HILGARDIA

A JOURNAL OF AGRICULTURAL SCIENCE PUBLISHED BY
THE CALIFORNIA AGRICULTURAL EXPERIMENT STATION

Volume 38, Number 3 · March, 1967

Developmental Aspects of Field-to-Field Variations in Selected Cantaloupe Characteristics

(*Cucumis melo* L. var. *reticulatus* Naud.)

R. M. Davis, Jr., G. N. Davis, U. Meinert, K. A. Kimble,
L. C. Brown, D. M. May, G. E. May, L. C. Hendricks, Jr.,
R. W. Scheuerman, V. H. Schweers, and D. N. Wright

UNIVERSITY OF CALIFORNIA DIVISION OF AGRICULTURAL SCIENCES

This paper presents observations on the week-to-week development of selected cantaloupe characteristics under several different sets of field conditions. The analysis is especially concerned with detecting the period or periods of melon development during which variations in each characteristic seem to arise. The information is presented under several headings: *Time required for maturation, Development of flesh color, Melon size, Fruit shape, Surface netting, Suture netting, Ground-spot size, Flesh thickness and flesh proportion, Soluble solids concentration,* and *Correlation of seed number with melon characteristics.* The observations recorded here may be regarded as directly related to those published by the senior author in 1964, with several of the same co-workers (Hilgardia, Volume 35, Number 16, July). The latter paper is frequently cited in the present text.

THE AUTHORS:

R. M. Davis, Jr., is Associate Olericulturist, Department of Vegetable Crops, Kearney Horticultural Field Station, Reedley.

G. N. Davis is Professor and Olericulturist, Department of Vegetable Crops, Davis.

U. Meinert was Laboratory Technician II, Department of Vegetable Crops, Davis. His present address is Gilroy Foods, Gilroy, California.

K. A. Kimble is Laboratory Technician IV, Department of Plant Pathology, Davis.

L. C. Brown is Associate Agriculturist, Agricultural Extension Service, Hanford.

D. M. May is Assistant Agriculturist, Agricultural Extension Service, Fresno.

G. E. May is Agriculturist, Agricultural Extension Service, Modesto.

L. C. Hendricks, Jr., is Assistant Agriculturist, Agricultural Extension Service, Los Banos.

R. W. Scheuerman is Assistant Agriculturist, Agricultural Extension Service, Merced.

V. H. Schweers is Agriculturist, Agricultural Extension Service, Visalia.

D. N. Wright is Agriculturist, Agricultural Extension Service, Bakersfield.

R. M. Davis, Jr., G. N. Davis, U. Meinert, K. A. Kimble, L. C. Brown, D. M. May, G. E. May, L. C. Hendricks, Jr., R. W. Scheuerman, V. H. Schweers, and D. N. Wright

Developmental Aspects of Field-to-Field Variations in Selected Cantaloupe Characteristics[1]

(*Cucumis melo* L. var. *reticulatus* Naud.)[2]

INTRODUCTION

THE VARIATIONS in cantaloupe characteristics in response to environmental variation may be considerable and complex (Davis *et al.*, 1964).[3] Factors causing some of the variations in a few characteristics, such as fruit size, are discerned without great difficulty. There are important field-to-field variations in certain characteristics of which the explanation remains hypothetical. Notable among these are fruit shape, netting of sutures, flesh thickness, and concentration of soluble solids.

Demonstrating the cause of such variations is hindered not only by the elusiveness of the causative factors, but by the somewhat superficial knowledge of the variations themselves. Discovering and proving their source would be facilitated by information showing the period(s) in melon development when the variates are established. Changes in soluble solids during melon growth under widely differing circumstances have not been charted comparatively; the stage when large, unnetted sutures are established has not been determined; and so on with a number of other characteristics.

This paper presents the results of a study made for the purpose of gathering such information. In a few instances, such as the relation of color or net development to stage of maturity, "average" courses of development appear to have meaning for a wide range of situations. For most characteristics, however, the analyses and discussions are not focused upon calculating average courses of development, but upon methods of characterizing the development of variations in constantly changing material, upon means of detecting early meaningful divergences, and upon methods of drawing valid inferences regarding the periods when variations in mature characteristics are initiated or determined.

---

[1] Submitted for publication April 27, 1966.

[2] The term "cantaloupe" shall be used here in preference to "muskmelon." "Muskmelon" may be applied to all varieties of *Cucumis melo*, hence to many diverse forms of fruit. In America, by popular consent, "cantaloupe" is applied specifically to *C. melo* L. var. *reticulatus* Naud., noted for its netted fruit having the characteristic of separating itself from the plant at maturity.

[3] See "Literature Cited" for citations, referred to in the text by author and date.

SAMPLING METHOD

Plantings for observation were selected in commercial fields in the counties of Kern, Kings, Fresno, Merced, and Stanislaus in California. In addition, plantings were made at the University of California farm at Davis, and at the West Side, Kearney Horticultural, and Lindcove Field stations of the University, located in Fresno and Tulare counties. The cultivar PMR 45 was observed. For all University plantings, seed came from the same sample. Fields C and D were the same physical field, partitioned by differential treatment. Field D was composed of randomly distributed plots in which the soil was ripped 2 feet deep directly under the seeding line. Field C was composed of plots not so treated. Table 1 presents information pertinent to each site observed.

When a selected field had a large population of young fruits, 100 young fruits 2 to 3 inches in length were tagged and staked for identification, and observations were started. Since the procedure required the sacrificing of individual fruits of the sample, a new sample was required for each observation date, and the analysis depended on statistical treatment of the data. On each observation date, at mostly 7-day intervals, 10 melons were taken at random from the originally tagged group. The last observation date for each field was the one when all fruits of the sample were at the full-slip stage (i.e., incipient abscission).

