° F. was favorable when the maximum reached 80° to 90° F., while a minimum below 60° F. was unfavorable when the maximum failed to reach the 80° to 90° F. 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 temperatures. He further found that flight commenced at temperatures varying from 55° to 80° F., with a most frequent range of 66° to 70° F. during the main honey flow. Kremer (10) states that temperatures below 60° F. retard bees, reduce the number of trips per day, but do not stop them completely.

Diurnal ranges in temperatures were between 20 and 24 degrees on 204 of the 240 best days. On the other hand, 79 of the 120 poorest days had a diurnal range of 19 degrees or less, while only 6 had above 24 degrees as compared with 39 out of 80 good days. This tends to substantiate Mitchener's (13) opinion that the greater the difference between night and day temperatures, the greater the increase in weight of the hive. Lundie (11), however, states that 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 recording our own observation that alsike clover is one of the few major honey plants apparently producing some honey below 70° F.; alfalfa and sweet clover on the other hand are on the other end of the range, producing nectar even at temperatures above 90° F. It might be observed: "A good honey day is one with a heavy dew in the morning which turns off hot."

WIND AND NET GAIN

Inasmuch as no data were available for wind velocity at Ann Arbor, comment is possible only on wind direction for each of the 240 good and poor days. Observations were recorded for 7:30 p.m. and represent the prevailing wind direction for the day. Doubtless there were changes in wind direction on some days but in the majority of cases, the wind direction recorded was that for the period of bee activity. On good days prevailing winds were from the southeast, south, and southwest; while on poor days the wind was more likely to be from the northwest, north, and northeast, especially northeast (Table 2). Kenoyer (9) similarly observed that a south wind was favorable while an east wind was unfavorable for honey production. Presumably south, southeast and southwest winds were associated with relatively high temperatures and north, northeast and northwest winds with lower temperatures.

On exactly 100 single days for all years there was recorded under remarks such notes as "windy," "high wind," "strong winds." Correlating these notes with the corresponding records for daily gains and losses, it was found:

52 days showed an average gain of 4 pounds (9 pounds to 1 pound range)

48 days showed an average loss of 1⅓ pounds (0 to 6 pound range)

Probably a moderate wind in itself has no great influence on gain, but a strong wind in combination with other factors such as high temperature or low humidity does have an effect. It may dry up nectar flow and at the same time 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. In this study the observation was recorded: "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. . . . never got a big yield on days of east wind. An east wind would dry up a cow."

SUNSHINE AND NET GAIN

There is considerable evidence on the positive correlation between sunshine and light, 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° F. 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 observations correspond closely with the data here reported on the relation of amount of sunshine to net gain (Table 2). Of the 80 best days, only 10 were cloudy, 49 were clear. Of the total good days, 133 were clear and 43 cloudy. On the other hand, 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. Perhaps an even greater effect of sunshine would be evident 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. Observations lead to the belief that best yields come on clear days, and that warm and partly cloudy days are fair, while cloudy days are poorest since the temperature is lowered. Apparently the higher the temperature the less is the effect of clouds, particularly on the basswood honey flow.

Table 5 presents averages of clear, partly cloudy and cloudy days for the 12 good and poor Junes and Julys. On their face they do not strongly support the conclusions already drawn. However, July is normally a sunnier and hotter month than June and the retarding influence of cloudiness on nectar secretion and honey production therefore not so evident or important as it is in June.

TABLE 5—*Averages of sky cover for good and poor Junes and Julys.*

	12 good Junes	12 poor Junes	12 good Julys	12 poor Julys
Number of clear days	10.5	9.7	13.0	13.7
Number of partly cloudy days	10.5	9.8	10.1	10.9
Number of cloudy days	9.0	10.5	7.9	6.4

HUMIDITY AND NET GAIN

Comparatively little information is available on the influence of relative humidity on honey production. Vansell (16) has noted that honeybees often gathered pollen only when the concentration of sugar in nectar was below 5 percent. Hambleton (6) is of the opinion that a wide diurnal range in relative humidity is favorable for honey production. He also states that a dry atmosphere has a beneficial effect upon changes in colony weight. The data in Table 2 indicate that relative humidities below 39 and above 80 percent were very unfavorable for honey gathering; the range for "good" days was between 50 and 69 percent, suggesting that this may be the optimum.

