A diallel analysis of the quantitative production characters in sweet peppers, *Capsicum annuum* L.

by

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DEDICATION

I dedicate this thesis to my late parents,

Minnie and George Ruffin

with eternal love and appreciation.

INTRODUCTION

The sweet green pepper, *Capsicum annuum* L., is a vegetable grown widely for its fruit. In the United States, the large, thick-fleshed sweet or nonpungent varieties are often used in salads or are stuffed and cooked. Nutritionally, peppers possess a high vitamin C content (1.5-1.8 mg/gm fresh weight) (14). This value is higher than that found in tomatoes (0.20-0.25 mg/gm). When compared with 22 principal vegetables grown in the United States, peppers rank 17th in total acreage and 15th in total value (30).

This study was undertaken to determine the inheritance of eight quantitative traits in peppers. The ideal sweet pepper should possess the following characteristics. Fruits should be blocky, about 4 inches long and equally wide. The apex should be 3- to 4-lobed. Flesh should be as thick as possible. The flavor should be mild (14). In order to breed for these characteristics, it is essential to know how they are inherited. In an attempt to show how the characters number of marketable pepper fruit, marketable pepper fruit weight, number of cull pepper fruit, cull pepper fruit weight, pepper fruit length, pepper fruit diameter, number of pepper lobes, and pepper fruit wall thickness are inherited, five different commercial bell pepper inbreds were crossed in a 5 x 5 parent half-diallel. The resulting F_1 seeds were used in this study.

REVIEW OF LITERATURE

Fruit Weight and Number

Soh et al. (28) found that both fruit weight and fruit number are controlled by additive gene action. Similar results were found by Silvetti and Giovannelli (22). In contrast, research by Khalf-Allah et al. (10) suggests that dominance gene effects were greater than additive effects for early yield, total yield, and number of fruits per plant, while additive gene effects were greater for the trait fruit weight. This was reflected by the high estimated values for the variance of specific combining ability (SCA) (0.01, 0.02, 665.56, and 95.64, respectively) (9).

Miyazawa (17) found that 52 genes control the inheritance of the trait fruit weight. A significant maternal effect was reported by Silvetti and Grassia (23) for average weight of fruits. Silvetti and Grassia (23) observed a significant paternal x maternal interaction for both average fruit weight and number of fruits per plant. Popova and Mihailov (19) observed that in the F_1 generation, large fresh weight and large absolute dry weight were inherited in an overdominant manner.

Singh and Singh (26) found heterosis for yield in peppers. In their work, a majority of the crosses showed duplicate epistasis. Singh et al. (27) observed heterosis in peppers for yield per plant and fruit number per plant. Rocchetta et al. (20) observed similar behavior for the traits yield and fruit number. Their results indicated that a significant negative correlation between fruit weight and number (-0.45, p = 0.05) was present only in intermediate yielding cultivars. In addition, they found that major yield components were fruit weight and fruit number. Lippert

(13) found heterosis for the traits percent mature fruit and dry weight per plant.

However, heterosis is not observed in all populations. Sakai (21) has established that total fruit weight per plant exhibited heterosis in some combinations, but not others. In general, few fruits per plant were inherited in an incompletely dominant manner. Soh et al. (28) found that, of all the traits studied, only the trait weight per fruit produced midparent heterosis.

Gill et al. (6) reported that populations having significant SCA effects for total yield also possessed significant SCA effects for both fruit weight and number of fruits per plant. Generally, high yielding parents were also high general combiners. The genetic diversity of the parents and the magnitude of heterosis in the F_1 were directly proportional.

Fruit Length, Width, Size, and Shape

Milkova (16) reported that both additive and dominant gene effects play a significant role in the control of pepper traits fruit length, width, and shape. Dale (2) discovered that the factors for fruit length have proportionate, rather than additive, effects. For example, in a cross between a 23.2 mm and a 159.9 mm long hot pepper, the F_2 and back-cross data produced normal curves when plotted logarithmically, and skewed curves when plotted on cartesian coordinates. Both Singh et al. (27) and Lippert (13) observed heterosis for fruit length. Soh et al. (28) observed midparent heterosis for fruit length and width.

Deshpande (4) observed a heterotic response for fruit width. In a cross between a wide (1.6 cm) and a narrow (1.2 cm) hot pepper, an F_1

population mean of 1.8 cm was produced. Width extremes in the F_2 population exceeded the parental values. Miyazawa (17) found that the number of genes controlling fruit width (9.5) was much greater than the number of genes controlling fruit length (0.79). He also calculated that only 1.1 genes control the fruit length/width ratio. Since the estimate of the number of genes controlling fruit length was small, the results suggest that some genes may produce pleiotropic effects.

Deshpande (4) concluded that short fruits were inherited as monogenic dominants. Transgressive segregation for both fruit length extremes was reported by Dempsey (3). Legg and Lippert (12) found that both fruit length and width data were continuously distributed.

Sakai (21) concluded that small fruit size was partially dominant over large fruit size. Kaiser (8) reported that fruit size was genetically determined by the geometric interaction of a number of size genes, but was subject to considerable modification by environmental factors.

Dempsey (3) revealed that fruit shape was controlled by the interaction of one incompletely dominant gene and the multiplicative effects of other loci. Kaiser (8) demonstrated that the ultimate pepper fruit phenotype depends on the interaction of genes governing the relative growth rates of its dimensions and genes controlling its absolute size. Their data suggest that a single major gene controlled the relative growth rates for fruit length and width in each cross population studied. In some populations, the relationship between the growth rates for fruit length and fruit width was constant. In others, it changed as growth proceeded. Silvetti and Grassia (23) have shown that fruit shape includes a large environmental component.

Fruit Wall Thickness

Milkova (16) reported that both additive and nonadditive gene effects exert statistically significant control over pericarp thickness in pepper. The vast majority of hybrids studied by Singh and Singh (25) showed a significant decrease in the shell portion, suggesting that this trait was controlled by negative nonadditive gene action. Deshpande (4) concluded that fruit wall thickness was inherited in a simple monogenic manner. Heterosis was manifested in the F_1 for this trait. Soh et al. (28) found only midparent heterosis. Fruit wall thickness was reported by Dempsey (3) to be controlled by eight pairs of genes with multiplicative, accumulative effects. Silvetti and Grassia (23) reported significant maternal and environmental effects for exocarp thickness. In contrast, the maternal x paternal interaction was not statistically significant at the 5 percent level.

An association between fruit thickness, yield per plant, and fruit length was observed by Singh et al. (27). Thick fruits showed complete dominance over thin fruits.

Number of Locules

Deshpande (4) found that locule number varied in fruits harvested from the same plant.

Seed Components

Omar and Lippert (18) showed that an increase in endocarp weight was generally associated with a decreased seed weight. Variability in fruit components among F_1 hybrids was predominantly attributable to general combining ability (GCA). Neither mean heterosis in hybrids nor mean squares for specific combining ability (SCA) were significant for any of the fruit components. GCA effects and GCA variances of parents for endocarp and seed components compared favorably with parental performance. Miyazawa (17) found that 6.5 genes control the number of seeds in peppers. Popova and Mihailov (19) reported that the traits 1000 seed weight and embryo size were inherited over-dominantly (above heavy seed parent and large embryo parent) in the F_1 generation. Significant low-parent heterosis was found by Singh and Singh (25) for seed weight in peppers.

MATERIALS AND METHODS

Procedures

Five sweet pepper inbreds from commercial seed companies were used in this study. The soil mixture used consisted of one part perlite, one part peat, and one part field soil. Seeds were planted in 2-gallon round plastic pots and placed in the greenhouse during August, 1979. Most seeds germinated within 14 days after seeding. Flowering occurred 59 to 60 days after germination.