We have found that young melons usually will survive and develop if they have reached a length of 2 to 3 inches and appear healthy. This size is reached about 1 week after anthesis. Of the 10 groups of melons, 4 were unusual in that a large proportion of the tagged melons failed to develop. In Fields A, E, and K, about 30 per cent of the tagged melons shriveled. In Field J, about 50 per cent shriveled, permitting samples of only 9, 8, and 9 melons on the last 3 observation dates. Observation on the 4 fields showed the same mortality for untagged fruits of the same age group.

For describing the timewise development of certain characteristics such as fruit size, the statistical computation of their regression on the logarithmic function of time (log time) proved extremely useful. In some instances, the value of a characteristic calculated from such a regression for a particular date was undoubtedly a more accurate estimate of the true value than the sample mean for that date.

At all fields, plant crown samples were taken to test for possibly occurring pathogenic fungi or bacteria. The results of laboratory isolation procedures are noted in table 1 (bottom).

In this study, the use of the 2″–3″ size as a starting point was a practical necessity, yet the assumption that such a criterion can serve as a basis for comparison across fields needs examination. The visually obvious change in melon size and appearance during the first week of observation at all locations provided assurance that there could not have been more than 2 to 3 days' difference in maturity between the largest and smallest specimens of any sample. A thorough review of the tables and conclusions of this report does not provide reason for belief that the 2″–3″ size criterion could or did introduce error into any of the conclusions.

OBSERVATIONS AND ANALYSES

Time required for maturation. For all fields except Field J, the full-slip stage was reached 5 weeks after the 2″–3″ size. For Field J, it was reached in 4 weeks. At Fields C and D, maturity was advanced by about 2 days. In the 3 time-shortened fields, the plants obviously were damaged by some disorder.

TABLE 1

INFORMATION CONCERNING SITES FROM WHICH SAMPLE CANTALOUPES WERE OBTAINED

Field	County	Operation	Lateral position in valley	Soil series	Soil texture*	Observation dates in 1965		Observation intervals, accumulated†
						First	Last	
A........	Kern	Commercial	East	Cajon	sl	6/8	7/12	1, 8, 15, 22, 29, 35
B........	Kings	Commercial	West	Panoche	fsl	6/18	7/23	1, 8, 15, 22, 25, 29, 36
C........	Fresno	University	East	Hanford	fsl	6/21	7/26	1, 8, 15, 22, 29, 36
D........	Fresno	University	East	Hanford	fsl	6/21	7/26	1, 8, 15, 22, 29, 36
E........	Fresno	Commercial	West	Panoche	fsl	6/30	8/4	1, 8, 15, 22, 29, 36
F........	Yolo	University	West	Yolo	fsl	7/8	8/12	1, 8, 15, 21, 29, 36
G........	Merced	Commercial	West	Lost Hills	cl	7/9	8/11	1, 6, 13, 20, 27, 34
H........	Tulare	University	East	San Joaquin	l	8/9	9/13	1, 8, 15, 22, 30, 36
J........	Stanislaus	Commercial	West	Pleasanton	gcl	8/10	9/7	1, 8, 15, 22, 29
K........	Fresno	University	West	Panoche	cl	8/13	9/17	1, 6, 13, 18, 24, 29, 36

Field	Leaf necrosis	Proportion of crowns yielding pathogenic organisms	Organisms isolated	Visual evidence of mosaic-type infection
A.......	Moderate, at end of growing period......................	0:4	None	Slight
B......	Negligible..	1:6	*Macrophomina phaseoli*	None
C......	Moderate, beginning early..............................	0:3	None	None
D......	Moderate, beginning early..............................	0:3	None	None
E......	Severe, large mite population...........................	3:7	*Macrophomina phaseoli*	None
F......	Negligible..	3:4	*Verticillium albo-atrum*	None
G......	Slight at end of growing period, small mite population	0:4	None	None
H......	Severe at end of growing period, large aphid population	3:10	*Macrophomina phaseoli*	Moderate
J.......	Very severe, beginning mid-season.....................	0:4	None	None
K......	Negligible, (Only 1 vine with each fungus was found.)	2:8	*Verticillium* and *Macrophomina*	Slight

* c = clay, f = fine, g = gravelly, l = loam, s = sandy.
† Days accumulated to each observation date. First day = 1.

The observed time required for maturation closely fits the observations of McGlasson and Pratt (1963), allowing a correction of 5 to 7 days between anthesis and the 2″–3″ size. Evidently, so long as plants are not severely disordered, the mean developmental period for the cultivar PMR 45 is remarkably constant. These "constant periods" are, of course, means, and there is noteworthy variation within these means, accurately reflected in the confidence limits of McGlasson and Pratt (1963).

Development of flesh color. Table 2 presents figures which indicate the development of internal fruit color in terms of the per cent of flesh, from cavity to rind, which had changed from green to pink. At the 2″–3″ size, there was no detectable pink color. The following week, faint pink was almost universally visible in seed attachments. The boundary between the expanding pink ring and the original green was indistinct, so perhaps there is a subjective error of $\pm$ 5 to 10 percentage units in addition to the sampling error in the means of table 2. Inspection of the table shows major color development to occur normally in the fourth week after the 2″–3″ size. Taking into consideration the more rapid maturation of Fields C, D, and J, it seems generally true that most color development occurs in the week preceding the last week of maturation. Evidently, for melons having about 50 per cent color development, full-slip will occur in about 10 to 14 days.

Melon size. Melon size, as measured by cross diameter, increased until full-slip, as previously described (Leeper,

TABLE 2

PER CENT OF FLESH COLOR CHANGED FROM GREEN TO PINK AS A FUNCTION OF FIELD AND TIME

Field	Accumulated observation time (days)*																
	1	6	8	13	15	18	20	21	22	24	25	27	29	30	34	35	36
A	0		0		0				16				90			95	
B	0		0		0				23		49		60				95
C	0		0		0				55				84				95
D	0		0		1				64				85				95
E	0		0		5				40				92				95
F	0		0		0			10					78				77
G	0	0		0			28					52			100		
H	0		0		0				39					92			85
J	0		0		1				71				83				
K	0	0		0		0				64			63				76

* Time 1 = first observation date; melon length = approximately 2 inches. Last observation date for each field = day on which all sample melons were mature.

