COMPREHENSIVE RESEARCH ON RICE
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PROJECT TITLE:
Genetic and Environmental Influences on Head Rice in California

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OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

The objective of the project is to determine to what extent the genetical and environmental factors affect California head rice, and what are some important traits of panicle and seed that can be used for selection to improve the head rice percentages. Two approaches are taken to collect the information for analyses.

I. Computer analyses of the documented farm records of Rice Grower's Association (RGA) and the climatological data of the National Oceanographic and Atmospheric Association (NOAA) stations in northern California, to determine the impact of cultivar and weather on California head rice under field conditions. The RGA data that were analyzed in this report included 1413 lots of rice harvested in 1984 and a total of 9428 lots harvested since 1979. Ten NOAA weather stations in the rice growing regions were used to study the environmental effects on rice. A combined analysis that crossed locations and years provided quantitative estimates of cultivar and environmental factors on head rice yields.

II. Experiments were conducted at three locations: Biggs, Colusa and Davis, to study the growth and development of panicles and their relationships to seed quality characteristics and head rice. Six cultivars with different maturity and grain size were planted and compared at each of the three locations. Samples were taken twice a week after the 100% flowering time. Panicles were divided into 3 parts to evaluate the uniformity of the kernel characteristics over time. This information provided an answer to some of the reasons for the differentials in head rice among cultivars.

SUMMARY OF 1985 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

OBJECTIVE I

Rice data were obtained from the Rice Grower's Association in Sacramento and the Butte County Rice Growers Association (BUCRA). Temperature data were obtained via the computer system of the Integrated Pest Management (IPM) office at the Davis Campus of the University of California. These data were entered into the micro- and mini-computer systems in the Department of Agronomy and Range Science for analyses. The data were divided and arranged according to ten locations of NOAA weather stations, so that the impact of weather on head rice and other rice traits could be evaluated.

Analyses of 1984 data. A total of 1413 lots of rice received by RGA and BUCRA were analyzed for head rice, total milled rice, moisture content and temperature at harvest time. Results led to the following conclusions:

The overall average head rice percentage for 1984 was 49.5, the lowest of any year since 1979 (Table 1). Large differences among cultivars (40.7 to 60.7) and locations (36.8-56.6) were observed but part of the differences among locations was attributable to the different cultivars grown at each location.

Overall averages for total milled rice among cultivars and locations showed only small and probably insignificant differences (Table 2).

The moisture content of the kernels at harvest time for the 1984 rice crop was uniformly low in all locations except Orland and for all cultivars except M7. The lower than usual kernel moisture content at harvest time in 1984 probably accounts in part for the low head rice yields in this year but a further contributing factor may be that growers were shifting to growing earlier maturing cultivars (Table 3).

When cultivars were grouped according to maturity from very early to late, the percentages of head rice, total milled rice and kernel moisture increased (Table 4). Locations with more than 30 percent of the lots of rice in the very early maturity class resulted in head rice yields of less than 50 percent (Table 5).

The 1984 rice data were reorganized and summarized according to maturity group and location (Tables 6, 7 and 8) for percentage head rice, percentage total milled rice and percentage kernel moisture at harvest, respectively. Differences among locations became much smaller when compared within maturity groups. This further supports the conclusion that to a large extent differences among locations were caused by the cultivars being grown, with any differences in local environments being of lesser importance.

Analyses of six years data (1979-1984). Data from a total of 9428 lots of rice have been and stored on our computer system over the last six years. When yearly means of 1984 are presented together with previous yearly means, it becomes obvious that the percent head rices of both very early and early cultivars are the lowest since 1979, while intermediate and late cultivars yield comparable head rice in 1984 (Table 10). The moisture contents at harvesting time also are the lowest in 1984 for very early and early cultivars. The time of

harvesting of the maturity groups averaged over the six years are plotted in Figure 1. The very early and early cultivars were harvested over a much wider period of time than intermediate and late cultivars. Over all six years, for every date of harvesting more very early and early cultivars were harvested than intermediate and late cultivars. Thus, cultivars can be compared for a given harvesting date or under similar climatic conditions.

It is generally believed that the difference in grain quality among cultivars with different maturities result from the different environments in which grain filling and harvesting occurs. One of the important environmental factors that may affect grain quality is the temperature at harvesting time. To examine these effects, we have plotted the % total milled rice, % head rice and % moisture of each lot against the average high temperature when the rice was harvested (Figure 2). Several comments can be made regarding the effects of temperatures at harvest time: 1) There is a clear separation between maturity groups for the total milled rice and head rice. These quality characteristics increase from early to late maturity classes. 2) Except for very early cultivars, they are remarkably stable to high temperatures at harvest, for head rice and total milled rice, and also to harvest date. 3) The head rice of the very early cultivars decreased with temperatures above 90°F.

There was considerable variation in weather conditions over the six years. Figures 3, 4 and 5 present the curves for total milled rice, head rice and grain moisture at harvest time for the various maturity groups for each year. There is a clear separation between maturity groups in % TR and in % HR for every year. Most of the rice was harvested at high temperatures less than 90°F for years 1979 to 1983, but in 1984 much of the rice was harvested at high temperatures above 90°F. As already noted, the total milled rice and head rice for 1984 were the lowest since 1979 (Table 9).

When % moisture is plotted against high temperature as shown in Figure 5 for 1984, no clear relationship between the two variables can be seen. Apparently the average high temperature was but one of the critical environmental factors that affect the moisture content in the grain. Other climatic conditions such as high temperature during the growing season, low humidity or north wind at the harvesting time will all contribute to the low moisture content in the grain. The average high and low temperatures at each harvesting time are shown in Figure 6 for each maturity type of rice for combined data of 1979-1984 and for 1984 data alone. The average yields of head rice and total milled rice for each cultivar planted in the last five years are shown in Figure 7.

A comparison between 1983 and 1984 (Table 9) shows that an increase of 3% moisture content in grain (from 19.8 to 23.2%) corresponds to an 8% increase in head rice (from 49.5 to 57.8% HR), and that a replacement of very early cultivars by early cultivars would increase head rice 11% in 1984 conditions (from 41.0% to 52.4% HR).

In short, both climatic impact and genetic effect on head rice are clearly demonstrated in the above combined data analyses. The difference between cultivars persisted in every environment for each year and between years, whether the environmental conditions were favorable or

not. Equally evident is the environmental impact which produced drastic contrast of head rices between years, particularly between 1983 and 1984. All climatic factors that affect head rice appear to affect head rice indirectly, whereas moisture content in the grain has a direct cause effect relationship to the % HR.

OBJECTIVE II

Panicle samples of six cultivars (M-101, S-201, M-201, L-202, M-202 and M7) were taken from 4 replicates in 3 locations (Biggs, Colusa and Davis), twice a week after the 100% flowering time in the 1985 season. The planting dates were May 10, May 3, and May 12, and the last days of harvesting were October 16, October 18 and October 14 for trials in Biggs, Colusa and Davis, respectively. Rice seedlings were transplanted from the greenhouse to the field in Davis on June 12, direct seed sown method was employed at the other two locations (which were part of the rice growth model project of Dr. J. E. Hill and B. Miller).

The length, fresh and dry weights of 10 panicles from each plot were measured at each sampling time. In addition, grain samples were taken from 3 panicle parts: upper, middle and lower part, according to the position of the branches on the panicle. One-hundred-grain weight was measured for each grain sample and at each sampling time. The kernel characteristics, kernel size, smoothness, greenness, chalkiness and head rice of grain samples at harvesting time are still being measured. Some preliminary findings of the data obtained so far are reported below.

Panicle length. Panicle length was pretty much fixed since 100% flowering time or early panicle initiation time. Cultivar differences in panicle length are obvious (Figure 8). The average panicle length of M-101, S-201, M-201, L-202, M-302 and M7, respectively, are 18.6, 16.9, 18.2, 18.2, 18.4 and 17.4 cm long. Among the cultivars, S-201 has the shortest panicles and M7's panicle is second shortest on average. There is no clearly detectable relationship between the panicle length and the maturity of the cultivars. It is very possible, however, panicle length may be related to some of the uniformity characters of the kernel. This possibility will be investigated as soon as the kernel measurements are obtained.

Panicle weight. Panicles usually reach the maximum weight shortly before maturation. The maximum panicle weights of the six cultivars differed more at Davis than at the other two locations (Figure 9). The days required to reach the maximum weight after the panicle initiation are 25, 28, 35, 35, 37 and 38 for cultivars M-101, M-201, S-201, M7, L-202 and M-302, respectively. The corresponding maximal weights of these cultivars are 2.2, 2.5, 2.5, 2.1, 1.8 and 2.2 grams. Note that there exists a considerable amount of variation of the rate of growth and development of panicles between varieties. M-101 and M-201 required 7 to 10 days less than the other cultivars for the panicles to mature. L-202's panicles weighed less than M7's which in turn weighed less than the other cultivars. S-201 has shorter but heavier panicles than the other cultivars. L-202 has rather long panicles but weighed the least while M7 has short but light-weight panicles.