When plants reached 1.5 feet tall, they were bound to wooden stakes using twistems. Temik 15G was used monthly at a rate of 0.31 g/sq m to control thrips. To control aphids, the plants were sprayed weekly with Pirmor at a rate of 0.60 g/ℓ. Plants were watered daily using an automatic trickle system. Fertilizer (20-20-20) was applied to plants once a week at a rate of 200 ppm. The greenhouse temperature was set at 80°F (26.6°C).

One half of all possible crosses between five inbreds, 'Fordhook,' 'Golden Calwonder', 'Calwonder 300', 'Pip', and 'Delaware Belle', were made during the fall and winter of 1979. A half diallel table illustrating the crossing scheme can be found in Table 1. Pollination began when two cultivars passed anthesis. Fresh pollen was collected daily and kept in five small, colored, plastic containers. Extra pollen was held at 65°F (18.3°C). Toward the end of the pollination period, some cultivars failed to produce flowers. When this occurred, pollen as old as one week was used. Fruits were harvested at the mature red stage 60 days after pollination. Seeds were removed and air-dried prior to storage. Fifteen plant populations were produced. Five were parental self-pollinations, while 10 were F_1

populations. Seeds of these populations were treated with Arasan SF-X fungicide, and planted in 6 cm^2 (2.25 in^2) peat pots on April 15, 1980. Soil mix composition and greenhouse temperature were the same as noted previously. The seedlings were exposed to a natural daylength. Seedlings were transferred to the Horticulture Station two weeks before transplanting. Growing conditions were changed to provide a hardening period. Six week old seedlings were transplanted to the field on May 28, 1980.

Table 1. 5x5 half-diallel

		Female parent				
		Fordhook (F)	Golden Calwonder (GC)	Calwonder 300 (CW)	Pip (P)	Delaware Belle (DB)
Male parent	Fordhook	Self-poll.	GC x F	CW x F	P x F	DB x F
	Golden Calwonder		Self-poll.	CW x GC	P x GC	DB x GC
	Calwonder 300			Self-poll.	P x CW	DB x CW
	Pip				Self-poll.	DB x P
	Delaware Belle					Self-poll.

Prior to transplanting, the field was plowed. Six hundred sixty-six pounds of 15-15-15 were applied per acre. Treflan 4 EC was applied at a rate of 1.2ℓ per acre. Both the fertilizer and the herbicide were pre-plant incorporated one week prior to transplanting. The field was marked to produce a grid 0.9 m (3 ft) between rows and 0.5 m (20 in) between plants within rows. Pepper populations were transplanted into a randomized complete block design where each of the 15 plant populations was represented by 7 plants per plot in 4 replications. A total of 420 plants were planted. Plots were cultivated as needed.

Mature green fruits were hand harvested from each plant 55 (July 22), 76 (August 12), and 89 (August 25) days after transplanting. All fruits were weighed in pounds and both marketable and cull weights were obtained for each of the 420 plants in this experiment on the day of harvest. In addition, the number of marketable fruit and culls and the mean number of lobes per fruit were recorded. The next day, data were collected from a five-fruit sample for fruit length, diameter, and wall thickness.

Statistical Analysis

In this study, the diallel data were analyzed using methods developed by Griffing (7). Griffing's terminology may be expressed as follows:

σ^2_{gca} = general combining ability variance;

σ^2_{g} = variance component of general combining ability;

σ^2_{sca} = specific combining ability variance;

σ^2_{s} = variance component of specific combining ability;

σ^2_{G} = genotypic variance;

σ^2_{p} = phenotypic variance;

σ^2_e = sampling error variance;

σ^2_a = additive genetic variance.

In the analysis of variance tables for individual plant data, Griffing's terminology for expectations may be expressed as follows:

a = number of crosses = 10;

b = number of replications = 4;

c = number of plants per plot = 7;

v = crosses

$$\phi(b) = \frac{1}{b-1} \sum_k b_k^2;$$

$$\phi(v) = \frac{1}{a-1} \sum_i v_i^2;$$

$$\phi(bv) = \frac{1}{(a-1)(b-1)} \sum_{i<j} \sum_k (bv)_{ijk}^2.$$

Heritability for the mean plant data was estimated using the following formulas:

narrow sense heritability = $\hat{h}^2 = \sigma^2_a / \sigma^2_p$, and

broad sense heritability = $\hat{H} = \sigma^2_G / \sigma^2_p$.

The model of random effects used in this study to analyze for the combining ability may be expressed as

$$X_{ij} = u + g_i + g_j + s_{ij} + 1/b(\sum_k b_k) + 1/b[\sum_k (bv)_{ijk}] + 1/bc(\sum_{kl}\sum e_{ijkl}),$$

where

x_{ij} = the population mean of a cross between the i^{th} and j^{th} lines;

u = the total population mean;

g_i and g_j = the general combining ability effects of the i^{th} and j^{th} lines, respectively;

s_{ij} = the specific combining ability effect of line i with line j, such that $s_{ij} = s_{ji}$;

b = the number of replications;

c = the number of plants per plot; and

e_{ijkl} = the error effect peculiar to the l^{th} individual of the k^{th} replication of a cross between the i^{th} and j^{th} lines.

General combining ability (g_i) for each line was estimated as

$$\hat{g}_i = \frac{1}{p(p-2)} [pX_{i.} - 2X..],$$

where

p = number of parental lines;

x_{ij} = the mean of each cross averaged over replications;

$X_{i.}$ = the sum of x_{ij} for the i^{th} parental array; and

$X..$ = the sum of all x_{ij} .

The estimated variance for each g_i was:

$$\hat{\sigma}^2_{gca} = (g_i)^2 - \frac{(p-1)}{p(p-2)} \sigma^2 .$$

Specific combining ability (s_{ij}) was estimated as:

$$\hat{s}_{ij} = x_{ij} - \frac{1}{p-2}(X_{i.} + X_{.j}) + \frac{2}{(p-1)(p-2)} X_{..},$$

where

$X_{.j}$ = the sum of x_{ij} for the j^{th} parental array.

The estimated variance for each s_{ij} was:

$$\hat{\sigma}^2_{sca} = \frac{1}{p-2} \sum_{i \neq j} s_{ij}^2 - (p-3)\sigma^2 / (p-2).$$

Sums of squares for general (GCA) and specific (SCA) combining ability may be expressed as:

Source	Degrees of freedom	Sum of squares
GCA	p-1	$\sum_i X_{i.}^2 / (p-2) - 4X_{..}^2 / [p(p-2)]$
SCA	p(p-3)/2	$\sum_{i<j} \sum x_{ij}^2 - \sum X_{i.}^2/(p-2) + 2X_{..}^2/[(p-1)(p-2)]$.

The expected mean squares for GCA and SCA assuming a completely random model are as follows:

Source	EMS
GCA	$\sigma^2 + \sigma^2_{sca} + (p-2)\sigma^2_{gca}$
SCA	$\sigma^2 + \sigma^2_{sca}$
Error	σ^2 .

The standard error for σ^2_{gca} was estimated as

$$\{[2/(p-2)^2][MS^2_{gca}/(P+1) + MS^2_{sca}/(2+\overline{pp-3}/2)]\}^{\frac{1}{2}}.$$

The standard error for $_{sca}$ was estimated as

$$2\{MS^2_{sca}/(2+\overline{pp-3}/2) + (\sigma^2_e + c\sigma^2_{bv})/[(b-1)(a-1) + 2]\}$$

where

MS_{gca} = the mean square for general combining ability;

MS_{sca} = the mean square for specific combining ability; and

σ^2_{bv} = the variance of the replication by cross interaction using individual plant data.