1951; McGlasson and Pratt, 1963). The cross-diameter growth rates after the 2″–3″ size at all the fields closely fit straight-line functions on log time. Growth curves for 2 fields are shown in figure 1. Mean initial and terminal diameters calculated from log functions are shown in table 3. Also shown are the coefficients of log time (cm/log time) and the correlation coefficients for the regression of cross diameter on log time. Also shown are the sample cross-diameter means for each location for the terminal date and a pooled estimate of the lowest significant difference between means.

Since the growth rate is fastest initially, initial variations in environment must have a dominant effect on final size. Since growth increments are so closely associated with log time, it appears that even later growth rates reflect much the same influences that affect early growth rates. Thus we may imagine, for example, that if soil moisture conditions are optimum in the first 20 days, a subsequent drought could intensify but gradually, and as plant stress would increase with time, its range of effect upon ultimate size would diminish.

An illustration of this proposal occurred in Field J. There, we did not tag the first group of fruits to be initiated, but did tag a group initiated perhaps 10 days later. On the tagging date, it was noted that some disorder was starting. From an unknown cause (table 1, bottom), 75 per cent of all leaves were dead at harvest time. The tagged fruits (as well as untagged fruits of the same age) matured as small, poor-quality melons. The fruits set earlier matured as large, high-quality melons, although at least the last half of their developmental period occurred when plant vigor was declining rapidly.

Fruit shape. The shape of cantaloupes of the variety PMR 45, as shown by Davis *et al.* (1964), and as observed in this study, can vary considerably from field to field. Table 4 shows the statistically calculated initial and terminal shapes for each field. The calculations assume that the association of shape with time is lineal on log time. The slope of the function (the modification of shape with time) and the coefficient of correlation between shape and log time are also presented. Two examples, showing the modification of shape with time, are presented in figure 2. As expected, shape becomes rounder with time. It will be noted in table 4

TABLE 3
MELON CROSS-DIAMETER GROWTH STATISTICS

Field	Cross-diameter mean for terminal date*	Cross diameter for initial date; from regression equation (the intercept)	Cross diameter for terminal date; from regression equation	Slope (*b*) of regression equation of cross diameter on log time	Coefficient of correlation (*r*) of regression of cross diameter on log time
	cm	*cm*	*cm*	*cm/log time*	
A..........	11.9	3.9	12.2	5.34	.974 (.001)†
B..........	13.1	3.9	13.2	5.98	.996 (.001)
C..........	10.7	3.7	11.5	5.05	.985 (.001)
D..........	11.9	3.7	12.0	5.28	.995 (.001)
E..........	11.6	3.8	11.9	5.19	.988 (.001)
F..........	13.0	4.3	12.6	5.32	.982 (.001)
G..........	13.1	3.3	13.2	6.43	.993 (.001)
H..........	12.3	4.0	12.3	5.34	.992 (.001)
J..........	9.8	4.5	10.6	4.18	.979 (.01)
K..........	13.2	4.3	13.0	5.53	.989 (.001)

* Lowest significant difference = 0.8 (P_n = .05).
† Numbers in parentheses are the statistical probabilities of significance (null hypothesis, P_n).

that there are significant differences among the slopes of the functions.

When do the comparative shapes of immature melons become representative of their comparative shapes at maturity? Using for each field the shapes calculated on the basis of log time regression for that field, the correlation coefficient was determined between the terminal shapes and shapes for preceding dates. These coefficients were, successively from the first date: 0.16 (.50), 0.58 (.10), 0.81 (.01), 0.93 (.001), 0.99 (.001). The values in parentheses are the approximate probabilities that the null hypothesis (no correlation) is true. Comparative melon shapes did not become truly representative of final shapes until the second week before harvest. Evidently, although one may predict at an early date the final shape in some fields by casual observation, such prediction is not reliable over a wide range of situations.

Does this mean that the trend toward ultimate shape may be effectively altered until the final two weeks of growth? A reasonably good hypothesis is that it cannot, and the reasons are advanced in the following discussion.

The examples of figure 2 illustrate

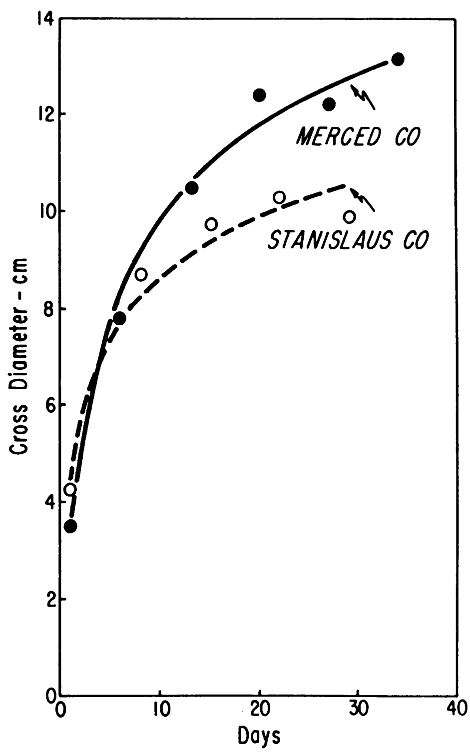

Fig. 1. Fruit growth as a function of time, at two locations. Dots (for Merced County) and circles (for Stanislaus County) indicate sample means on certain dates. Lines are derived from statistical analyses based on the assumption of a log time relationship.