Grain weight. One hundred grain weight was taken from each of the three parts of panicle samples at each sampling time. These data provide information on the uniformity of the grain development at various parts of the panicle. The growth curves of the grain were shown in Figures 10, 11 and 12 for each cultivar and location. These growth curves reveal that some varieties such as S-201, M-302 and M7 have similar growth patterns over locations and others such as L-202, M-101 and M-201 varied greatly from location to location. The differences among cultivars in response to changes of environments may be related to their difference in stability of the milling qualities over environments.

Average grain weight seems being negatively correlated to the maturity of the cultivar. That is, M7 has smaller grains than M-302, and M-302 has smaller grains than M-201 and S-201 which in turn yielded smaller grains than M-101.

The difference in grain weight between upper and lower part of the panicle is calculated and plotted in Figure 13 for all cultivars and locations. These differentials are not separable between cultivars planted at Colusa and Davis, but are clearly separable at Biggs. Generally speaking, L-202, M-101 and M-201 can be classified into one group in which the maximal differentials between grain weights of upper and lower part of panicles are greater than 0.7 gram, whereas S-201, M-302 and M7 have a maximal differential less than 0.65 grams. These differentials estimate part of the non-uniformity of the grain size or maturity at harvesting time which may in turn cause poor milling qualities.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

1. Less than 3% of the 1984 rice crop in California belonged to intermediate or late maturing cultivars. About 70% was early and 27% was very early cultivars.

2. The average percent head rices of very early and early cultivars were respectively 41% and 52.4% which were the lowest since 1979. The difference in head rice between the maturity groups, 11.4%, was the greatest. Overall, the head rice decreased 8.3% from 1983.

3. The moisture content in grain at harvesting time also was the lowest since 1979. They are 17.9% and 19.8%, respectively, for very early and early cultivars. The moisture content appears to have a direct cause-effect relationship to the head rice.

4. If the moisture level at harvest time could be raised to above 20% or near to 23%, RGA would increase 1.68 million dollars income. If the very early cultivars were replaced by early cultivars, it could add another 0.72 million dollars to the RGA rice growers. Since RGA consists of about 45% of California rice growers, the impact of the above scenarios to the overall California rice growers could reach a potential of 5 million dollars more in return for the 1984 rice industry.

5. Panicle lengths are different among cultivars, particularly panicles of S-201 and M7 are significantly shorter than that of the other cultivars.

6. On average, L-202's panicle weighed less than M7's panicle which in turn weighed less than the other cultivars.

7. The analyses of the growth curves of grains from three parts of the panicles showed that L-202, M-101 and M-201 are more sensitive to changes of environments and that these cultivars have larger difference in grain weight between the three parts of panicles than the other cultivars. These panicle characters may explain in part why cultivars differ in milling qualities.

Table 1. Average percent head rice and number of lots (in parentheses) of cultivars at each location, RGA and BUCRA (1984).

	Very Early				Early			Interm.	Late	
	M-101	Earlirose	Cal Pearl	Calif. Belle	M-9	S-201	M-201	M-302	M-7	Location Average
Orland	-	-	-	29.9(1)	45.4(1)	56.9(2)	59.5(9)	-	59.4(4)	56.6(17)
Chico	-	-	-	-	-	44.8(9)	58.2(6)	-	-	50.1(15)
BUCRA	34.1(2)	-	46.6(14)	-	46.0(2)	51.5(310)	54.6(18)	-	-	51.3(346)
Willows	55.0(1)	-	-	39.6(30)	51.7(19)	48.8(102)	56.4(57)	59.1(7)	61.1(2)	50.2(218)
Colusa	43.8(7)	-	-	42.1(27)	54.0(4)	52.7(50)	58.0(56)	58.4(17)	61.0(15)	53.7(176)
Marysville	44.2(2)	-	-	40.5(44)	50.0(6)	49.0(37)	59.0(50)	-	-	49.8(139)
Sacramento	42.1(47)	-	-	42.1(61)	49.9(23)	50.4(105)	57.3(47)	-	-	48.3(283)
Davis	-	-	-	39.1(27)	48.9(11)	47.8(10)	52.1(13)	52.9(1)	61.2(1)	45.5(63)
Stockton	35.8(8)	44.4(1)	-	-	-	-	-	-	-	36.8(9)
Modesto	40.1(93)	45.5(12)	-	35.7(9)	-	51.2(30)	42.2(3)	-	-	42.6(147)
Cultivar Average	40.7(160)	45.5(13)	46.6(14)	40.6(199)	50.4(66)	50.7(655)	57.1(259)	58.3(25)	60.7(22)	49.5(1413)

Table 2. Average total milled rice and number of lots (in parentheses) for cultivar, RGA and BUCRA (1984).

	Very Early				Early			Interm.	Late	
	M-101	Earlirose	Cal Pearl	Calif. Belle	M-9	S-201	M-201	M-302	M-7	Average
Orland	-	-	-	56.5(1)	67.6(1)	70.0(2)	67.7(19)	-	69.6(4)	67.8(17)
Chico	-	-	-	-	-	67.9(9)	68.2(6)	-	-	68.1(15)
BUCRA	67.4(2)	-	69.2(14)	-	67.7(2)	68.0(310)	68.1(18)	-	-	68.0(346)
Willows	68.3(1)	-	-	66.1(30)	68.2(19)	68.8(102)	68.0(57)	68.9(7)	68.6(2)	68.2(218)
Colusa	66.9(7)	-	-	66.6(27)	69.3(4)	69.3(50)	68.7(56)	69.2(17)	69.5(15)	68.6(176)
Marysville	67.1(2)	-	-	65.8(44)	68.3(6)	69.0(37)	68.1(50)	-	-	67.6(139)
Sacramento	67.9(47)	-	-	65.9(61)	67.4(23)	68.7(105)	67.2(47)	-	-	67.6(283)
Davis	-	-	-	65.4(27)	68.5(11)	68.1(10)	68.0(13)	66.5(1)	67.1(1)	67.0(63)
Stockton	68.22(8)	67.9(1)	-	-	-	-	-	-	-	68.2(9)
Modesto	67.9(93)	67.6(12)	-	66.2(9)	-	68.8(30)	67.2(3)	-	-	67.9(147)
Cultivar Average	67.6(160)	67.6(13)	69.2(14)	65.9(199)	68.0(66)	68.4(655)	68.0(259)	69.0(25)	69.3(22)	67.9(1413)

Table 3. Average percent moisture and number of lots (in parentheses) for cultivars at each RGA and BUCRA (1984) location.

	Very Early				Early			Interm.	Late	
	M-101	Earlirose	Cal Pearl	Calif. Belle	M-9	S-201	M-201	M-302	M-7	Average
Orland	-	-	-	20.1(1)	19.2(1)	22.7(2)	25.6(9)	-	25.5(4)	24.5(17)
Chico	-	-	-	-	-	19.0(9)	21.2(6)	-	-	19.9(15)
BUCRA	19.8(2)	-	17.7(14)	-	18.5(2)	20.2(310)	20.9(18)	-	-	20.1(346)
Willows	20.5(1)	-	-	17.3(30)	20.0(19)	18.5(102)	20.0(57)	20.8(7)	23.1(2)	19.0(218)
Colusa	19.6(7)	-	-	16.5(27)	21.2(4)	19.8(50)	20.3(56)	20.6(17)	21.7(15)	19.7(176)
Marysville	23.5(2)	-	-	17.4(44)	19.4(6)	19.4(37)	22.1(50)	-	-	19.8(139)
Sacramento	20.6(47)	-	-	17.3(61)	20.7(23)	20.0(105)	22.4(47)	-	-	20.0(283)
Davis	-	-	-	16.5(27)	19.0(11)	19.9(10)	18.7(13)	20.6(1)	24.1(1)	18.1(63)
Stockton	18.2(8)	21.5(1)	-	-	-	-	-	-	-	18.6(9)
Modesto	19.6(93)	20.4(12)	-	18.0(9)	-	22.4(30)	22.1(3)	-	-	20.2(147)
Cultivar Average	19.9(160)	20.5(13)	17.7(14)	17.1(199)	20.0(66)	19.9(655)	21.2(259)	20.7(25)	22.6(22)	19.8(1413)

Table 4. Average head rice, total milled rice and percent moisture of cultivars harvested in 1984. (RGA and BUCRA combined).

Cultivar	Total lots	% Head Rice		Total Milled		% Moisture	
		Mean	SD	Mean	SD	Mean	SD
Very Early							
Earlirose	13	45.5	5.84	67.6	1.05	20.5	2.60
M-101	160	40.7	7.27	67.9	1.40	19.9	2.72
Cal Pearl	14	46.6	5.93	69.2	1.07	17.7	2.04
Calif. Belle	199	40.6	5.64	65.9	1.58	17.1	2.41
Very Early	386	41.0	6.52	66.9	1.81	17.9	2.89
Early							
S-201	655	50.7	7.38	68.4	1.26	19.9	2.92
M-201	259	57.1	5.47	68.0	1.31	21.2	2.99
M-9	66	50.3	7.04	68.0	1.43	20.0	3.10
Early	980	52.4	7.45	68.3	1.30	19.8	3.01
M-302	25	58.3	5.25	69.0	1.20	20.7	2.29
Intermediate	25	58.3	5.25	69.0	1.20	20.7	2.29
M-7	22	60.7	2.92	69.3	1.45	22.6	2.50
Late	22	60.7	2.92	69.3	1.45	22.6	2.50

Table 5. Distribution of rice types in California (1984) and the head rice and moisture levels at harvest in major areas.