The direction of dominance was calculated as:

$$DD = \overline{X} - mp$$

where

$\overline{X}$ = mean of a cross, and

mp = midparent value.

Approximate standard deviation of the direction of dominance was calculated using the rules of linear function variance as described by Steel and Torrie (29) as follows:

$$V(v-mp) = V(v) + V(mp),$$

where

v = value of a cross, and

mp = midparent value.

High-parent heterosis (H') and its standard deviation ($\sqrt{V(H')}$) were calculated according to Bailey et al. (1) as:

$$H' = (SCF1 - HP) / (HP),$$

where

SCF 1 = a single cross F_1 population mean, and

HP = the population mean of the high parent.

Sampling variance for high-parent heterosis was estimated as:

$$V(H') = 1/n(\sigma/HP)^2[2+2H'+(H')^2],$$

where

n = the number of replications, and

σ = the experimental error standard deviation.

RESULTS AND DISCUSSION

Number of Marketable Pepper Fruit per Plant

First harvest

An analysis of variance table based on a fixed model using individual plant data from F_1 plots is presented in Table 2. There was no significant difference among crosses for number of marketable pepper fruit, first harvest. The number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for number of marketable pepper fruit, first harvest, are presented in Table 3. The direction of dominance values are generally positive, which means that the F_1 population means were larger than their midparent means for this trait. No significant differences were found between F_1 population means and their respective midparent means. This suggests that gene action is primarily additive. There is no significant high-parent heterosis for this trait in the first harvest.

No significant differences among general or specific combining ability effects were observed. No significant difference was observed between parent or F_1 means when a Duncan's Multiple Range Test was applied.

To determine how much of the phenotypic variability was genetic, heritability estimates were produced. Heritability estimates can be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. Genotypic variance was estimated as $\sigma^2_G = 2\sigma^2_g + \sigma^2_s = 0.02$. Phenotypic variance was estimated as $\sigma^2_p = \sigma^2_G + \sigma^2_e = 0.69$. Additive genetic variance was estimated as $\sigma^2_a = 2\sigma^2_g = 0.003$. Heritability estimates may now be produced. A broad sense heritability estimate was

Table 2. Analysis of variance of individual plant data for the trait number of marketable pepper fruit, first harvest

Source	Degrees of freedom	Mean square	Expectations		F^a
			Random model	Fixed model	
Replications	3	0.97	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	1.27
Cross	9	0.69	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	0.91
Cross*Replications	23	0.52	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	0.68
Error	120	0.76	σ^2_e	σ^2_e	
Total[b]	155				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 155 due to missing data.

Table 3. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait number of marketable pepper fruit per plant, first harvest

Cross	Number of plants (n)	Mean ($\overline{x}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{x}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	9	1.11	0.78	--	--	--	--
Golden Calwonder x Golden Calwonder	13	1.23	0.44	--	--	--	--
Calwonder 300 x Calwonder 300	3	1.00	0.00	--	--	--	--
Pip x Pip	11	1.18	0.60	--	--	--	--
Delaware Belle x Delaware Belle	8	1.25	0.46	--	--	--	--
Golden Calwonder x Fordhook	22	1.41	1.01	1.17	0.24	0.15	0.29
Calwonder 300 x Fordhook	10	1.00	0.67	1.05	-0.05	-0.10	0.42
Calwonder 300 x Golden Calwonder	17	1.12	0.86	1.11	0.01	-0.09	0.40
Pip x Fordhook	13	1.38	0.65	1.14	0.24	0.17	0.46
Pip x Golden Calwonder	17	1.18	0.63	1.20	-0.02	-0.04	0.41
Pip x Calwonder 300	12	1.08	0.29	1.09	-0.01	-0.08	0.41
Delaware Belle x Fordhook	19	1.21	1.08	1.18	0.03	-0.03	0.39
Delaware Belle x Golden Calwonder	23	1.65	1.07	1.24	0.41	0.32	0.47
Delaware Belle x Calwonder 300	4	1.25	0.50	1.12	0.13	0.00	0.40
Delaware Belle x Pip	19	1.10	0.74	1.21	-0.11	-0.12	0.37

Table 4. Analysis of variance of individual plant data for the trait number of marketable pepper fruit, second harvest

Source	Degrees of freedom	Mean square	Expectations		F[a]
			Random model	Fixed model	
Replications	3	1.55	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	0.50
Cross	9	20.50	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	6.63**
Cross*Replications	27	3.88	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.25
Error	206	3.09	σ^2_e	σ^2_e	
Total[b]	245				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 245 due to missing data.

**Significant at the 1 percent level.

Table 5. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait number of marketable pepper fruit per plant, second harvest

Cross	Number of plants (n)	Mean ($\bar{x}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{x}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	27	4.37	2.07	--	--	--	--
Golden Calwonder x Golden Calwonder	22	1.95	1.43	--	--	--	--
Calwonder 300 x Calwonder 300	7	0.86	0.90	--	--	--	--
Pip x Pip	16	1.31	1.30	--	--	--	--
Delaware Belle x Delaware Belle	20	1.80	1.00	--	--	--	--
Golden Calwonder x Fordhook	25	2.20	1.87	3.16	-0.96	-0.50	0.24
Calwonder 300 x Fordhook	27	3.11	1.69	2.61	0.50	-0.29	0.26
Calwonder 300 x Golden Calwonder	21	2.19	1.54	1.40	0.79	0.12	0.75
Pip x Fordhook	27	2.63	1.73	2.84	-0.21	-0.40	0.26
Pip x Golden Calwonder	22	1.64	1.53	1.63	0.01	-0.16	0.65
Pip x Calwonder 300	20	2.45	1.88	1.08	1.37	0.87	1.59
Delaware Belle x Fordhook	28	4.64	2.31	3.08	1.56**	0.06	0.33
Delaware Belle x Golden Calwonder	26	2.61	2.06	1.87	0.74	0.34	0.84
Delaware Belle x Calwonder 300	25	2.80	1.68	1.33	1.47*	0.55	1.01
Delaware Belle x Pip	25	1.48	1.08	1.55	-0.07	-0.18	0.71

*Significant at the 5 percent level.

**Significant at the 1 percent level.

calculated as $H = \sigma^2_G / \sigma^2_p$ = 3 percent, while a narrow sense heritability estimate was calculated as $h^2 = \sigma^2_a / \sigma^2_p$ = 3 percent.

Second harvest

A fixed model analysis of variance table based on individual F_1 plant data is presented in Table 4. A highly significant difference was observed between F_1 populations for the trait number of marketable pepper fruit, second harvest. The number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for number of marketable pepper fruit, second harvest, are presented in Table 5. The direction of dominance values are primarily positive, suggesting that the F_1 populations yielded more fruit than their respective midparent population means. Two F_1 population means significantly exceeded their respective midparent values, suggesting that partial dominance for many fruit is present. However, additive genetic effects appear to predominate. No significant high-parent heterosis was observed for this trait during this harvest period.

The analysis of variance for general and specific combining ability is presented in Table 6.

Table 6. Analysis of variance for general and specific combining ability for the trait number of marketable pepper fruit, second harvest

Source	Degrees of freedom	Mean square	F[a]
GCA	4	1.16	2.47
SCA	5	0.47	3.36*
Error	28	0.14	

[a]Random model assumed.

*Significant at the 5 percent level.