Table 4

MELON SHAPE AS A FUNCTION OF TIME*

Field	Shape for initial date; from regression equation (the intercept)	Shape for terminal date; from regression equation	Slope (*b*) of regression equation of shape on log time	Coefficient of correlation (*r*) of regression of shape on log time
A	1.59	1.06	−.345 ± .083	.985 (.001)†
B	1.56	1.02	−.349 ± .063	.990 (.001)
C	1.37	1.02	−.221 ± .094	.956 (.01)
D	1.33	1.06	−.172 ± .046	.982 (.001)
E	1.56	1.12	−.280 ± .067	.985 (.001)
F	1.43	1.13	−.191 ± .051	.982 (.001)
G	1.58	1.10	−.315 ± .070	.987 (.001)
H	1.48	1.08	−.254 ± .071	.981 (.001)
J	1.46	1.12	−.229 ± .112	.956 (.01)
K	1.42	1.08	−.219 ± .060	.972 (.001)

* Melon shape = polar diameter/cross diameter.
† Numbers in parentheses are the probabilities of significance.

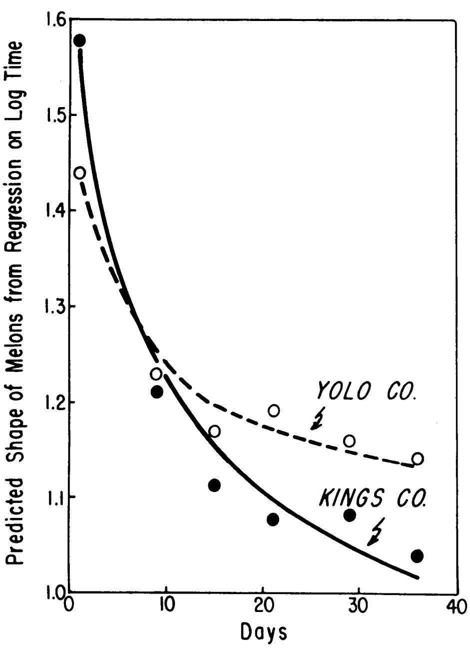

Fig. 2. Melon shape as a function of age, at two locations. Shape is defined as the decimal ratio, longitudinal diameter/cross diameter. Dots (for Kings County) and circles (for Yolo County) indicate sample means on certain dates. Lines are derived from statistical analyses based on the assumption of a log time relationship. The University Farm at Davis is the Yolo County location.

the basis for possible lack of correlation between terminal shapes and earlier shapes. There may be a "comparative" reversal of shape, yet there is a continuous relationship between later shape modification and earlier shape modification. As in the determination of size, since major growth occurs in the first half of the developmental term, major shape determination must occur during the same period.

Terminal shapes not only had no simple correlation with initial shapes, but a low coefficient of correlation (0.27) with the slope of the regression of shape on log time. Neither were there significant correlations between initial sizes and either initial shape or slope. There is, however, a relationship between the initial shape (a) and the slope (b) ($r = 0.92$, $P_n = .001$). Thus, a slope (b_e) might be predicted fairly accurately from the initial shape (a) by the relationship,

$$b_e = .699 - .647a. \qquad \text{I}$$

If one hypothesizes that growth from the initial shape occurs in equal absolute increments along all radii (Sinnott, 1936), one may deduce a formal relationship between the initial shape and the subsequent modification in the form,

$$b_h = .463 - .463a. \qquad \text{II}$$

Functions I and II, I being empirical and II being rational, are not statistically different, and both have the property that given an initial shape (a) of 1.0, the subsequent modification (b) would be zero and the terminal shape would be 1.0. If there is a real difference between Functions I and II, it appears to be such that the empirical regression

(I) has a more-than-geometrical compensating effect on initially longer fruits. It is as though the stresses of growth were somewhat resolved in the direction of sphericity.

The formal regression (Function II) undoubtedly accounts for a major portion of the shape change during fruit development; that is, for the fruits' becoming rounder. It cannot, however, account for ultimate variation in shape between fields; that is, it cannot account for the initial shape, and given an initial shape, cannot provide an intersection or "crossing over" of regressions within a finite period of time.

Since terminal shapes had very low coefficients of correlation with initial shapes and with subsequent slope of change (b), it must require the particular combination of initial shape and subsequent modification of this shape to reliably reproduce the ultimate shape for each field. Thus, in looking for factors influencing the ultimate shape, we must pay particular attention not only to, say, the first half of the developmental term, but to the period in which the very young fruit or ovary is developing.

For seeking basic relationships, we must not overlook the important observations of: (a) Rosa (1928) on the relationship of melon shape to flower type (perfect versus pistillate) in the variety Salmon Tint; (b) Weetman (1935) on the relationship of melon shape to ovary and cotyledon shape across and sometimes within cultivars and hybrids; and (c) Sinnott (1944) on the relationship between the orientation of mitotic axes and variation of fruit shape owing to variety.

Surface netting. We characterized net development in 3 ways: (1) by per cent of fruit surface occupied by the incipient net—small initial epidermal cracks, always longitudinally oriented; (2) by per cent of surface occupied by developed net, i.e., the network of corky tissue developing from these cracks and from transverse cracks which join them; and (3) by an estimate of the average diameter of the interspaces between the net strands.

The incipient net (table 5) reached its maximum extent about 1 week after the 2″–3″ size. In most fields, the average melon with such a net, being about 8 cm in cross diameter, became ripe approximately 4 weeks later. The corky net was almost fully ramified 3 weeks after the 2″–3″ size (table 6). In general, the size of net interspaces appeared not to vary with time once the net was ramified (table 7). Since fruits continued to expand past this time, surface growth must have been accompanied by equivalent expansion of the net strands.

Surface netting is a distinguishing feature of the cantaloupe. Its characteristics vary with location in ways which cannot be described simply. Since netting as a quality feature *per se* is not an important variant so long as it covers the fruit surface uniformly, a simple uniformity rating may be the best for the immediate future. A great deal of attention commonly is paid to net characteristics as indicators of internal eating quality, but the slight association which the size of interspaces (net tightness) and net height have with flesh concentration of soluble solids is so variable as to have no predictive value (Davis *et al.*, 1964). For a field to have many cantaloupes with poor and nonuniform coverage with net is practically positive evidence of substandard eating quality. On the other hand, handsome net is not reliable evidence of good eating quality.