Inasmuch as the observations on relative humidity were 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 the bees' working hours.

BAROMETRIC PRESSURE AND NET GAIN

As stated previously, no official barometric pressures were available from the Ann Arbor Weather Bureau station 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 at Ypsilanti with an elevation of approximately 745 feet above sea level.

The daily effect of barometric pressure can be seen from Table 2. Pressures below 29.80 inches seem unfavorable, while extremely high pressures seem 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.

Table 6 gives mean barometric pressures for the 12 best and poorest Junes and Julys, with their mean ranges. 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.

Table 6—*Relation of average mean barometric pressures to normal for good and poor Junes and Julys.*

	Normal	12 good Junes	12 poor Junes	Normal	12 good Julys	12 poor Julys
Mean barometric pressure in inches..................	29.01	29.03	28.99	29.05	29.05	29.05
Mean barometric pressure range, inches............	.72	.71	.724	.61	.60	.63

DISCUSSION

Obviously the environmental factors influencing nectar flow and honey production considered in this study are beyond any direct control of the beekeeper. He must take temperature, precipitation, humidity, sunshine, and wind as they come and certain extremes or combinations of them may "make or break" him regardless of how skillful an operator he may be. On the other hand, many, if not most, commercial honey producers distribute their apiaries of 50 to 100 colonies each over a considerable area. Some may be placed 200-300 miles from the home or central establishment. Locations for these outlying units are selected on the basis of past experience and on information of prevalence or acreage of the more important nectar producing plants.

The data here presented, however, suggest that the last consideration alone may be misleading. Bees will make little honey from an extensive acreage of sweet clover or alfalfa if it is located where prevailing environmental conditions are unfavorable for their flight or for nectar secretion on the part of the flowers. Study of weather data—more especially March-July temperatures, precipitation, sunshine and humidity—will indicate that certain areas are much more favorable than others from the standpoint of environment. If the individual places his apiaries in locations where both weather and bee pasturage conditions are favorable, his chances of obtaining good honey yields will be much better than if no attention is paid to either factor or if attention is paid to only one of them.

SUMMARY

The scale hive (at least for this study) represents the trend of the average hive in most years.

Good and poor years tended to come in series rather than alternating with each other in the area and period covered by this study.

In southern Michigan it is the June-July period that determines whether a season will be "good" or "poor" from the viewpoint of honey production. July provided 49.7 percent of the total honey produced; June provided 42.4 percent; August and May yielded negligible amounts.

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

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

The influence of precipitation in the months preceding and during the honey flow on yearly net gain is somewhat variable.

In the study reported, amount of snowfall the winter preceding seemed to have little influence on honey flow, though a good snowcover during January seemed to have a favorable influence.

Considerable rainfall during the honey flow period was distinctly unfavorable for heavy production.

A good honey crop is more likely to follow a fall, winter and spring of above normal temperatures than one with below normal temperatures. A warm March, April and May are distinctly favorable for honey production later in the season.

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

Maximum daily temperature ranging between 80° and 90° F. during June and July was more favorable for honey production than lower temperatures.

Southerly winds were more favorable than northerly winds. 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 was unfavorable for honey production. The optimum range of relative humidities was between 50 and 69 percent. (Humidity readings were taken at 7:30 p.m. when the relative humidity was in most cases somewhat higher than earlier in the day when most of the honey was gathered.)

A barometric pressure normal or slightly above, appears favorable for honey production. In this study the optimum range of barometric pressures was between 29.90 and 30.09 inches.

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