Significant differences were found among specific combining ability estimates. This suggests that some combinations produced significantly more than others. Estimates of general and specific combining ability effects and their associated variances are presented in Tables 7 and 8. The parents 'Fordhook' and 'Delaware Belle' were much better general combiners than 'Pip', 'Golden Calwonder', or 'Calwonder 300'. Parent and F_1 means for number of marketable pepper fruit per plant, second harvest, are listed in Table 9. The data suggest that 'Fordhook' produced significantly more peppers during this harvest period when compared with the other parents. Within F_1 populations, the population 'Delaware Belle' x 'Fordhook' significantly outproduced other F_1 populations. In contrast, the population 'Delaware Belle' x 'Pip' produced significantly fewer fruit.

To determine how much of the phenotypic variability was genetic, heritability estimates were produced. Heritability estimates can be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 6). The genotypic variance was estimated as $\sigma^2_G = 2\sigma^2_g + \sigma^2_s = 0.79$. Phenotypic variance was estimated as $\sigma^2_p = \sigma^2_G + \sigma^2_e = 3.64$. Additive genetic variance was estimated as $\sigma^2_a = 2\sigma^2_g = 0.46$. From the estimates above, broad sense heritability was calculated as $H = \sigma^2_G / \sigma^2_p$ = 22 percent, while narrow sense heritability was calculated as $h^2 = \sigma^2_a / \sigma^2_p$ = 13 percent.

Third harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots suggests that significant differences between F_1

Table 7. Estimates of general combining ability and their associated variances for the trait number of marketable pepper fruit, second harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.76	54.75
Golden Calwonder	-0.55	27.24
Calwonder 300	0.08	2.37
Pip	-0.70	45.99
Delaware Belle	0.41	13.80

[a] $\sigma^2 g_i$ = 0.23, S.E. = 0.27.

[b] Multiply by 10^{-2} for actual values.

Table 8. Estimates of specific combining ability and their associated variances for the trait number of marketable pepper fruit, second harvest

Parent	Specific combining ability (s_{ij}) [a]				σ^2_{sca} [b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	-0.58	-0.31	-0.01	0.89	33.29
Golden Calwonder		0.08	0.32	0.18	8.38
Calwonder 300			0.49	-0.27	6.32
Pip				-0.81	25.76
Delaware Belle					44.25

[a] $\sigma^2 s_{ij}$ = 0.36, S.E. = 2.12.

[b] Multiply by 10^{-2} for actual values.

Table 9. Parent and F_1 means for the trait number of marketable pepper fruit per plant, second harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		2.20 bcd	3.11 b	2.63 bc	4.64 a	4.37 a
	Golden Calwonder			2.19 bcd	1.64 cd	2.61 bc	1.95 b
	Calwonder 300				2.45 bcd	2.80 bc	0.86 b
	Pip					1.48 d	1.31 b
	Delaware Belle						1.80 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 10. Analysis of variance of individual plant data for the trait number of marketable pepper fruit, third harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	7.67	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	3.72
Cross	8	5.48	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	2.66*
Cross*Replications	14	4.00	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.94
Error	48	2.06	σ^2_e	σ^2_e	
Total[b]	73				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 73 due to missing data.

*Significant at the 5 percent level.

Table 11. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait number of marketable pepper fruit per plant, third harvest

Cross	Number of plants (n)	Mean ($\bar{x}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{x}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	17	2.18	1.43	--	--	--	--
Golden Calwonder x Golden Calwonder	1	1.00	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	1	0.00	0.00	--	--	--	--
Pip x Pip	1	2.00	0.00	--	--	--	--
Delaware Belle x Delaware Belle	3	1.67	0.58	--	--	--	--
Golden Calwonder x Fordhook	6	1.50	1.52	1.59	-0.09	-0.31	0.56
Calwonder 300 x Fordhook	12	3.58	2.35	1.09	2.49	0.64	0.88
Calwonder 300 x Golden Calwonder	2	1.50	0.71	0.50	1.00	0.50	1.80
Pip x Fordhook	7	1.00	0.58	2.09	-1.09	-0.50	0.56
Pip x Golden Calwonder	6	2.00	1.41	1.50	0.50	0.00	0.71
Pip x Calwonder 300	0	0.00	0.00	0.50	-0.50	-1.00	0.50
Delaware Belle x Fordhook	17	2.06	2.07	1.92	0.14	-0.05	0.63
Delaware Belle x Golden Calwonder	8	1.37	0.74	1.33	0.04	-0.18	0.77
Delaware Belle x Calwonder 300	6	2.00	1.55	0.83	1.17	0.20	0.94
Delaware Belle x Pip	10	1.60	0.97	1.83	-0.23	-0.20	0.64

population means exist (Table 10). Various parent and F_1 population statistics are presented in Table 11. The direction of dominance values are primarily positive, suggesting that the F_1 populations yielded more fruit than their respective midparent populations. No significant differences were found between F_1 population means and their associated midparent means. This suggests that dominant gene action is absent and additive gene action predominates for this trait. There is no significant high-parent heterosis for number of marketable pepper fruit in this harvest, which means that no F_1 population significantly outyielded its high parent.

Table 12. Analysis of variance for general and specific combining ability for the trait number of marketable pepper fruit, third harvest

Source	Degrees of freedom	Mean square	F^a
GCA	4	0.57	0.57
SCA	5	1.02	7.28**
Error	28	0.14	

[a]Random model assumed.

**Significant at the 1 percent level.

The analysis of variance for general and specific combining ability is presented in Table 12. Significant differences were found among specific combining ability estimates. This suggests that some combinations produced significantly more fruit than others. Estimates of general and specific combining ability and their associated variances are presented in Tables 13 and 14. 'Fordhook' was a much better general combiner than the

Table 13. Estimates of general combining ability and their associated variances for the trait number of marketable pepper fruit, third harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.50	22.39
Golden Calwonder	-0.09	1.80
Calwonder 300	0.14	0.63
Pip	-0.68	43.63
Delaware Belle	0.13	0.36

[a] $\sigma^2 g_i$ = -0.15, S.E. = 0.13.

[b] Multiply by 10^{-2} for actual values.

Table 14. Estimates of specific combining ability and their associated variances for the trait number of marketable pepper fruit, third harvest

Parent	Specific combining ability (s_{ij}) [a]				σ^2_{sca} [b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	-0.57	1.28	-0.48	-0.23	68.36
Golden Calwonder		-0.21	0.11	-0.33	50.47
Calwonder 300			-1.12	0.07	91.53
Pip				0.49	92.04
Delaware Belle					7.03

[a] $\sigma^2 s_{ij}$ = 0.93, S.E. = 2.24.

[b] Multiply by 10^{-2} for actual values.

other parents. Parent and F_1 means for number of marketable pepper fruit per plant, third harvest, are listed in Table 15. There was no significant difference among parent means when tested at the 5 percent level by a Duncan's Multiple Range test. The F_1 population mean, for the cross 'Calwonder 300' x 'Fordhook' significantly exceeds every other F_1 mean.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates can be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 12). The genotypic variance was estimated as $\sigma^2_G = 2\sigma^2_g + \sigma^2_s = 0.58$. The phenotypic variance was estimated as $\sigma^2_p = \sigma^2_G + \sigma^2_e = 2.65$. Additive genetic variance was estimated as $\sigma^2_a = 2\sigma^2_g = -0.30$. The additive genetic variance is assumed to approach zero since the GCA variance component estimate (σ^2_g) was negative (Table 13). From the estimates above, broad sense heritability was calculated as $H = \sigma^2_G / \sigma^2_p = 22$ percent. Narrow sense heritability could not be estimated, since σ^2_g was negative.