Location	Total lots	Percent of Cultivars VE	E	I	L	% Head rice ± SD	% Total rice ± SD	% Moisture ± SD
Orland	17	6	71	0	23	56.6±8.16	67.8±3.30	24.5±3.02
Chico	15	0	100	0	0	50.1±10.92	68.1±1.17	19.9±2.90
BUCRA (Butte Co.)	346	5	95	0	0	51.3±7.02	68.0±1.18	20.1±2.52
Willows	218	14	82	3	1	50.2±8.90	68.2±1.66	19.0±3.08
Colusa	176	19	62	10	9	53.7±8.00	68.6±1.56	19.7±2.90
Marysville	139	33	67	0	0	49.8±9.77	67.6±1.68	19.8±3.21
Sacramento	283	38	62	0	0	48.3±8.54	67.6±1.68	20.0±3.32
Davis	63	42	54	2	2	45.5±7.89	67.0±1.77	18.1±3.05
Stockton	9	100	0	0	0	36.8±5.92	68.2±1.10	18.6±2.07
Modesto	147	78	22	0	0	42.6±8.63	67.9±1.52	20.2±3.19
Overall	1413	26	70	2	2	49.5±8.91	67.9±1.60	19.8±3.08

Table 6. Average percent head rice and number of lots (in parentheses) of maturity groups at each location, RGA and BUCRA (1984).

	Very Early	Early	Interm.	Late	Location average
Orland	29.9(1)	57.9(12)	-	59.4(4)	56.6(17)
Chico	-	50.1(15)	-	-	50.1(15)
BUCRA	45.1(16)	51.7(330)	-	-	51.3(347)
Willows	40.1(31)	51.5(178)	59.1(7)	61.1(2)	50.2(218)
Colusa	42.4(34)	55.5(110)	58.4(17)	61.0(15)	53.7(176)
Marysville	40.5(46)	54.4(93)	-	-	49.8(139)
Sacramento	42.1(108)	52.2(175)	-	-	48.3(283)
Davis	39.1(27)	49.8(34)	52.9(1)	61.2(1)	45.5(63)
Stockton	36.8(9)	-	-	-	36.8(9)
Modesto	40.3(114)	50.4(33)	-	-	42.6(147)
Group Average	41.0(386)	52.4(980)	58.3(25)	60.7(22)	

Table 7. Average total milled rice and number of lots (in parentheses) for maturity groups at each location, RGA and BUCRA (1984).

	Very Early	Early	Interm.	Late	Location average
Orland	56.5(1)	68.1(12)	-	69.6(4)	67.8(17)
Chico	-	68.1(15)	-	-	68.1(15)
BUCRA	69.0(16)	68.0(330)	-	-	68.0(347)
Willows	66.2(31)	68.5(178)	68.9(7)	68.6(2)	68.2(218)
Colusa	66.6(34)	69.0(110)	69.2(17)	69.5(15)	68.6(176)
Marysville	65.8(46)	68.5(93)	-	-	67.6(139)
Sacramento	66.8(108)	68.1(175)	-	-	67.6(283)
Davis	65.4(27)	68.1(34)	66.5(1)	67.1(1)	67.0(63)
Stockton	68.2(9)	-	-	-	68.2(9)
Modesto	67.7(114)	68.6(33)	-	-	67.9(147)
Group Average	67.0(386)	68.3(980)	69.0(25)	69.3(22)	

Table 8. Average percent moisture and number of lots (in parentheses) for maturity groups at each location, RGA and BUCRA (1984).

	Very Early	Early	Interm.	Late	Location average
Orland	20.1(1)	24.6(12)	-	25.5(4)	24.5(17)
Chico	-	19.9(15)	-	-	19.9(15)
BUCRA	17.6(16)	19.8(330)			20.1(346)
Willows	17.4(31)	19.1(178)	20.8(7)	23.1(2)	19.0(218)
Colusa	17.1(34)	20.1(110)	20.6(17)	21.7(15)	19.7(176)
Marysville	17.6(46)	20.9(93)	-	-	19.8(139)
Sacramento	18.7(108)	20.8(175)	-	-	20.0(283)
Davis	16.5(27)	19.2(34)	20.6(1)	24.1(1)	18.1(63)
Stockton	18.6(9)	-	-	-	18.6(9)
Modesto	19.5(114)	22.4(33)	-	-	20.2(147)
Group Average	17.9(386)	19.7(980)	20.2(25)	22.5(22)	

Table 9. Average percent head rice, total rice, moisture content at harvest and the number of lots analyzed for each maturity group of rice from 1979 to 1984.

Years	Maturity Groups				All Varieties
	Very Early	Early	Intermediate	Late	
	% head rice (% total rice)				
1979	47.5 (67.8)	56.3 (69.2)	57.0 (68.4)	58.9 (69.5)	55.4 (68.9)
1980	48.5 (67.6)	54.6 (68.9)	57.1 (68.3)	58.4 (69.4)	54.7 (68.7)
1981	50.5 (67.4)	54.1 (68.7)	57.3 (68.7)	60.0 (69.5)	54.7 (68.4)
1982	49.9 (67.4)	53.5 (68.6)	57.5 (69.2)	58.0 (69.3)	52.7 (67.9)
1983	56.3 (68.6)	59.0 (69.0)	62.2 (70.0)	57.5 (68.3)	57.8 (68.6)
1984	41.0 (66.9)	52.4 (68.3)	58.3 (69.0)	60.7 (69.3)	49.5 (67.9)
	% moisture content (number of lots)				
1979	20.2 (245)	21.1 (851)	21.6 (58)	20.0 (752)	20.7 (1906)
1980	21.6 (122)	21.2 (1058)	22.8 (8)	20.7 (207)	21.3 (1395)
1981	22.1 (295)	21.3 (1319)	21.5 (22)	21.5 (231)	21.5 (1867)
1982	23.8 (437)	22.3 (1184)	21.9 (49)	21.7 (42)	22.7 (1712)
1983	22.5 (516)	23.6 (604)	24.3 (10)	25.0 (5)	23.2 (1135)
1984	17.9 (386)	19.8 (980)	20.7 (25)	22.6 (22)	19.8 (1413)

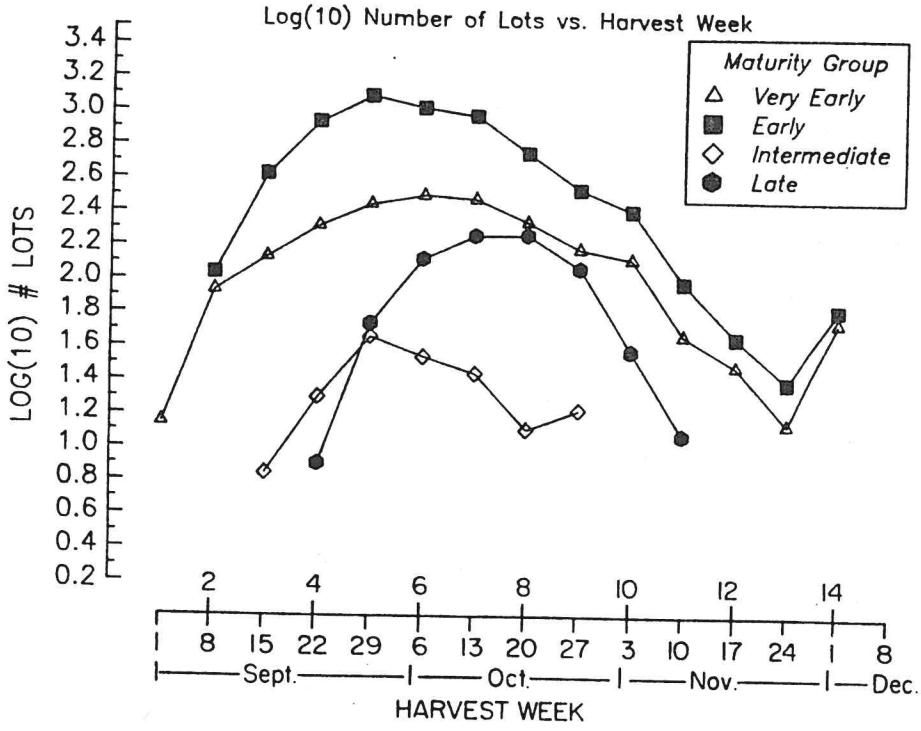

Figure 1. The distribution of harvesting time of rice for each maturity group during 1979-1984.

