Climatic Conditions and Attractiveness of Apple Varieties* (Part II)

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Results and Discussion

From Table 2 the climatic and geographic ranks of the eight locations, represented by apple samples for evaluation at Carbondale in 1958, were subjected to correlation analysis in an attempt to determine the relationships between geographic position and climatic conditions. High latitude is closely associated with low average precipitation during all periods and with low average temperature during the spring and summer months. High elevation is not associated with climatic conditions in any period.

In addition to written descriptions of the apple samples, all possible comparisons of climatic effects on apple development were recorded on 32 Kodachrome transparencies showing 29 varieties grown in two to six locations. For each variety the fruits from different locations shown on the transparencies were evaluated and ranked for general attractiveness, red overcolor intensity and extent, prominence of dots, and comparative number of dots. The variety ranks for each location were averaged for each characteristic. Table 3 shows the locations ranked in order of most desirable apple samples for each of these characteristics. The visual ranks of the locations for attractiveness in 1958 (Table 3) were compared ($r = .48$) with the climatic ranks for attractiveness (Table 2). The visual ranks, with few exceptions, are higher than the climatic ranks. Errors might arise because: (1) the samples may not be representative of the locations, or (2) the average climatic records may not be representative of the conditions necessary for attractive fruits in a specific year.

The associations between the location ranks for geographic and climatic conditions favorable for attractive apples and the location ranks for attractive fruit characteristics obtained by examination of Kodachrome transparencies, are shown in Table 4. High latitude is significantly associated with less prominent dots. This association is supported by the uniformly close association of high latitude with low average precipitation (indicating lower absolute humidity and greater light intensity) during the growing season. High elevation is significantly correlated with attractiveness and few dots. This association generally confirms reports in the literature.

Throughout the entire growing season, average absolute humidity and sunlight intensity—conditions associated with precipitation—have a greater effect on fruit characteristics influencing attractiveness of a wide range of varieties than average temperature. A significant correlation between high precipitation in the four weeks after bloom and red overcolor intensity at maturity reflects the importance of favorable climatic conditions for growth of the fruit early in the fruit development period. Low

*This paper is Part II of publication No. 11 of the Illinois Horticultural Experiment Station. Part I was published in F.V.H.D. Vol. 14, No. 3, pages 53–56.

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Table 2. **Percentile group ranks[1] of geographic and climatic conditions for locations represented by apple samples evaluated for attractiveness at Carbondale, Illinois in 1958.**

Location	Geographic position		First critical period				July	
	Lat.	Eleva.	Avg. precip.	Avg. abs. hum.	Avg. sun intens.	Avg. temp.	Avg. abs. hum.	Avg. daily max. temp.
Wash., Yakima	1	5	1	9	1	3	2	7
Kans., Manhattan	8	5	1	1	9	8	7	9
Mo., Louisiana	8	7	2	2	8	8	8	8
Ill., Urbana	7	7	2	2	8	5	7	8
Ill., Carbondale	9	8	1	1	9	5	9	10
N. J., New Brunswick	6	10	2	2	8	7	7	5
N. Y., Geneva	4	8	3	3	7	5	6	4
Ohio, Wooster	6	6	2	2	8	6	7	5

Location	Summer				Second critical period				
	Avg. precip.	Avg. abs. hum.	Avg. % poss. sun	Avg. temp.	Avg. precip.	Avg. abs. hum.	Avg. sun intens.	Avg. temp.	Avg.[2]
Wash., Yakima	1	1	3	1	1	1	1	6	1
Kans., Manhattan	9	9	3	8	2	8	8	8	10
Mo., Louisiana	9	9	5	8	1	9	9	8	10
Ill., Urbana	8	8	3	6	2	8	8	7	8
Ill., Carbondale	9	9	4	8	2	8	8	9	10
N. J., New Brunswick	10	10	7	6	2	8	8	7	10
N. Y., Geneva	7	7	7	3	4	6	6	2	4
Ohio, Wooster	9	9	7	5	4	6	6		

[1]The range of each factor from Table 1 is divided into ten equal percentile groups. Each group is identified by a rank number: rank 1 being the most favorable condition of the factor for attractive apples at harvest.