Total harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots suggests that significant differences exist between F_1 population means (Table 16). Various parent and F_1 population statistics are presented in Table 17. Generally, the direction of dominance values are positive, suggesting that the F_1 populations outyielded their respective parent populations. Several F_1 population means very significantly exceeded their midparent means. This suggests that partial dominance for many fruit is present. However, it appears that additive gene action is

Table 15. Parent and F_1 means for the trait number of marketable pepper fruit per plant, third harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		1.50 b	3.58 a	1.00 b	2.06 b	2.18 a
	Golden Calwonder			1.50 b	2.00 b	1.37 b	1.00 a
	Calwonder 300				--	2.00 b	0.00 a
	Pip					1.60 b	2.00 a
	Delaware Belle						1.67 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 16. Analysis of variance of individual plant data for the trait total number of marketable pepper fruit

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	20.94	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	5.02
Cross	9	47.27	$\sigma^2_3 + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	11.33**
Cross*Replications	27	6.70	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.61*
Error	225	4.17	σ^2_e	σ^2_e	
Total[b]	264				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 264 due to missing data.

*Significant at the 5 percent level.

**Significant at the 1 percent level.

Table 17. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait total number of marketable pepper fruit per plant

Cross	Number of plants (n)	Mean ($\bar{x}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{x}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	28	5.89	2.57	--	--	--	--
Golden Calwonder x Golden Calwonder	25	2.40	1.44	--	--	--	--
Calwonder 300 x Calwonder 300	10	0.90	0.99	--	--	--	--
Pip x Pip	19	1.89	1.63	--	--	--	--
Delaware Belle x Delaware Belle	23	2.22	1.24	--	--	--	--
Golden Calwonder x Fordhook	28	3.39	2.28	4.14	-0.75	-0.42	0.04
Calwonder 300 x Fordhook	27	5.07	2.81	3.39	1.68	-0.14	0.05
Calwonder 300 x Golden Calwonder	27	2.52	1.45	1.65	0.87	0.05	0.38
Pip x Fordhook	27	3.55	1.93	3.89	-0.34	-0.40	0.04
Pip x Golden Calwonder	25	2.72	2.01	2.14	0.58	0.13	0.41
Pip x Calwonder 300	23	2.69	1.82	1.39	1.30*	0.42	0.87
Delaware Belle x Fordhook	28	6.71	2.69	4.05	2.66**	0.14	0.07
Delaware Belle x Golden Calwonder	28	4.18	2.29	2.31	1.87**	0.74	0.73
Delaware Belle x Calwonder 300	25	3.48	2.18	1.56	1.92**	0.57	0.73
Delaware Belle x Pip	27	2.74	1.53	2.05	0.69	0.23	0.53

*Significant at the 5 percent level.

**Significant at the 1 percent level.

primary for total number of marketable pepper fruit. There was no significant high-parent heterosis for total number of marketable pepper fruit, which suggests that no F_1 population significantly outyielded its high parent.

Table 18. Analysis of variance for general and specific combining ability for the trait total number of marketable pepper fruit

Source	Degrees of freedom	Mean square	F[a]
GCA	4	2.95	3.83
SCA	5	0.77	5.13**
Error	28	0.15	

[a]Random model assumed.

**Significant at the 1 percent level.

The analysis of variance for general and specific combining ability is presented in Table 18. Significant differences were found among specific combining ability estimates, suggesting that some combinations produced significantly more fruit than others. Estimates of general and specific combining ability and their associated variances are presented in Tables 19 and 20. 'Fordhook' was a much better general combiner than the other parents. Parent and F_1 means for total number of marketable pepper fruit are listed in Table 21. A Duncan's Multiple Range test revealed that 'Fordhook' produced significantly more peppers than the other parents. Within F_1 populations, the population 'Delaware Belle' x 'Fordhook' significantly outproduced other F_1 populations.

Table 19. Estimates of general combining ability and its associated variance for the trait total number of marketable pepper fruit

Parent	General combining ability (g_i)[a]	σ^2_{gca}[b]
Fordhook	1.30	165.00
Golden Calwonder	-0.67	40.89
Calwonder 300	-0.35	8.25
Pip	-1.04	104.16
Delaware Belle	0.76	53.76

[a] $\sigma^2 g_i$ = 0.73, S.E. = 0.68.

[b] Multiply by 10^{-2} for actual values.

Table 20. Estimates of specific combining ability and its associated variance for the trait total number of marketable pepper fruit

Parent	Specific combining ability (s_{ij})[a]				σ^2_{sca}[b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	-0.95	0.41	-0.42	0.94	61.02
Golden Calwonder		-0.17	0.72	0.38	43.14
Calwonder 300			0.37	-0.64	14.78
Pip				-0.69	33.59
Delaware Belle					53.79

[a] $\sigma^2 s_{ij}$ = 0.62, S.E. = 11.67.

[b] Multiply by 10^{-2} for actual values.

Table 21. Parent and F_1 means for the trait total number of marketable pepper fruit per plant

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent mean[b]
Male parent	Fordhook		3.39 cd	5.07 b	3.55 cd	6.71 a	5.89 a
	Golden Calwonder			2.52 d	2.72 d	4.18 bc	2.40 b
	Calwonder 300				2.69 d	3.48 cd	0.90 c
	Pip					2.74 d	1.89 bc
	Delaware Belle						2.22 bc

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

To determine what percentage of the phenotypic variability was genetic, heritability estimates were produced. Heritability estimates can be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 18). From this analysis, the genotypic, phenotypic, and additive genetic variances may be estimated as 2.08, 6.25, and 1.46, respectively. From these estimates, broad sense heritability was estimated as 33 percent, while narrow sense heritability was estimated as 23 percent.

Discussion

Many conclusions may be drawn from the analyses about the inheritance of number of marketable fruit in peppers. The study suggests that 'Fordhook' was the best parent in this study for producing a large number of marketable pepper fruit. The best yielding hybrid was 'Delaware Belle' x 'Fordhook.'

Gene action seems to be primarily additive with partial dominance for a large number of marketable fruit. Similar results were found by Soh et al. (28). In Table 17, the direction of dominance values were usually positive, suggesting that the F_1 populations produced more fruit than their respective parents. Several F_1 means were significantly larger than their midparent mean. In addition, there was no high-parent heterosis for this trait.

Significant differences were found among SCA estimates, suggesting that some combinations produced significantly more fruit than others (Table 18). An analysis of mean plant data provides estimates of the general and specific combining abilities for each line and cross (Tables 19 and 20). The values acquired can be interpreted as follows. The overall mean ($\overline{X}$) for number of marketable pepper fruit for individual F_1 plants was 3.74. The mean for any cross (parents i and j) is predicted as follows:

$$\overline{X}_{ij} = \overline{X} + g_i + g_j + s_{ij},$$

where g_i and g_j are the general combining abilities of the two lines, and s_{ij} is specific combining ability (24). 'Fordhook' and 'Delaware Belle' can be expected to increase the overall mean. In contrast, 'Golden Calwonder', 'Calwonder 300', and 'Pip' can be expected to decrease the overall mean. Specific combinations of these lines, such as 'Fordhook' x 'Golden Calwonder', should produce a decrease in the total number of marketable pepper fruit relative to the overall mean. For example:

$$\overline{X}_{12} = \overline{X} + g_1 + g_2 + s_{12}$$

$$= 3.74 + 1.30 + (-0.67) + (-0.95)$$

$$= 3.42.$$

Heritability estimates for number of marketable pepper fruit varied from 3 to 22 percent for broad sense heritability, and 0.43 to 13 percent for narrow sense heritability. Broad and narrow sense heritabilities for total number of marketable pepper fruit were 33 and 23 percent, respectively. Using the narrow sense heritability estimate, the response to selection, R, can be determined (5). The response to selection represents the difference between the mean of the original population and the mean of the selected population. The expected response to selection is given by the relationship

$$R = (h^2)(i)(\sigma_p),$$

where

h^2 is narrow sense heritability,

i is the selection intensity, and

σ_p is the phenotypic standard deviation.