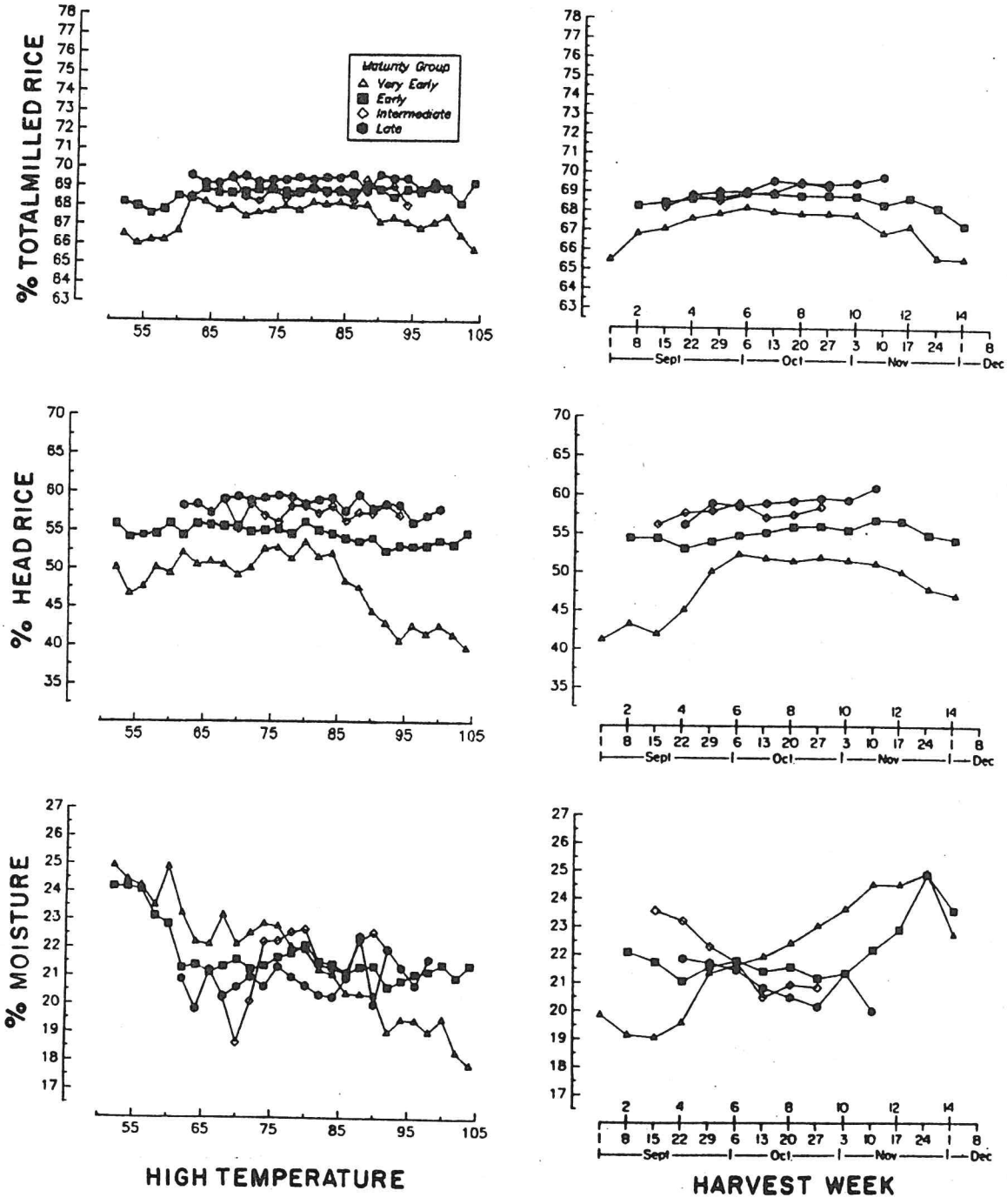

Figure 2. Percent total milled rice, percent head rice, and percent moisture content in the grain at each harvesting week and the average high temperature under which the crop was harvested.

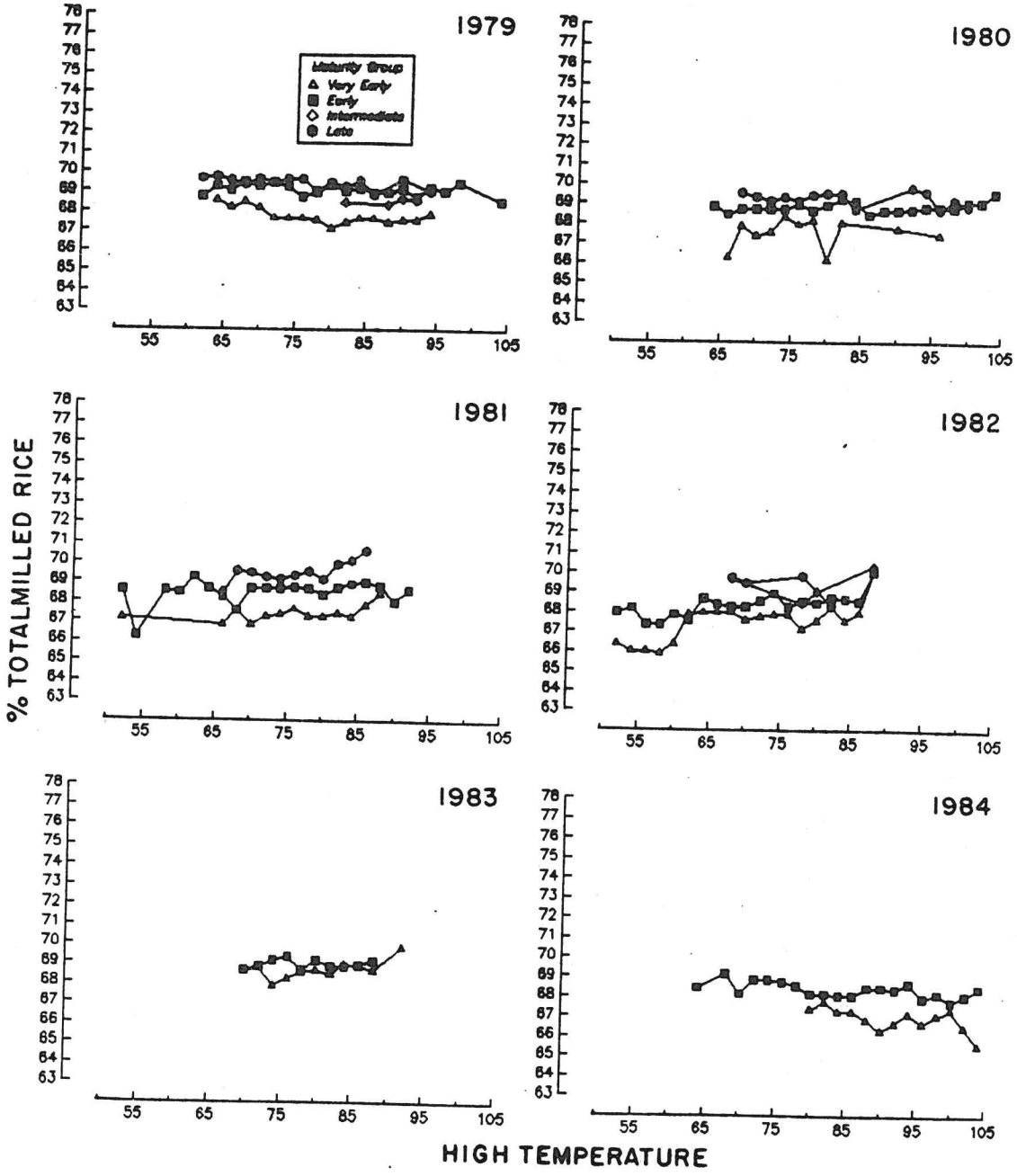

Figure 3. Percent total milled rice in relationship to the average high temperature at the harvesting time.