[2]Percentile group rank for the average of the ranks for latitude, elevation, and average absolute humidity and average temperature in the growing season, (omitting July because it is part of summer period).

average absolute humidity in July is significantly correlated with greater attractiveness, greater amount of red overcolor and less prominent dots. During the summer months low average absolute humidity is significantly correlated with less prominent dots. Low average temperature during the summer months is also closely associated with less prominent dots at harvest. This is the only comparison where average temperature was significantly correlated with any fruit characteristic influencing attractiveness.

The attractiveness of a wide range of apple varieties at harvest is significantly correlated with high elevation and with low average absolute humidity in July. These correlations confirm the observations by Magness (2). The extent of red overcolor is associated exclusively with low average absolute humidity in July—confirming the report (2) concerning the beneficial effects of low humidity and high light intensity on development of red overcolor. The effect of low night temperatures during the four weeks before harvest (5) could not be

Table 3. **Percentile group rank of locations in 1958 for fruit characteristics influencing attractiveness of apple varieties recorded on Kodachrome transparencies and comparison of visual and climatic ranks for attractiveness (r = .48).**

Location[1]	Avg. climatic rank	Attractiveness	Over-color amount	Over-color intens.	Prominence of dots	Number of dots
Yakima, Wash.	1	1	1	8	1	1
Geneva, N. Y.	4	5	5	5	1	5
Wooster, Ohio	6	3	1	1	5	2
Urbana, Ill.	8	6	2	4	5	6
Manhattan, Kans.	10	1	3	1	5	1
Louisiana, Mo.	10	5	8	6	3	5
New Brunswick, N. J.	10	6	5	7	8	4
Carbondale, Ill.	10	10	10	6	9	6

[1]Locations listed in order of relative expectation for attractiveness derived from average climatic rank in Table 2.

adequately tested. However, average temperature is not associated with the extent of color development. Over-color intensity is associated only with high average precipitation and high average absolute humidity during the first four weeks after bloom. Indirectly this association reflects the importance of conditions favorable for growth and accumulation of carbohydrates (2).

The frequency of dots is not associated with a specific climatic condition in any period, and the reports (1, 3, 4) of the influence of environment on dot development cannot be confirmed. The prominence of dots at harvest is significantly associated with high average absolute humidity during July and the summer months, and also with high average temperature during the summer months. These results confirm the report by Verner (6) on the effect of high relative humidity during the summer. Reports on the effect of high temperature on the prominence of dots are not evident in the literature.

By grouping the location ranks for average absolute humidity and average temperatures from Table 2, the respective averages of these climatic conditions are more readily compared to visualize their effects on the attractiveness of apples. In Table 5 the growing season average absolute humidity is identical for Urbana, Illinois; Manhattan, Kansas; and Carbondale, Illinois.

Evidently the major climatic condition responsible for the difference in apple attractiveness is the difference in growing season average temperature, although the ranks for attractiveness do not reflect the influence of temperature differences as expected from the literature. Similarly, New Brunswick, New Jersey, has a lower growing season average temperature than Louisiana, Missouri, although the growing season average absolute humidity is the same. Again rank for attractiveness does not confirm the expected rank indicated by the difference in average temperatures. On the other hand, the growing season average temperature is identical for Yakima, Washington and Geneva, New York, and also for Manhattan, Kansas and Louisiana, Missouri. In these sets of locations the decisive factor in apple attractiveness is the difference in the growing season average absolute humidity. Characteristically, the ranks for attractiveness in the latter sets of locations agree with the expected effect of differences in the growing season average ranks for

Table 4. **Correlation coefficients (r) for relationships between percentile group ranks for geographic and climatic conditions and for fruit characteristics favorable for attractiveness of apple samples in 1958.**