Table 22 provides a comparison of R values for two selection intensities. Increasing the number of marketable pepper fruit by established breeding methods should be a fairly rapid process, especially at high selection intensities.

Table 22. Response to selection for total number of marketable pepper fruit per plant

Narrow sense heritability	σ_p	Percent saved	i	Response to selection (R)
23.00%	2.50	5%	2.06	1.18
23.00%	2.50	1%	2.66	1.53

Because heritabilities are variance ratios, their estimation may be subject to considerable error. In addition, certain model assumptions must be met for analysis of variance components to predict additive and dominance variances. Both the analysis of plot means and the analysis of individual plant data must assume random selection of parental lines (7, 15). In addition, the Griffing diallel analysis assumes there is no epistasis (7). The first assumption, random selection of parental lines, was met. However, because a regression of the covariance on the variance was not performed, it is not certain that the second assumption was met. Therefore, the validity of the heritability estimates may be questioned. The estimates do show, however, that the amount of environmental variation is large compared with the amount of additive and dominance variance.

Marketable Pepper Fruit Weight per Plant

First harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 23. There was no significant difference among crosses for marketable pepper fruit weight, first harvest. Various parent and F_1 population statistics are presented in Table 24. Direction of dominance values were generally positive. No significant differences were found between F_1 population means and their respective mid-parent means. This suggests that gene action is primarily additive. No significant high-parent heterosis was observed for this trait in the first harvest period.

No significant differences were observed among general or specific combining ability effects. When a Duncan's Multiple Range test was applied, no significant difference was observed between parent or F_1 means.

To determine how much of the phenotypic variability was genetic, heritability estimates were produced. These estimates can be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. The genotypic variance was estimated as $\sigma^2_G = 2\sigma^2_g + \sigma_s = 0.002$. The phenotypic variance was estimated as $\sigma^2_p = \sigma^2_G + \sigma^2_e = 0.073$. Additive genetic variance was estimated as $\sigma^2_a = 2\sigma^2_g = 0.00$. From these estimates,

Table 23. Analysis of variance of individual plant data for the trait marketable pepper fruit weight, first harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.18	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	2.25
Cross	9	0.05	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	0.62
Cross*Replications	23	0.06	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	0.75
Error	120	0.08	σ^2_e	σ^2_e	
Total[b]	155				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 155 due to missing data.

Table 24. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait marketable pepper fruit weight (lbs.) per plant, first harvest

Cross	Number of plants (n)	Mean ($\bar{x}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{x}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	9	0.34	0.22	--	--	--	--
Golden Calwonder x Golden Calwonder	13	0.45	0.14	--	--	--	--
Calwonder 300 x Calwonder 300	3	0.33	0.06	--	--	--	--
Pip x Pip	11	0.42	0.26	--	--	--	--
Delaware Belle x Delaware Belle	8	0.39	0.10	--	--	--	--
Golden Calwonder x Fordhook	22	0.45	0.31	0.39	0.06	0.00	0.37
Calwonder 300 x Fordhook	10	0.39	0.29	0.33	0.06	0.15	0.56
Calwonder 300 x Golden Calwonder	17	0.38	0.26	0.39	-0.01	-0.15	0.35
Pip x Fordhook	13	0.44	0.17	0.38	0.06	0.05	0.41
Pip x Golden Calwonder	17	0.40	0.24	0.43	-0.03	-0.11	0.35
Pip x Calwonder 300	12	0.44	0.10	0.37	0.07	0.05	0.41
Delaware Belle x Fordhook	19	0.43	0.37	0.36	0.07	0.10	0.47
Delaware Belle x Golden Calwonder	23	0.56	0.35	0.42	0.14	0.24	0.42
Delaware Belle x Calwonder 300	4	0.42	0.12	0.36	0.06	0.08	0.47
Delaware Belle x Pip	19	0.42	0.23	0.40	0.02	0.00	0.40

Table 25. Analysis of variance of individual plant data for the trait marketable pepper fruit weight, second harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.50	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	0.96
Cross	9	2.32	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	4.46**
Cross*Replications	27	0.54	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.04
Error	206	0.52	σ^2_e	σ^2_e	
Total[b]	245				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 245 due to missing data.

**Significant at the 1 percent level.

Table 26. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait marketable pepper fruit weight (lbs.) per plant, second harvest

Cross	Number of plants (n)	Mean ($\bar{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	27	1.43	0.70	--	--	--	--
Golden Calwonder x Golden Calwonder	22	0.82	0.57	--	--	--	--
Calwonder 300 x Calwonder 300	7	0.41	0.46	--	--	--	--
Pip x Pip	16	0.69	0.60	--	--	--	--
Delaware Belle x Delaware Belle	20	0.87	0.50	--	--	--	--
Golden Calwonder x Fordhook	25	0.86	0.72	1.12	-0.26	-0.40	0.30
Calwonder 300 x Fordhook	27	1.33	0.70	0.92	0.41	-0.07	0.36
Calwonder 300 x Golden Calwonder	21	0.97	0.60	0.61	0.36	0.18	0.69
Pip x Fordhook	27	1.20	0.80	1.06	0.14	-0.16	0.35
Pip x Golden Calwonder	22	0.79	0.64	0.75	0.04	-0.04	0.62
Pip x Calwonder 300	20	1.23	0.90	0.55	0.68*	0.78	1.08
Delaware Belle x Fordhook	28	1.73	0.80	1.15	0.58**	0.21	0.41
Delaware Belle x Golden Calwonder	26	1.10	0.77	0.84	0.26	0.26	0.68
Delaware Belle x Calwonder 300	25	1.27	0.67	0.64	0.63**	0.46	0.75
Delaware Belle x Pip	25	0.74	0.52	0.78	-0.04	-0.15	0.56

*Significant at the 5 percent level.

**Significant at the 1 percent level.

broad and narrow sense heritabilities were calculated as $H = \sigma^2_G / \sigma^2 p$ = 3 percent and $h^2 = \sigma^2_a / \sigma^2 p$ = 0 percent, respectively.

Second harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 25. There was a highly significant difference among crosses for this trait. Direction of dominance values were primarily positive. Three F_1 means significantly exceeded their respective midparent means, indicating that partial dominance is present. However, additive genetic effects appear to be predominant. There was no significant high-parent heterosis for this trait (Table 26).

Table 27. Analysis of variance for general and specific combining ability for the trait marketable pepper fruit weight, second harvest

Source	Degrees of freedom	Mean square	F^a
GCA	4	0.12	2.00
SCA	5	0.06	3.00*
Error	28	0.02	

[a]Random model assumed.

*Significant at the 5 percent level.

The analysis of variance for general and specific combining ability is presented in Table 27. Significant differences were found among specific combining ability estimates. This suggests that some combinations significantly out-performed others. Estimates of general and specific combining ability and their associated variances are presented in Tables 28 and 29. 'Fordhook' was the best general combiner of all the parental lines studied. Estimates of specific combining ability variances (σ^2_{sca}) were very low. This suggests that each line should consistently transmit its yield ability to F_1 populations. Parent and F_1 means for marketable pepper fruit weight, second harvest, are listed in Table 30. The data suggest that 'Fordhook' produced significantly more marketable peppers than did the other cultivars. Among F_1 means, the population 'Delaware Belle' x 'Fordhook' significantly out-produced all others.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be calculated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 27). Under these assumptions, the genotypic variance was estimated as $\sigma^2_G = 2\sigma^2_g + \sigma^2_s = 0.08$. The phenotypic variance was estimated as $\sigma^2_p = \sigma^2_G + \sigma^2_e = 0.55$. Additive genetic variance was estimated as $\sigma^2_a = 2\sigma^2_g = 0.04$. From the estimates above, both broad and narrow sense heritabilities were estimated as 14 and 7 percent, respectively.