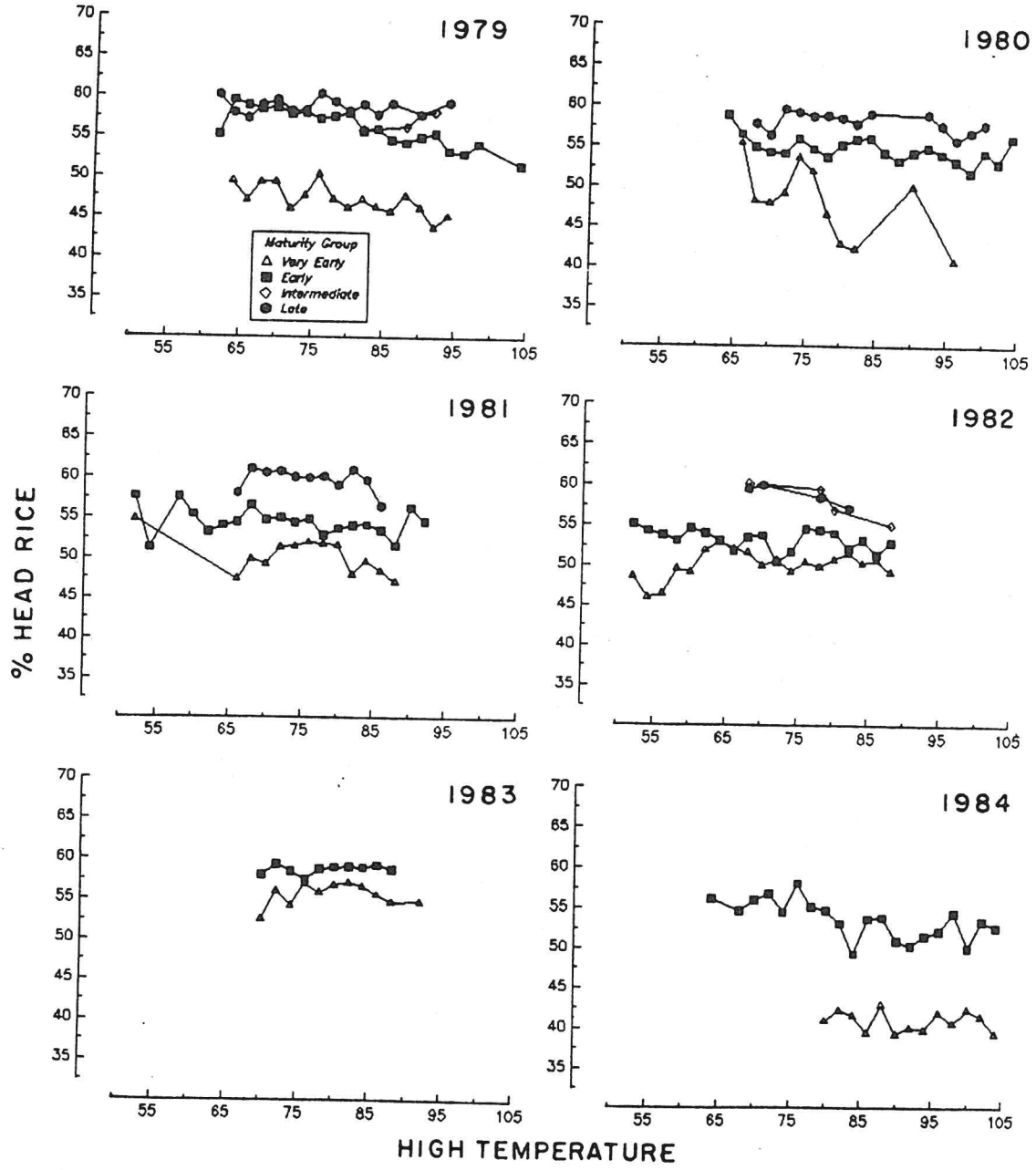

Figure 4. Percent head rice in relationship to the average high temperature at the harvesting time.

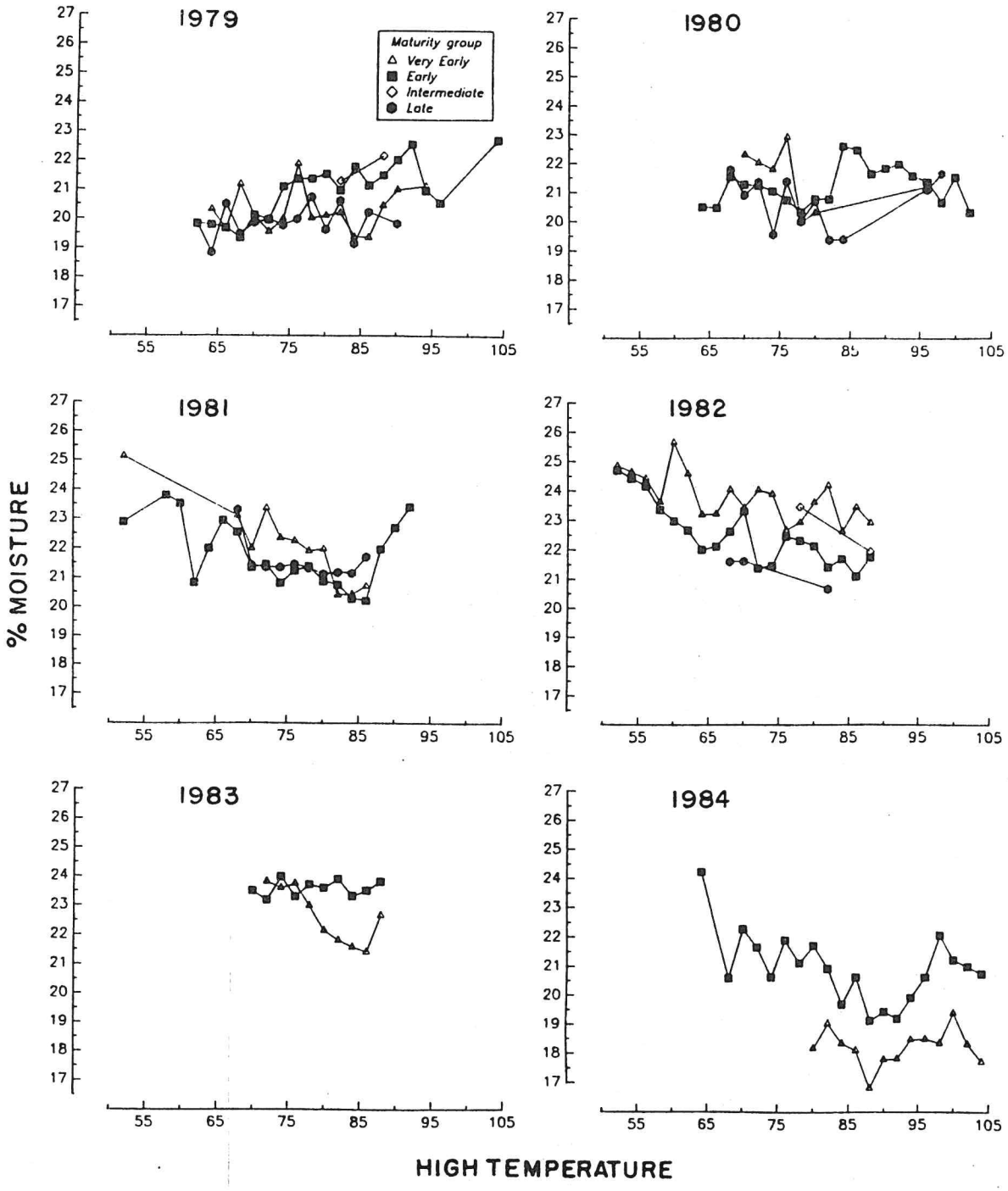

Figure 5. Percent moisture content in the grain in relationship to the average high temperature at the harvesting time.

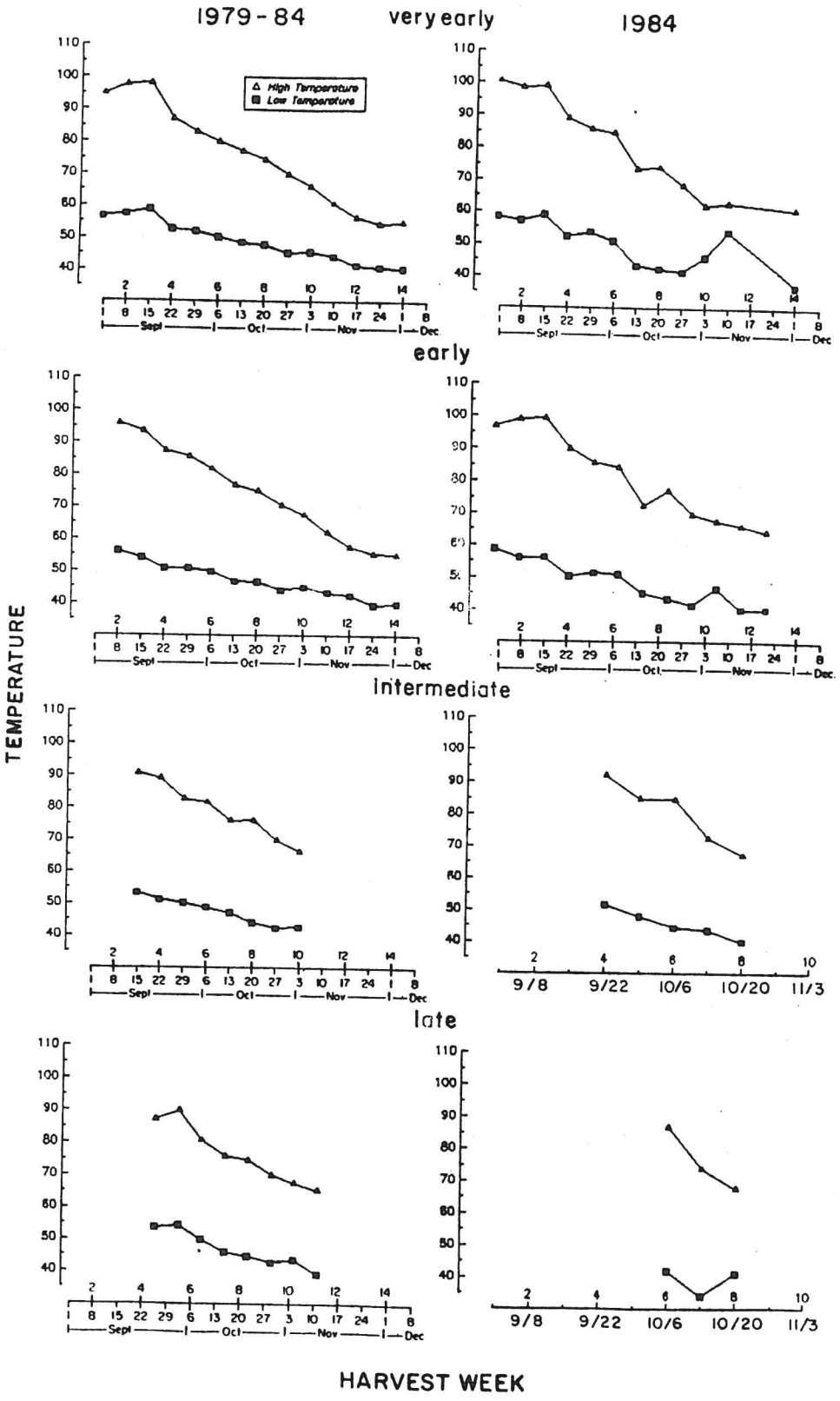

Figure 6. The average high and low temperatures at each harvesting time for the combined rice data of 1979-1984 and for 1984 data alone.