This study was not conclusive as to the time when poor net became evident, mainly because most fields had acceptable net. Melons of Field J ultimately had poor netting, but this was not evident early. In this case, one could imagine that later surface expansion was not accompanied by thickening of longitudinal net strands or extension of transverse strands. It is probably generally true that for melons with **poorly**

TABLE 5

PER CENT OF SURFACE COVERED WITH INCIPIENT NET AS A FUNCTION OF TIME

Field	Observation dates*					
	1	2	3	4	5	6
A	0	3	22	6	2	6
B	0	13	16	7	0	0
C	0	70	19	4	1	0
D	0	57	18	6	0	0
E	0	52	35	0	0	0
F	0	2	19	8	0	0
G	0	30	27	0	0	0
H	0	72	0	1	2	0
J	0	64	36	0	0	†
K	0	46	34	0	0	0

* Tables 5, 6, 7, 8, and 9 are tabulated on the basis of relative observation dates. Table 2 shows actual observation intervals.

† Melons ripened 1 week faster in Field J compared to the other locations.

TABLE 6

PER CENT OF SURFACE COVERED WITH DEVELOPED NET AS A FUNCTION OF TIME

Field	Observation dates*					
	1	2	3	4	5	6
A	0	0	65	91	98	92
B	0	5	84	93	100	100
C	0	4	81	93	99	100
D	0	1	82	94	100	100
E	0	0	65	100	100	100
F	0	0	81	92	100	100
G	0	0	73	100	100	100
H	0	1	100	99	98	100
J	0	0	64	100	100	†
K	0	0	66	100	100	100

* Tables 5, 6, 7, 8, and 9 are tabulated on the basis of relative observation dates. Table 2 shows actual observation intervals.

† Melons ripened 1 week faster in Field J compared to the other locations.

TABLE 7

AVERAGE DIAMETER (IN MM) OF NET INTERSPACES AS A FUNCTION OF TIME

Field	Observation dates*					
	1	2	3	4	5	6
A	..	..	3.3	2.8	3.6	2.7
B	..	..	2.4	2.3	3.1	2.9
C	..	..	2.6	2.9	2.9	2.4
D	..	..	2.4	3.0	2.7	2.8
E	..	..	3.2	3.2	3.2	3.4
F	..	..	2.9	2.2	2.5	2.3
G	..	..	2.5	2.9	3.0	2.1
H	..	..	2.2	2.2	2.1	2.7
J	..	..	3.0	2.1	5.2	†
K	..	..	3.3	2.6	2.5	2.8

* Tables 5, 6, 7, 8, and 9 are tabulated on the basis of relative observation dates. Table 2 shows actual observation intervals.

† Melons ripened 1 week faster in Field J compared to the other locations.

TABLE 8

UNNETTED SUTURE WIDTH AS A FUNCTION OF TIME*

Field	Observation dates†					
	1	2	3	4	5	6
A	..	..	16.3	12.4	38.2	9.7
B	..	..	5.5	7.7	14.4	11.8
C	..	..	12.6	25.4	15.5	2.5
D	..	..	15.4	7.0	2.6	2.5
E	..	..	3.4	3.2	1.8	.8
F	..	13.2	9.3	21.0	8.4	20.5
G	..	..	12.2	31.4	29.0	20.4
H	..	22.3	51.0	47.6	40.3	35.6
J	..	7.3	34.3	11.2	29.4	‡
K	..	.2	39.4	34.1	22.6	34.7

* Sample mean (number of unnetted sutures per melon × average width in mm of 3 largest unnetted sutures).

† Tables 5, 6, 7, 8, and 9 are tabulated on the basis of relative observation dates. Table 2 shows actual observation intervals.

‡ Melons ripened 1 week faster in Field J compared to the other locations.

developed net, interspaces tend to be longer longitudinally than transversely. These suggestions lack confirmation at present.

Suture netting. The use of the term "suture" will be continued here as it was employed in Davis *et al.* (1964), although it could be misleading. These differentiated stripes of surface tissue, 10 in number, running longitudinally, are associated with the vascular strands, 10 in number, in the receptacular tissue which envelops the carpels; not with the carpels, which are 3 in number.

The unnetted breadth of these differentiated tissues is positively correlated with fruit size (Davis *et al.*, 1964). There are important deviations from this relationship, however, and larger-than-expected sutures are occasionally associated with poor internal quality, in addition to contributing to the unsightliness of fruit.

In this study, unnetted sutures were rated in two ways: (1) as the number of unnetted sutures on each melon; and (2) as the average unnetted width of the 3 widest unnetted sutures, measured at the equator. These ratings were found to be closely correlated with each other. They were combined as a product to form the ratings presented in table 8.

The sample error inferable from table 8 indicates that 10 melons are not enough for an accurate index of this characteristic. An inspection of the table, however, indicates adequately the nature of suture net development.

For fields producing melons with very wide sutures, the fact was discernible when the first incipient netting appeared. Apparently sutures, if they are to develop netting, do so concurrently with the rest of the fruit surface, not afterward. The full, unnetted width of sutures was reached in the second or third week after the 2″–3″ size was reached. There is some indication that this width may have narrowed slightly during the last week of maturation. This presumably could occur only by extension of net strands into suture areas.

We may conclude that large deviations from normal suture netting are determined very early.