Third harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 31. Significant differences were found among crosses for the third harvest. The direction of dominance values are primarily negative, suggesting that the parent populations outyielded the F_1 populations. A significant difference was found between the F_1 mean of 'Calwonder 300' x 'Fordhook' and its associated midparent mean. This suggests that partial dominance for heavier fruit is involved in this trait. It appears that primary gene control is additive with

Table 28. Estimates of general combining ability and its associated variance for the trait marketable pepper fruit weight, second harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.21	3.90
Golden Calwonder	-0.26	6.25
Calwonder 300	0.10	0.49
Pip	-0.18	2.73
Delaware Belle	0.12	0.93

[a]$\sigma^2 g_i$ = 0.02, S.E. = 0.03.

[b]Multiply by 10^{-2} for actual values.

Table 29. Estimates of specific combining ability and its associated variance for the trait marketable pepper fruit weight, second harvest

Parent	Specific combining ability (s_{ij}) [a]				σ^2_{sca} [b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	-0.22	-0.11	0.04	0.28	3.41
Golden Calwonder		0.00	0.10	0.12	1.16
Calwonder 300			0.18	-0.07	0.38
Pip				-0.32	3.61
Delaware Belle					5.40

[a]$\sigma^2 s_{ij}$ = 0.04, S.E. = 0.30.

[b]Multiply by 10^{-2} for actual values.

Table 30. Parent and F_1 means for the trait marketable pepper fruit weight (lbs.) per plant, second harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		0.86 cd	1.33 b	1.20 bcd	1.73 a	1.43 a
	Golden Calwonder			0.97 bcd	0.79 d	1.10 bcd	0.82 b
	Calwonder 300				1.23 bcd	1.27 bc	0.41 b
	Pip					0.74 d	0.69 b
	Delaware Belle						0.87 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 31. Analysis of variance of individual plant data for the trait marketable pepper fruit weight, third harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.69	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	3.63
Cross	8	0.53	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	2.79*
Cross*Replications	14	0.38	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	2.00
Error	48	0.19	σ^2_e	σ^2_e	
Total[b]	73				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 73 due to missing data.

*Significant at the 5 percent level.

Table 32. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait marketable pepper fruit weight (lbs.) per plant, third harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	17	0.60	0.36	--	--	--	--
Golden Calwonder x Golden Calwonder	1	0.50	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	1	0.00	0.00	--	--	--	--
Pip x Pip	1	0.90	0.00	--	--	--	--
Delaware Belle x Delaware Belle	3	0.73	0.21	--	--	--	--
Golden Calwonder x Fordhook	6	0.47	0.49	0.55	-0.08	-0.22	0.65
Calwonder 300 x Fordhook	12	1.17	0.70	0.30	0.87*	0.95	1.12
Calwonder 300 x Golden Calwonder	2	0.50	0.28	0.25	0.25	0.00	0.87
Pip x Fordhook	7	0.36	0.18	0.75	-0.39	-0.60	0.37
Pip x Golden Calwonder	6	0.62	0.45	0.70	-0.08	-0.31	0.42
Pip x Calwonder 300	0	0.00	0.00	0.45	-0.45	-1.00	0.45
Delaware Belle x Fordhook	17	0.70	0.64	0.66	0.04	-0.04	0.58
Delaware Belle x Golden Calwonder	8	0.50	0.24	0.61	-0.11	-0.31	0.52
Delaware Belle x Calwonder 300	6	0.73	0.40	0.36	0.37	0.00	0.60
Delaware Belle x Pip	10	0.60	0.27	0.81	-0.21	-0.33	0.51

*Significant at the 5 percent level.

partial dominance for heavier fruit. No significant high-parent heterosis was observed for this trait (Table 32).

An analysis of variance for general and specific combining ability is presented in Table 33. Highly significant differences were found among specific combining ability estimates. This suggests that some parental combinations did significantly better than others. Estimates of general and specific combining ability and their associated variances are presented in Tables 34 and 35. 'Fordhook' was the best general combiner among the parents studied for this trait. The estimates of specific combining ability variances (σ^2_{sca}) were relatively low. This suggests that each line should consistently transmit its yield ability to F_1 populations. Parent and F_1 means for marketable pepper fruit weight, third harvest, are listed in Table 36. A Duncan's Multiple Range test shows that parent means did not differ significantly. The population, 'Calwonder 300' x 'Fordhook' significantly outproduced every other F_1 population.

Table 33. Analysis of variance for general and specific combining ability for the trait marketable pepper fruit weight, third harvest

Source	Degrees of freedom	Mean square	F^a
GCA	4	0.06	0.54
SCA	5	0.11	11.00**
Error	28	0.01	

[a]Random model assumed.

**Significant at the 1 percent level.

Table 34. Estimates of general combining ability and its associated variance for the trait marketable pepper fruit weight, third harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.15	2.12
Golden Calwonder	-0.06	0.23
Calwonder 300	0.05	0.12
Pip	-0.23	5.16
Delaware Belle	0.09	0.68

[a] $\sigma^2 g_i$ = -0.02, S.E. = 0.01.

[b] Multiply by 10^{-2} for actual values.

Table 35. Estimates of specific combining ability and its associated variance for the trait marketable pepper fruit weight, third harvest

Parent	Specific combining ability (s_{ij}) [a]				
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	σ^2_{sca} [b]
Fordhook	-0.19	0.41	-0.13	-0.10	7.28
Golden Calwonder		-0.06	0.34	-0.10	5.09
Calwonder 300			-0.39	0.03	10.40
Pip				0.17	10.03
Delaware Belle					1.24

[a] $\sigma^2 s_{ij}$ = 0.10, S.E. = 0.20.

[b] Multiply by 10^{-2} for actual values.

Table 36. Parent and F_1 means for the trait marketable pepper fruit weight (lbs.) per plant, third harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		0.47 b	1.17 a	0.36 b	0.70 b	0.60 a
	Golden Calwonder			0.50 b	0.62 b	0.50 b	0.50 a
	Calwonder 300				--	0.73 ab	0.00 a
	Pip					0.60 b	0.90 a
	Delaware Belle						0.73 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent letter.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 33). Under these assumptions, the genotypic variance estimate was $\sigma^2_G = 2\sigma^2_g + \sigma^2_s = 0.06$, and the phenotypic variance estimate was $\sigma^2_p = \sigma^2_G + \sigma^2_e = 0.23$. Additive genetic variance was estimated as $\sigma^2_a = 2\sigma^2_g = -0.04$. The additive genetic variance must approach zero, since the GCA variance component estimate (σ^2_g; Table 34) is negative. From the estimates above, broad sense heritability was estimated as 26 percent. Since σ^2_g was negative, narrow sense heritability could not be estimated.

Total harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots suggests that significant differences exist between F_1 population means (Table 37). Various parent and F_1 population statistics are presented in Table 38. The direction of dominance values are positive, suggesting that the F_1 populations outyielded their respective parent populations. Most F_1 population means significantly exceeded their mid-parent means. This suggests that the primary gene action is partial dominance for heavier fruit, while additive genes play a smaller role. Significant high-parent heterosis was observed for the F_1 population 'Delaware Belle' x 'Fordhook', which suggests that this population significantly outyielded its high parent.

The GCA-SCA analysis of variance is presented in Table 39. Highly significant differences were found between specific combining ability

Table 37. Analysis of variance of individual plant data for the trait total marketable pepper fruit weight

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	2.74	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	4.28
Cross	9	5.97	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	9.33**
Cross*Replications	27	0.90	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + \phi(bv)$	1.41
Error	239	0.64	σ^2_e	σ^2_e	
Total[b]	278				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 278 due to missing data.