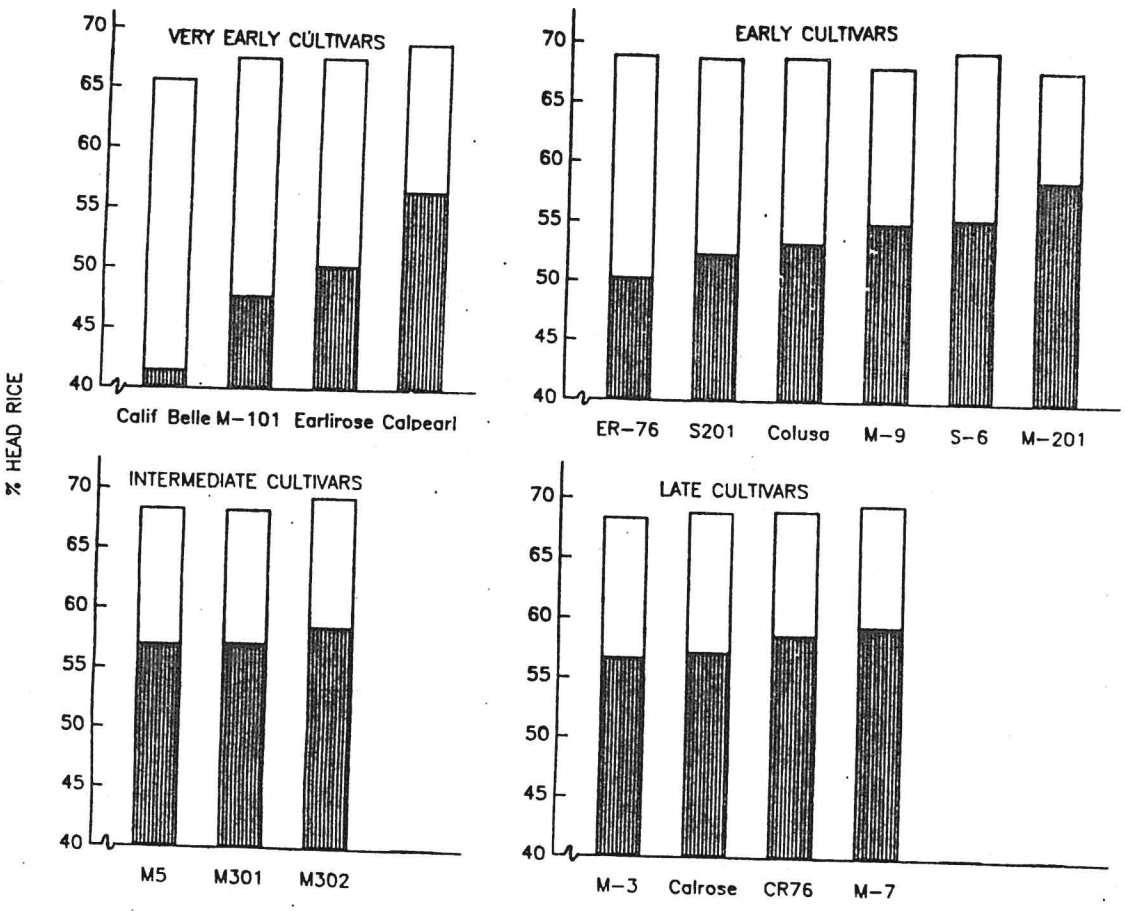

Figure 7. The average percent head rice (shaded bar) and the average total milled rice (unshaded bar) for each cultivar planted between 1979-1984.

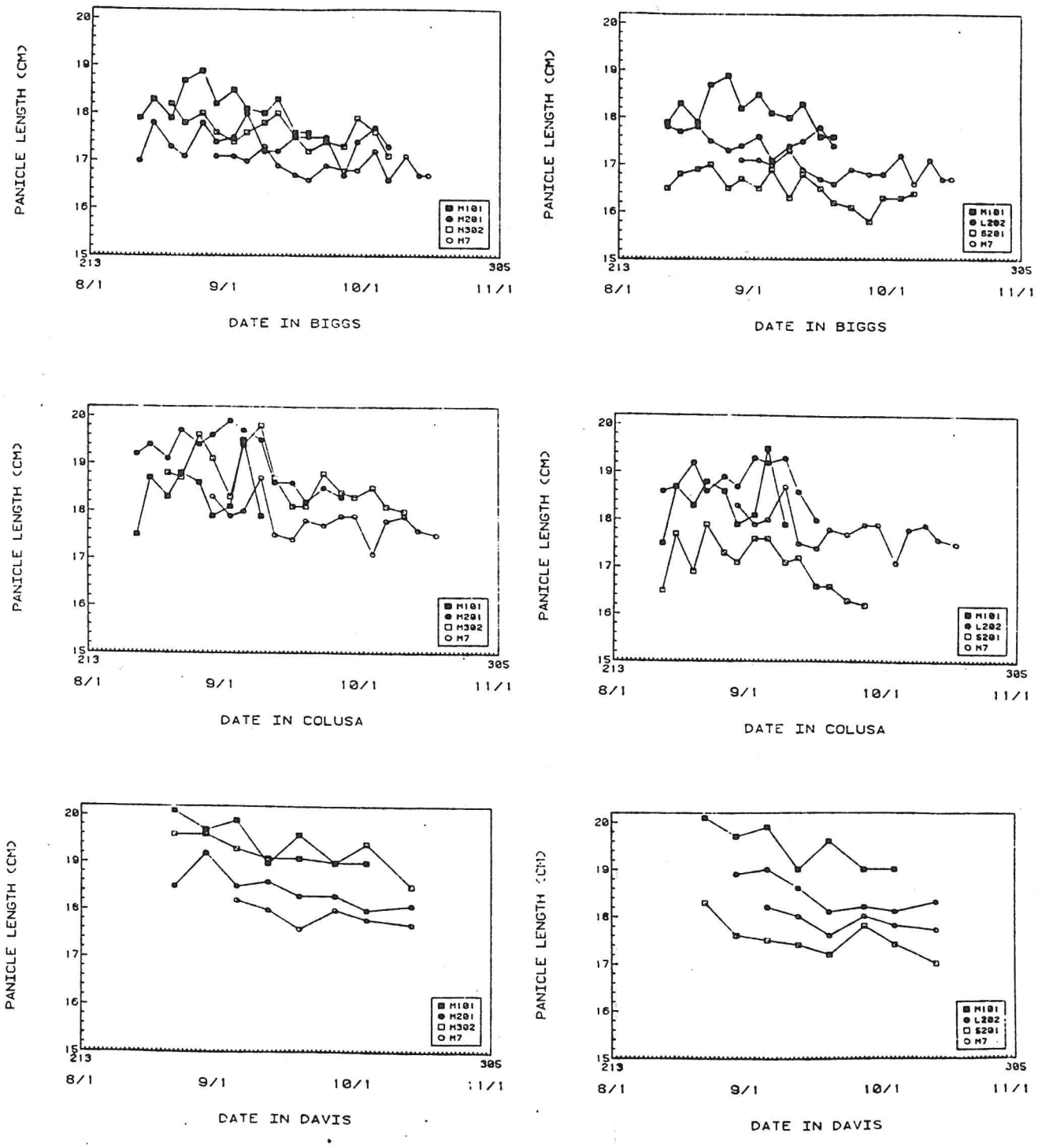

Figure 8. Average panicle length (cm) of six cultivars at three locations (1984 data).