Ground-spot size. Our earlier study (Davis *et al.*, 1964) indicated that the ground-spot varies independently of other quality characteristics. That study showed a significant tendency for the ground-spot to be smaller in those fields producing melons with a higher (more yellow, less green) color at the full-slip stage. This may have been because the ground-spot was less distinct on yellower melons. An attempt was made in the present study to rate the

TABLE 9
DIAMETER OF GROUND-SPOT (IN CM) AS A FUNCTION OF TIME*

Field	Observation dates†					
	1	2	3	4	5	6
A	2.2	2.3	2.5	2.6	2.8	1.9
B	.4	2.5	3.4	4.1	3.1	3.5
C	.7	2.6	3.3	3.8	4.3	4.2
D	.8	3.5	4.2	4.5	5.1	4.5
E	1.0	4.8	3.6	4.4	2.7	2.9
F	2.1	2.9	3.9	5.2	2.8	7.4
G	0.0	1.7	2.6	2.0	2.2	2.7
H	.7	3.9	2.8	2.9	6.5	2.1
J	.1	3.0	...	1.6	2.7	‡
K	1.1	2.6	2.2	2.3	5.6	4.1

* Sample mean.
† Tables 5, 6, 7, 8, and 9 are tabulated on the basis of relative observation dates. Table 2 shows actual observation intervals.
‡ Melons ripened 1 week faster in Field J compared to the other locations.

ground-spot solely by the diameter of the area on which the net was morphologically affected by its contact with the ground. In some cases, the visible effect was a deficiency of netting; in others, an over-growth or callusing of net. This distinction was not recorded, but perhaps should be noted in future studies.

In this set of observations, as in the previous study, there seems to be no association between ground-spot and other characteristics. It seems reasonable to propose, as is commonly held, that the character of the ground-spot is due more to the nature of the contact between fruit and soil than to fruit–plant relations. Fineness of tilth and humidity of interface would affect aeration, light diffusion, and activity of microorganisms. The contact area affords a protected site for insects and other pests, including those which feed preferentially on the net.

There are differences between fields to be inferred from table 9, although the range of variation is not so great as that observed in the previous study (Davis *et al.,* 1964). Some variations seemed to arise early in development; others, in the final 2 weeks.

It is probably safe to assume that prevention of badly affected ground-spot is chiefly a cultural problem, perhaps intensified by pathogens or insects acting directly on the melon surface.

Flesh thickness and flesh proportion. The proportion of flesh to melon diameter or to cavity diameter is a greater factor in subjective quality rating than flesh thickness *per se.* Flesh thickness is associated with fruit size, but the proportion of flesh thickness to fruit size is independent of fruit size (Davis *et al.,* 1964). These relationships are elaborated under the heading, "Correlation of seed number with melon characteristics."

The proportion of flesh to fruit size has been expressed as flesh:cavity ratio (Davis *et al.,* 1964). It is found to be better adapted to analysis if expressed as the ratio of flesh thickness to melon radius (or equivalently, the ratio of twice flesh thickness to melon diameter.)[4] The ratio of flesh thickness to melon radius will be called the flesh proportion. Flesh proportion (f) can be calculated from the flesh:cavity ratio (m) by the equation,

$$f = m/(m + .5).$$

Table 10 presents the calculated regressions of flesh thickness on log time for each location. It also presents the

[4] The largest equatorial diameter was used, and flesh thickness is calculated as .5 (cross diameter – cavity diameter). The cavity is essentially triangular in cross section, and was measured from base to apex along the general axis of the largest equatorial melon diameter.

Table 10

FLESH PROPORTION STATISTICS

Field	Regression of flesh thickness on log time						Flesh proportion from sample means (observation dates)			Flesh proportion from regression equations (observation dates)		
	Intercept (a) (cm)	Slope (b) ($cm/log\ time$)	r	P_n*	k_a†	k_b‡	1	2	Last	1	2	Last
A	1.007	1.372	.968	.01	.514	.513	.54	.46	.54	.51	.51	.51
B	.932	1.477	.991	.001	.477	.494	.50	.47	.49	.48	.49	.49
C	.831	1.367	.985	.001	.454	.541	.48	.47	.52	.45	.50	.51
D	.757	1.511	.986	.001	.406	.572	.44	.46	.54	.41	.50	.52
E	.941	1.515	.982	.001	.494	.583	.52	.52	.56	.49	.54	.56
F	1.029	1.465	.954	.01	.475	.551	.52	.47	.55	.48	.52	.53
G	.781	1.952	.990	.001	.469	.608	.51	.53	.58	.47	.55	.57
H	.985	1.483	.991	.001	.490	.556	.53	.49	.55	.49	.53	.53
J	1.168	1.055	.978	.01	.524	.505	.52	.52	.51	.52	.52	.51
K	1.122	1.599	.977	.001	.517	.578	.55	.52	.57	.52	.55	.56

* Statistical probability of significance (null hypothesis).
† Ratio of flesh thickness to melon radius on first date, calculated from intercepts of regression of each variable on log time.
‡ Ratio of flesh thickness increase to melon radius increase (see text), calculated from slopes of regression of each variable on log time.

flesh proportion for each lot of melons for 3 dates, calculated by 2 methods. The first method uses the mean flesh thickness and mean cross diameter for each date and each location. The second method uses the predicted flesh thickness and predicted cross diameter, calculated from the regression of each characteristic on log time for each location.

According to each set of calculations, for most locations flesh proportion increased from the initial date to the last date. There is a discrepancy between the two sets of calculations for the second date. In the set using sample means, for 6 locations the flesh proportion is lower on the second date than on the first. This is not reflected in the set using the log time regressions. The feeling of discrepancy is heightened when it is observed that for most fields on the first and last date, the predicted values are lower than the actual mean values, and for the second date, the predicted values are higher than the actual mean values. Evidently, the log time assumption does not reflect the development precisely. By and large, the predicted values fairly approximate the mean values for the last date and, since they reflect the total sample for all dates rather than for 1 date, they may be a better estimate for values on the final date than the sample means.

We may conclude that, in general, with significant exceptions, the flesh proportion increases with time, except for a brief period, say in the first or second week after the 2″–3″ size, when there is a temporary decrease in flesh proportion.

How are we to characterize the development of variation in flesh proportion due to location? The following discussion presents one method.