Geographic and climatic conditions	Fruit characteristics				
	Attractiveness	Overcolor extent	Overcolor intensity	Dot prominence	Dot frequency
Latitude	.53	.58	−.40	.69[a]	.03
Elevation	.74**	.54	.42	.49	.68[a]
First crit. period					
Avg. precip. & abs. hum.	−.49	59	.68[a]	−.33	.43
Avg. temp.	−.04	16	−.42	.30	−.01
July					
Avg. abs. hum.	67[a]	.65[a]	−.34	.68[a]	60
Avg. daily max. temp.	23	.39	−.03	.37	13
Summer period					
Avg. abs. hum. and sunlight intensity	.47	44	−.45	.67[a]	.41
Avg. temp.	.43	58	−.34	.67[a]	.35
Avg. % poss. sunshine	.17	10	−.04	.04	.13
Second crit. period					
Avg. abs. hum. and sunlight intensity	.53	56	32	.58	.57
Avg. temp.	.29	.45	15	.59	.14

[a]Significant at 10% level.
*Significant at 5% level.
**Significant at 1% level.

Table 5. **Percentile group rank of locations for climatic conditions (from Table 2) most important in affecting attractiveness of apple fruits compared with visual percentile group rank for attractiveness (from Table 3).**

Location[1]	Attractiveness rank	Average absolute humidity				Average temperature			
		Period			Avg. rank	Period			Avg. rank
		1st Critical	Summer	2nd Critical		1st Critical	Summer	2nd Critical	
Wash., Yakima	1	9	1	1	3.67	3	1	6	3.33
N. Y., Geneva	5	3	7	6	5.33	5	3	2	3.33
Ohio, Wooster	3	2	9	6	5.67	6	5	4	5.00
Ill., Urbana	6	2	8	8	6.00	5	6	7	6.00
Kans., Manhattan	1	1	9	8	6.00	8	8	8	8.00
Mo., Louisiana	5	2	9	9	6.67	8	8	8	8.00
N. J., New Brunswick	6	2	10	8	6.67	7	6	7	6.67
Ill., Carbondale	10	1	9	8	6.00	5	8	9	7.33

[1]Locations listed in order of relative expectation for attractiveness derived from average climatic rank in Table 2.

average absolute humidity. This situation is confirmation of previous statements that absolute humidity and sunlight intensity—conditions directly associated with precipitation—have greater influence on factors in attractiveness of apple fruits than average temperature throughout the growing season.

SUMMARY

Apple variety samples representing eight geographic locations in the United States were visually and photographically evaluated for fruit characteristics affecting attractiveness. Geographic and climatic conditions influencing attractiveness were summarized for each location. Fruit attractiveness and climatic conditions favoring attractiveness were compared by correlation analysis. The agreement between the location ranks for attractiveness, by the two methods, is not statistically significant. (r = .48).

For this group of locations high latitude is closely associated with low average precipitation throughout the growing season. Average absolute humidity varies directly with average precipitation (r = .80**) in July. High latitude is also associated with less prominent dots on apple fruits at harvest. High elevation is associated with greater attractiveness and fewer dots on apple fruits at harvest.

Throughout the growing season, precipitation (with associated absolute humidity and sunlight intensity) has greater effect than average temperature on characteristics affecting attractiveness of apple fruits at harvest. The percentage of possible summer sunshine is not associated with characteristics affecting attractiveness of apple fruits at harvest.

Low average absolute humidity in July is associated with greater attractiveness, greater amount of red overcolor and less prominent dots on apple fruits at harvest. Low average precipitation (indicating low average absolute humidity and high light intensity) and low average temperature during the summer months are associated with less prominent dots on apple fruits at harvest. These climatic conditions are more effective in influencing the development of less prominent dots during the summer months than during the four weeks before harvest. High precipitation during the four weeks after bloom was associated with high intensity of red overcolor in apple fruits at harvest—indirectly emphasizing the importance of favorable growing conditions for the accumulation of carbohydrates in fruits.

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