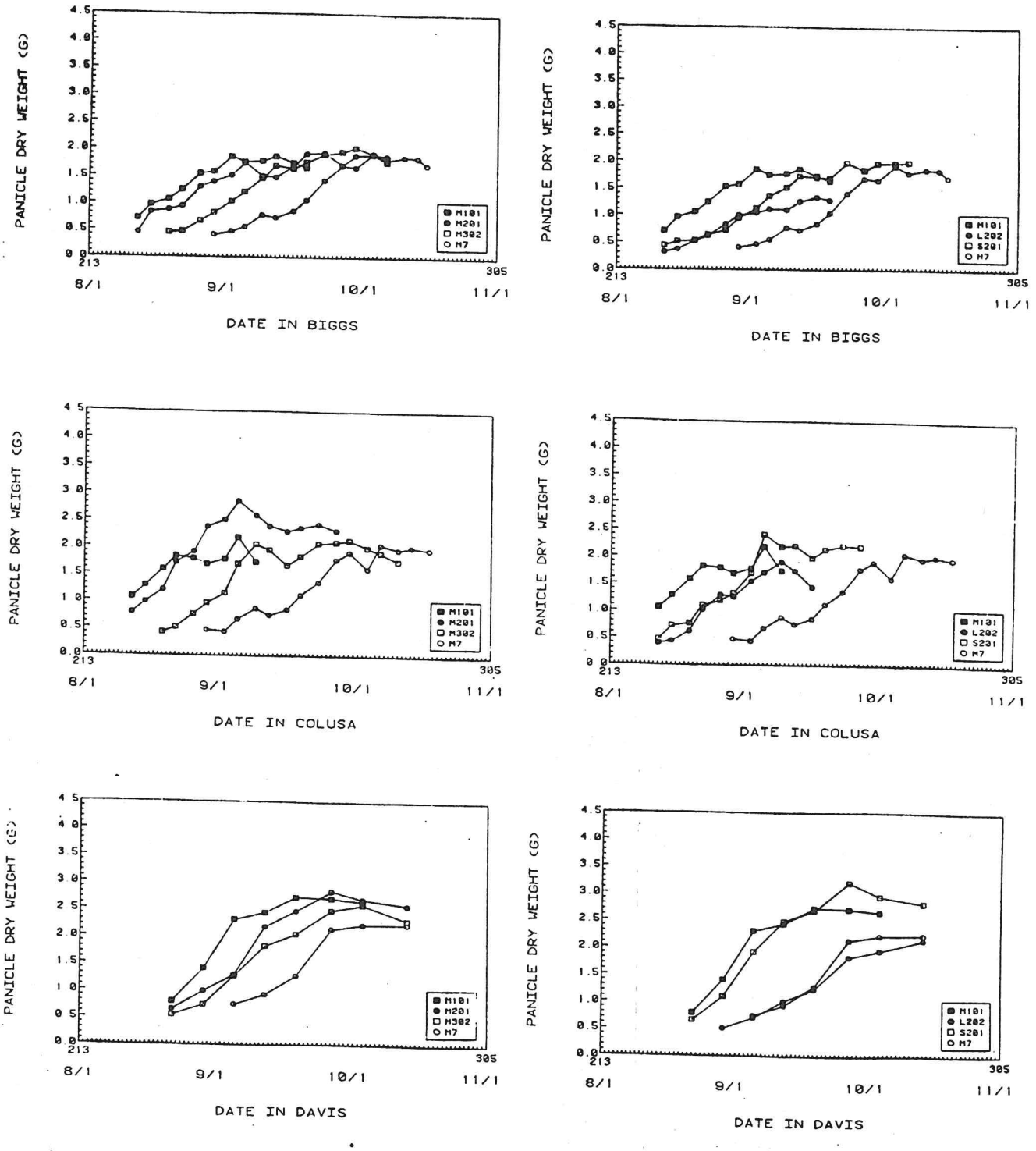

Figure 9. Average panicle dry weight (g) of six cultivars at three locations (1984 data).

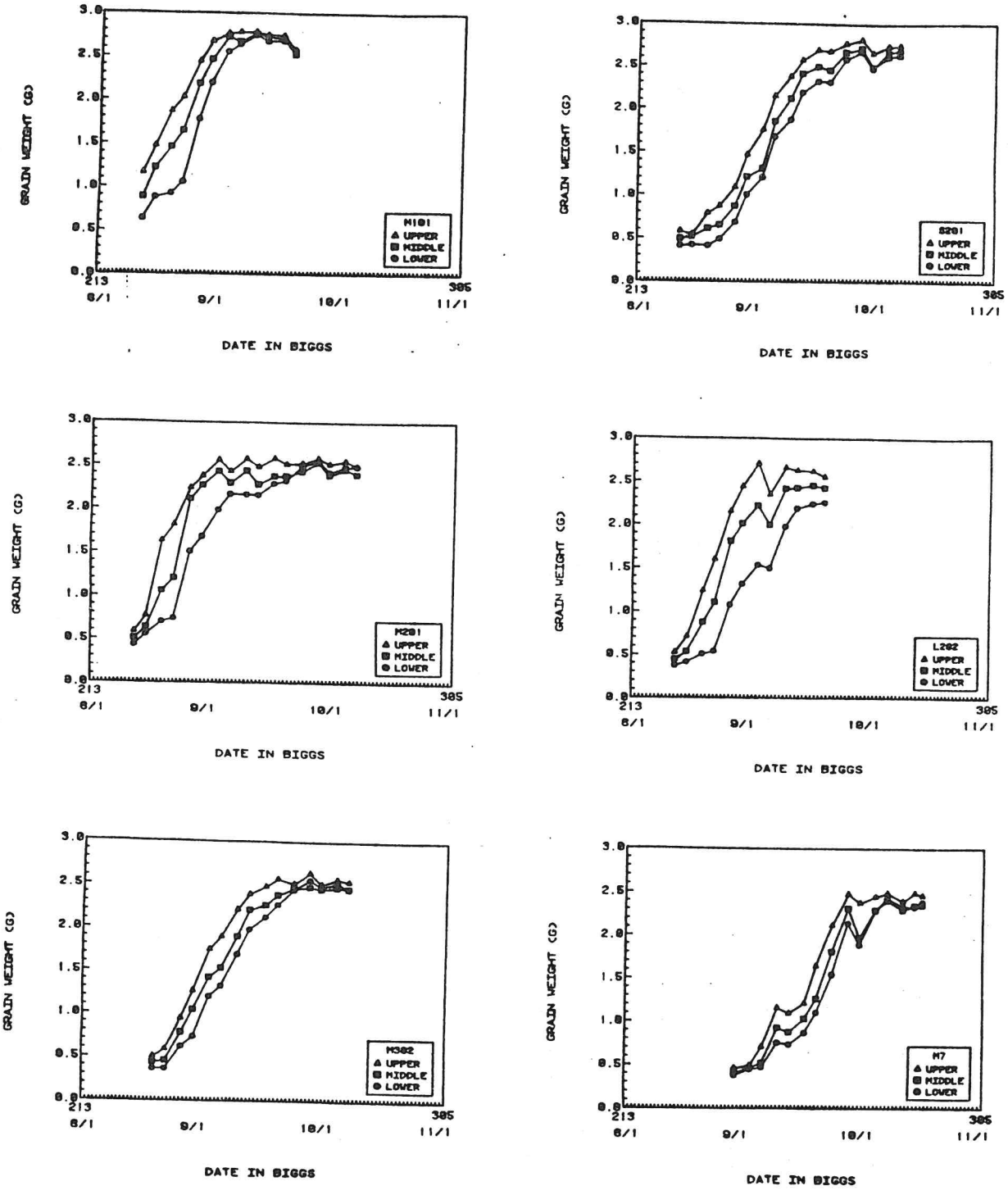

Figure 10. Grain-weight curves for three parts of panicles of six cultivars at Biggs (1984 data).