The general regression equations for the growth curves of the flesh and the cross diameter are:

$$Y_{(\text{flesh})} = a + b \log \text{time};$$

a being the probable initial flesh thickness on Date 1, b being the coefficient of change in flesh thickness with log time; and

$$Y'_{(\text{cross diam.})} = a' + b' \log \text{time};$$

a' being the probable initial cross diameter on Date 1, b' being the coefficient of change in cross diameter with log time; then

$$(Y-a)/(Y'-a') = b/b',$$

and since b and b' are constants for each lot of melons,

$$b/.5b' = k_b,$$

a constant representing flesh thickness increase/cross radius increase.

Values of k_b for each location are shown in table 10, which also shows values for k_a representing $a/.5a'$ or initial flesh thickness/initial cross radius.

There is no association between k_a and k_b among locations; that is, there is no association between the initially observed flesh proportion and its subsequent change. There is lack of association also between initial flesh proportions and terminal flesh proportions. There is a highly significant correlation ($r = .91$, $P_n = .001$) between the values of k_b and the predicted terminal flesh proportions. The related coefficient of determination (r^2) indicates that 83 per cent of the variance in terminal flesh proportions is associated with the variance in k_b, the ratio of flesh thickness increase to cross radius increase. In comparison with fruit shape, then, the final flesh proportion has very little relationship with the initial flesh proportion. Since growth of both cross diameter and flesh was proportional to log time, we must conclude that the factors most determinant in flesh proportion were being exerted early, and that their influence continued to predominate throughout melon development.

Soluble solids concentration. The soluble solids concentration is a major concern in cantaloupe eating quality. The U. S. No. 1 Grade rating requires a soluble solids level of at least 9.0. The

TABLE 11

SOLUBLE SOLIDS CONCENTRATION AS A FUNCTION OF TIME*

Field	Accumulated observation time (days)																
	1	6	8	13	15	18	20	21	22	24	25	27	29	30	34	35	36
A	4.5		4.4		4.6				5.8				6.6			9.6†	
B	3.6		3.5		3.9				4.4		5.6		6.7				11.4
C	5.5		4.3		4.1				6.7				10.9				11.4
D	4.7		4.3		4.2				6.6				9.5				11.2
E	4.5		4.3		4.6				5.4				8.9				9.3
F	2.7		3.4		3.7			5.7					8.0				10.8
G	3.5	3.6		4.9			4.7					7.2			9.7		
H	4.8		3.3		5.1				6.7					8.3			10.4
J	3.6		3.6		4.6				6.3				8.2				
K	3.4	3.6		5.1		4.3				6.9			8.9				13.2

* Soluble solids concentration is measured by the refractometer reading of unfiltered juice, calibrated as per cent sucrose.

† Lowest significant difference for mean on terminal date at each location = 1.0 (P_n = .05). Last observation date for each field = day on which all sample melons were mature.

range of soluble solids concentration at maturity was greater in this study than in the 1962 survey (Davis *et al.*, 1964), and the over-all mean was lower. The association between shape and soluble solids across fields in this study was less obvious, being not quite significant at the 10 per cent level. Extensive general observation indicates that this is a physiological relationship which is disturbed by conditions not understood, but resembling pathogenic conditions.

In this study, the relative terminal levels of soluble solids were not attained until the final week of maturation (table 11). There was no correlation between terminal levels and even those of the previous week. The final week appeared to be the one of greatest gain if there was to be a high final concentration. We cannot conclude from this that the determination of the ultimate concentration occurs, or occurs only, in the final week. At Field J, as discussed in the section headed "Melon size," the first cantaloupes to set and to ripen—those developing previous to the studied group, but on the same plants—were of high quality in appearance and in soluble solids concentration, though the plants were severely debilitated at harvest and obviously disordered for at least the last half of their developmental period.

An examination of table 11 indicates that soluble solids at different locations may attain their final concentrations along different regressions with time, but in all cases the ascent was continuous in the last 3 or 4 weeks. There were no instances of decline during the final period.

Correlation of seed number with melon characteristics. On one date at each field, the seeds were counted for the 10 melons in the sample. Only those seeds judged to be viable were counted. Seed viability was judged by fullness, color, and ease of detachment from the funiculus. Judgment was occasionally tested by water flotation, and the results were the same. At Field K, there was seed abnormality in several fruits, pronounced in 3; some seed coats were loosened, and there was some embryo swelling. Such seeds would often float, but they were counted as viable.

Table 12 presents the mean number of seeds per melon for each location, with confidence limits estimated for each group. On this basis, there are only 2 or 3 means which are significantly different from each other.

One purpose of making this observation was to detect correlations (if any) between seed number and quality characteristics. Coefficients of correlation were low and nonsignificant between seed number and terminal soluble solids concentration, shape, suture netting, and flesh proportion. Within some locations, there were significant correlations between seed number and cross diameter or flesh thickness, and there was a correlation between seed number and flesh thickness as they varied between locations. Table 12 presents these coefficients of correlation as well as estimates of variance for seed number, cross diameter, flesh thickness, and flesh proportion.

We may conclude that, at least at some locations, there was an important association between seed number and either cross diameter or flesh thickness or both, and that this relationship extended across locations. At locations where there was no evidence for such correlations, there was a low variance in one or more of the variables concerned. In the future, where there is difficulty in determining why a given field is producing melons of a given size or flesh thickness, the presence or absence of the seed number correlation should provide an additional aid to diagnosis. At present, of course, we do not know the causal nature of this association: whether the success of fertilization affects subsequent growth or whether an exogenous factor influences growth and the success of fertilization independently.

These results are consistent with those of 1962 (Davis *et al.*, 1964); there is a relationship between size and flesh thickness, but not between size and flesh proportion. Evidently the factors determining flesh proportion are independent of the association which links size, flesh thickness, and seed number per fruit.

TABLE 12

NUMBER OF SEEDS PER MELON; CORRELATION OF SEED NUMBER WITH, AND VARIANCE OF, CROSS DIAMETER, FLESH THICKNESS, AND FLESH PROPORTION

Field	Mean seed number per melon	Correlation coefficients (r)			Variance (s^2)			
		Seed × cross diameter	Seed × flesh thickness	Seed × flesh proportion	Seed number	Cross diameter	Flesh thickness	Flesh proportion
A	541 ± 79	.72(.02)*	.92(.001)	.50	61.7	1.24	.12	.0013
B	532 ± 94	.21	.27	.17	86.0	.46	.06	.0010
C	458 ± 95	.79(.01)	.73(.02)	.34	85.7	2.09	.18	.0013
D	463 ± 67	.23	.36	.39	43.8	.75	.08	.0006
E	518 ± 84	.71(.02)	.65(.05)	.48	69.3	1.21	.20	.0009
F	474 ± 94	.67(.05)	.75(.02)	.29	84.9	1.11	.09	.0007
G	605 ± 45	.23	.22	−.04	20.7	.57	.04	.0005
H	491 ± 90	.36	.23	.00	79.9	.43	.08	.0007
J	464 ± 107	.62(.10)	.53	.10	90.3	.61	.10	.0009
K	526 ± 56	.41	.18	−.24	31.8	.40	.03	.0007
r and s^2 among fields		.57(.10)	.75(.02)	.50	23.7	1.29	.09	.0007

* Numbers in parentheses are the probabilities of significance (null hypothesis).

SUMMARY OF CONCLUSIONS

The development of selected characteristics of the cantaloupe (*Cucumis melo* L. var. *reticulatus* Naud., cultivar PMR 45) was observed in 10 different sets of field conditions. In general, the early period of melon development seemed to be the dominant period in determining field-to-field variations in important fruit characteristics. This statement is qualified by the following list of conclusions concerning the development of each characteristic. Some of these in turn are qualified in the more extended discussions of the text.

Time required for maturation. Over a wide range of conditions, the *mean* time lapse from the 2″–3″ size fruit to full-slip was remarkably constant from field to field. The normal requirement of 5 weeks was abbreviated in fields where plants were obviously disordered.

Development of flesh color. Most flesh color development occurred in the week preceding the last week of maturation. For melons having about 50 per cent color development, full-slip occurred in about 10 to 14 days.

Melon size. Major field-to-field differences in melon size were related to variations in the growth of fruits while relatively young.

Fruit shape. Fruit shape was determined while fruits were young. A significant portion of field-to-field variation was attributable to the shape fruits had acquired at the 2″–3″ size.

Surface netting. In most fields, young melons in the incipient net stage required about 4 weeks to reach maturity. The size of net interspaces appeared not to vary once the net was ramified (2 weeks after the 2″–3″ size). An important exception to this statement occurred in the 1 field which produced melons having poor net at maturity. At this field, final increments in melon size apparently were not accompanied by equivalent extension and thickening of net strands.

Suture netting. The degree to which melon sutures were netted at maturity was evident at very early stages of netting, even at the incipient net stage.

Ground-spot size. Observations confirmed the commonly held opinion that the size and character of the ground-spot, aside from insect damage, depend chiefly on the nature of the contact surface between fruit and soil, rather than on plant–fruit relationships.

Flesh thickness and flesh proportion. The proportion of flesh thickness to melon radius was associated with growth subsequent to the 2″–3″ size. During this growth, nothing short of severe pathologic debilitation appeared to alter the function between time and flesh proportion in the later stages of fruit development from that obtaining in the earlier stages.

Soluble solids concentration. Field-to-field variations in the concentration of soluble solids at maturity exhibited no simple association with concentrations of soluble solids measured at previous weekly intervals. The regression of soluble solids concentration as a function of time varied between locations, but at no location was there evidence of a decline in soluble solids during the 3-week period preceding the full-slip stage.

Correlation of seed number with melon characteristics. Within certain fields, there were significant correlations between seed number per fruit and cross diameter or flesh thickness. There was a significant correlation between seed number and flesh thickness across fields. Seed number was not correlated, at least on a simple basis, with the other measured fruit characteristics.

LITERATURE CITED

DAVIS, R. M., JR., G. A. BAKER, and R. F. KASMIRE
1964. Muskmelon quality characteristics—their variability and interrelationships. Hilgardia **35**(16):479–89.

LEEPER, P. W.
1951. Growth and days from first net to maturity of Rio-Sweet cantaloupe. Proc. Amer. Soc. Hort. Sci. **58**:199–200.

MCGLASSON, W. B., and H. K. PRATT
1963. Fruit-set patterns and fruit growth in cantaloupe (*Cucumis melo* L., var. *reticulatus* Naud.). Proc. Amer. Soc. Hort. Sci. **83**:495–505.

ROSA, J. T.
1928. The inheritance of flower types in *Cucumis* and *Citrullus*. Hilgardia **3**(9):233–50.

SINNOTT, E. W.
1936. A developmental analysis of inherited shape differences in cucurbit fruits. Amer. Nat. **70**:245–54.
1944. Cell polarity and the development of form in cucurbit fruits. Amer. Jour. Bot. **31**: 388–91.

WEETMAN, L. M.
1935. Correlation of shape of fruits, cotyledons, and seeds in melons. Bot. Gaz. **97**:388–98.

4*m*-3,'67 (G9536) GVW 141

The journal HILGARDIA is published at irregular intervals, in volumes of about 650 to 700 pages. The number of issues per volume varies.

Single copies of any issue may be obtained free, as long as the supply lasts; please request by volume and issue number from:

Agricultural Publications
University Hall
University of California
Berkeley, California 94720

The limit to nonresidents of California is 10 separate titles. The limit to California residents is 20 separate titles.

The journal will be sent regularly to libraries, schools, or institutions in one of the following ways:

1. In exchange for similar published material on research.
2. As a gift to qualified repository libraries only.
3. On a subscription basis—$7.50 a year paid in advance. All subscriptions will be started with the first number issued during a calendar year. Subscribers starting during any given year will be sent back numbers to the first of that year and will be billed for the ensuing year the following January. Make checks or money orders payable to The Regents of The University of California; send payment with order to Agricultural Publications at above address.