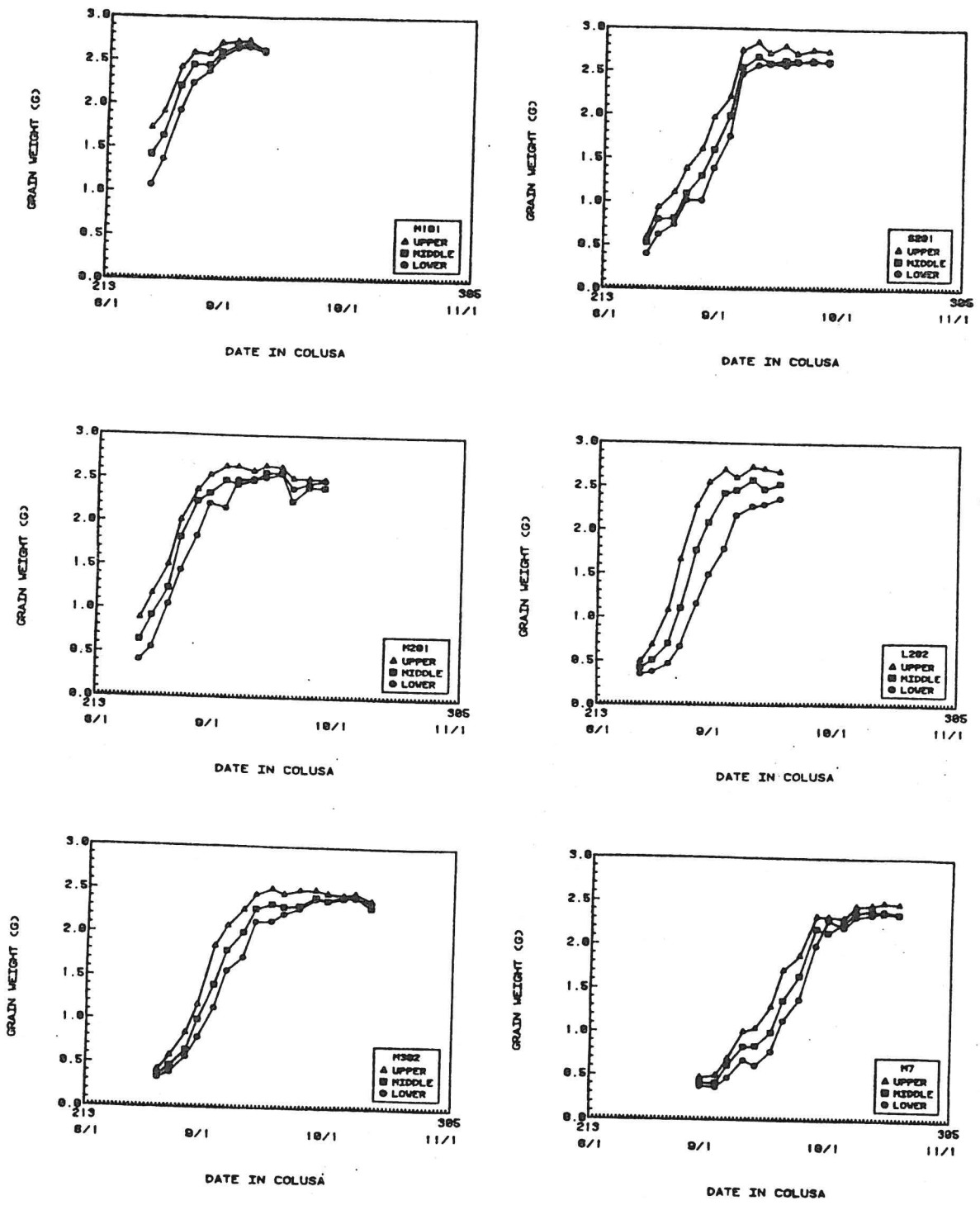

Figure 11. Grain-weight curves for three parts of panicles of six cultivars at Colusa (1984 data).

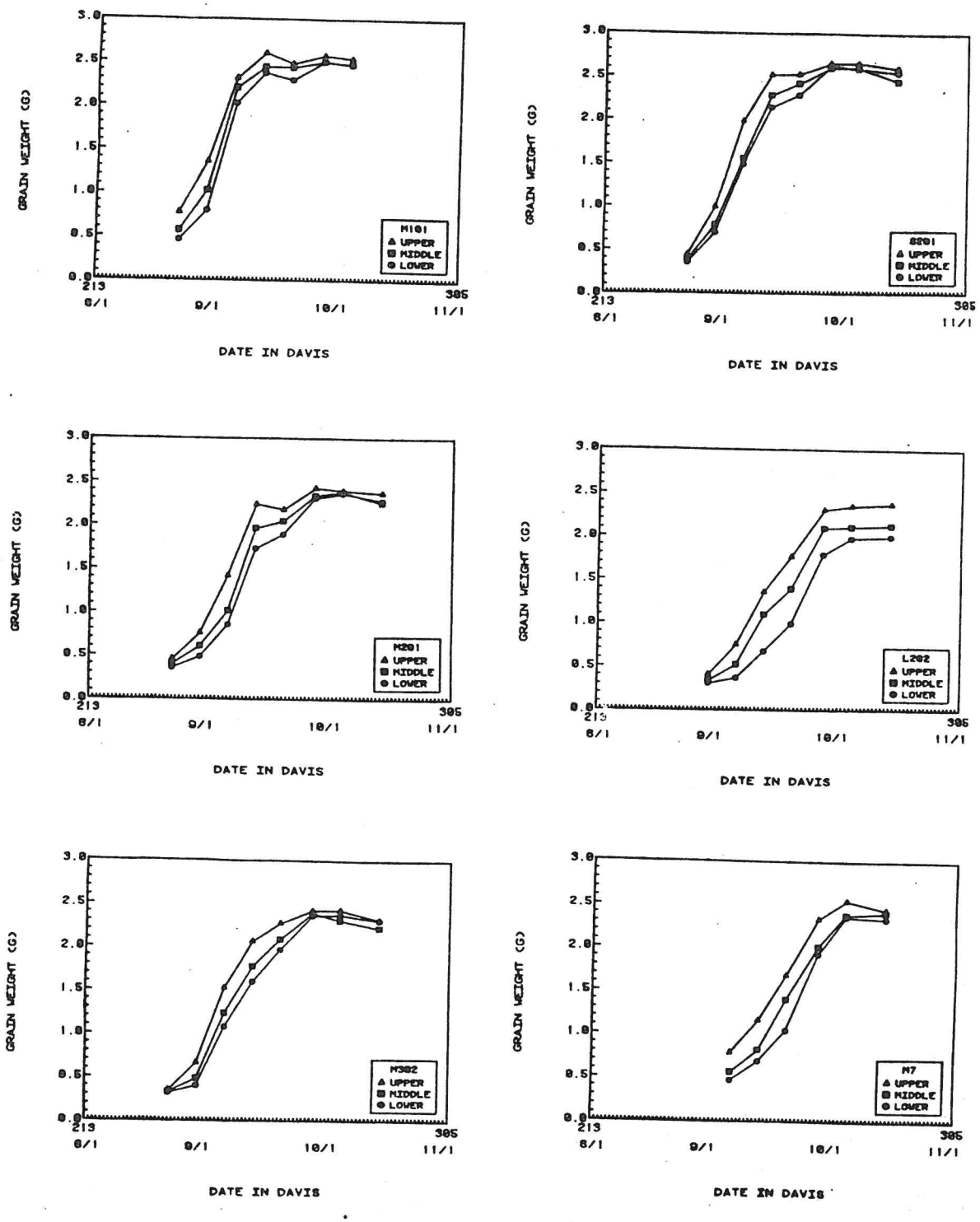

Figure 12. Grain-weight curves for three parts of panicles of six cultivars at Davis (1984 data).

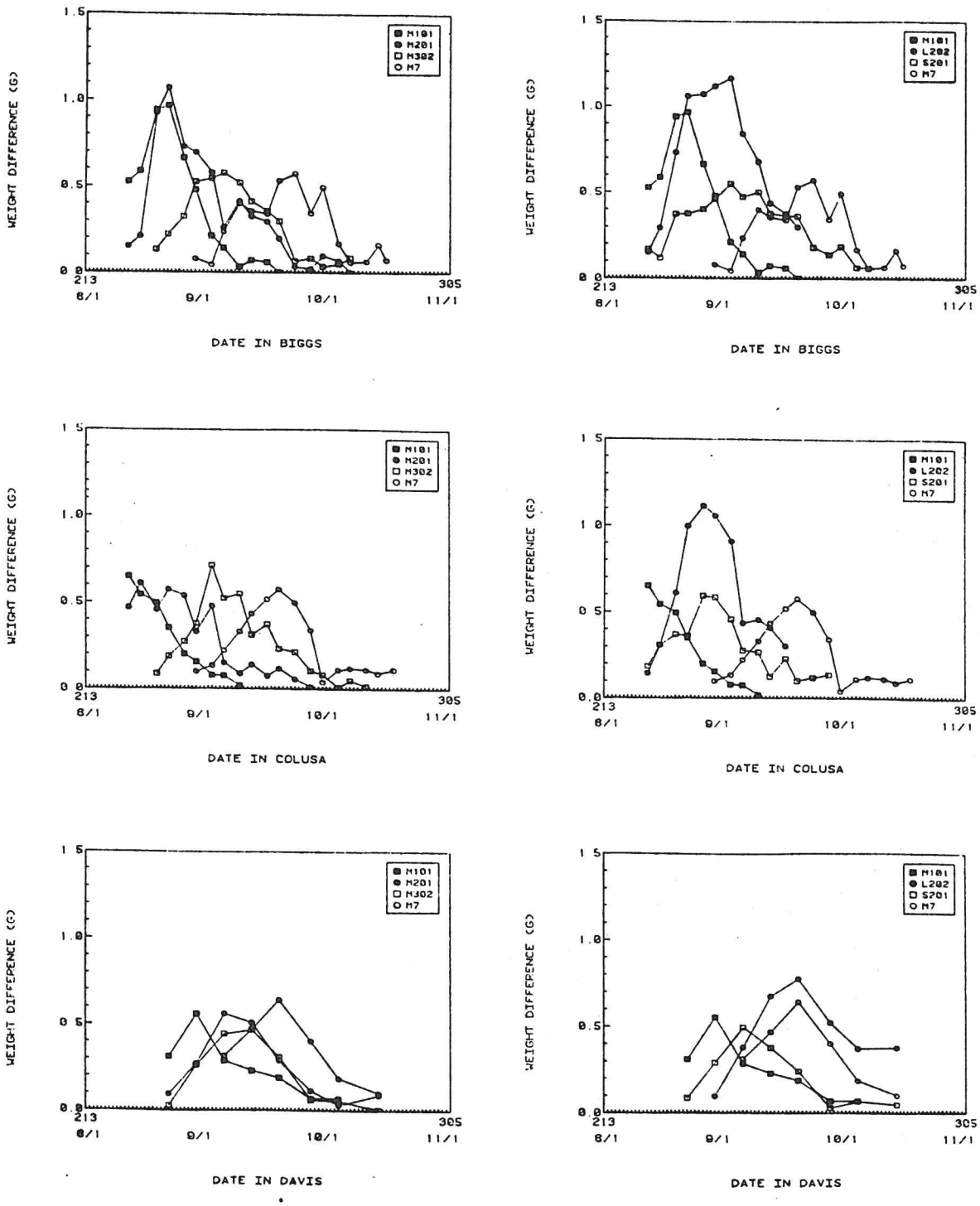

Figure 13. Grain weight difference between the upper and lower parts of panicles (1984 data).