**Significant at the 1 percent level.

Table 38. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait total marketable pepper fruit weight (lbs.) per plant

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	28	1.85	0.77	--	--	--	--
Golden Calwonder x Golden Calwonder	28	0.87	0.62	--	--	--	--
Calwonder 300 x Calwonder 300	27	0.14	0.33	--	--	--	--
Pip x Pip	28	0.59	0.72	--	--	--	--
Delaware Belle x Delaware Belle	28	0.81	0.64	--	--	--	--
Golden Calwonder x Fordhook	28	1.22	0.83	1.36	-0.14	-0.34	0.07
Calwonder 300 x Fordhook	28	1.92	0.97	0.99	0.93**	0.04	0.10
Calwonder 300 x Golden Calwonder	28	0.99	0.61	0.50	0.49*	0.14	0.49
Pip x Fordhook	28	1.45	0.90	1.22	0.23	-0.22	0.07
Pip x Golden Calwonder	28	1.00	0.77	0.73	0.27	0.15	0.49
Pip x Calwonder 300	27	1.11	0.92	0.36	0.75**	0.88	2.08
Delaware Belle x Fordhook	28	2.45	0.88	1.33	1.12**	0.32*	0.13
Delaware Belle x Golden Calwonder	28	1.62	0.82	0.84	0.78**	0.86	0.94
Delaware Belle x Calwonder 300	28	1.35	0.89	0.47	0.88**	0.67	0.92
Delaware Belle x Pip	28	1.16	0.66	0.70	0.46*	0.43	0.74

*Significant at the 5 percent level.

**Significant at the 1 percent level.

Table 39. Analysis of variance for general and specific combining ability for the trait total marketable pepper fruit weight

Source	Degrees of freedom	Mean square	F^a
GCA	4	0.37	4.11
SCA	5	0.09	4.50**
Error	28	0.02	

[a]Random model assumed.

**Significant at the 1 percent level.

estimates, suggesting that some combinations significantly outproduced others. General and specific combining ability estimates and their associated variances are presented in Tables 40 and 41. 'Fordhook' was by far the best general combiner of all the parents of this study for total marketable pepper fruit weight. Parent and F_1 means for total marketable pepper fruit weight are listed in Table 42. A Duncan's Multiple Range Test revealed that 'Fordhook' produced significantly more pepper fruit, while 'Calwonder 300' produced significantly less pepper fruit than the other parents. The F_1 population 'Delaware Belle' x 'Fordhook' significantly outproduced all other F_1 populations.

Heritability estimates were produced to determine what percentage of the phenotypic variability was genetic. These estimates can be calculated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 39). From this analysis the genotypic, phenotypic, and additive genetic variances may be estimated as 0.25, 0.89, and 0.18,

Table 40. Estimates of general combining ability and its associated variance for the trait total marketable pepper fruit weight

Parent	General combining ability (g_i)[a]	σ^2_{gca}[b]
Fordhook	0.44	18.83
Golden Calwonder	-0.29	7.88
Calwonder 300	-0.11	0.68
Pip	-0.33	10.36
Delaware Belle	0.29	7.88

[a]$\sigma^2 g_i$ = 0.09, S.E. = 0.07.

[b]Multiply by 10^{-2} for actual values.

Table 41. Estimates of specific combining ability and its associated variance for the trait total marketable pepper fruit weight

Parent	Specific combining ability (s_{ij})[a]				σ^2_{sca}[b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	-0.36	0.16	-0.09	0.29	441.33
Golden Calwonder		-0.03	0.20	0.20	201.77
Calwonder 300			0.13	-0.25	256.04
Pip				-0.23	188.01
Delaware Belle					391.84

[a]$\sigma^2 s_{ij}$ = 0.07, S.E. = 0.48.

[b]Multiply by 10^{-2} for actual values.

Table 42. Parent and F_1 means for the trait total marketable pepper fruit weight (lbs.) per plant

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
	Fordhook		1.22 cd	1.92 b	1.45 cd	2.45 a	1.85 a
	Golden Calwonder			0.99 d	1.00 d	1.62 bc	0.87 b
Male parent	Calwonder 300				1.11 d	1.35 cd	0.14 c
	Pip					1.16 cd	0.59 b
	Delaware Belle						0.81 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

respectively. From these estimates, broad sense heritability was estimated as 28 percent, while narrow sense heritability was estimated as 20 percent.

Discussion

Many conclusions may be drawn from the analyses about the inheritance of marketable fruit weight in peppers. It was shown that 'Fordhook' is the best parent in this study for producing heavier marketable fruit. For this trait, the best hybrid was 'Delaware Belle' x 'Fordhook.'

The primary gene action seems to be partial dominance for heavier fruit, while additive genes play a smaller role. In Table 38, the direction of dominance values were positive, suggesting that the F_1 populations produced more fruit than their respective parents. In addition, most F_1 population means significantly exceeded their midparent means, suggesting that partial dominance is the basic gene action controlling the inheritance of this trait. Table 38 also shows that significant high-parent heterosis was observed for the F_1 population 'Delaware Belle' x 'Fordhook', which suggests that this population significantly outyielded its high parent.

Significant differences were found among SCA estimates, suggesting that some combinations produced significantly more fruit than others. An analysis of mean plant data provides estimates of the general and specific combining abilities for each line and cross (Tables 40 and 41). The values obtained can be interpreted as follows. The overall mean $(\overline{X})$ for marketable pepper fruit weight for individual F_1 plants was 1.43 lbs. The mean for any cross (parents i and j) is predicted as follows:

$$\overline{X}_{ij} = \overline{X} + g_i + g_j + s_{ij},$$

where g_i and g_j are the general combining abilities of the two lines, and s_{ij} is the specific combining ability (24). 'Fordhook' and 'Delaware Belle' can be expected to increase the overall mean. Contrastingly, 'Golden Calwonder', 'Calwonder 300', and 'Pip' can be expected to decrease the overall mean.

Heritability estimates for marketable pepper fruit weight varied from 3 to 26 percent for broad sense heritability, and from 0 to 7 percent for narrow sense heritability. Broad and narrow sense heritability estimates for total marketable pepper fruit weight were 28 and 20 percent, respectively. Using the narrow sense heritability estimate, the response to selection, R, can be determined (5). The response to selection represents the difference between the mean of the original population and the mean of the selected population. The expected response to selection is given by the relationship

$$R = (h^2)(i)(\sigma_p),$$

where

h^2 is narrow sense heritability,

i is the selection intensity, and

σ_p is the phenotypic standard deviation.

Table 43 provides a comparison of R values for two selection intensities. Increasing marketable pepper fruit weight by established breeding methods should be a fairly rapid process, especially at high selection intensities.

Table 43. Response to selection for total marketable pepper fruit weight (lbs.) per plant

Narrow sense heritability	σ_p	Percent saved	i	Response to selection (R)
20.00%	0.94	5%	2.06	0.38
20.00%	0.94	1%	2.66	0.50

Because heritabilities are variance ratios, their estimation may be subject to considerable error. In addition, certain model assumptions must be met for analysis of variance components to predict additive and dominance variances. Both the analysis of plot means and the analysis of individual plant data must assume random selection of parental lines (7, 15). In addition, the Griffing diallel analysis assumes there is no epistasis (7). The first assumption, random selection of parental lines, was met. However, because a regression of the covariance on the variance was not performed, it is not certain that the second assumption was met. Therefore, the validity of the heritability estimates may be questioned. The estimates do show, however, that the amount of environmental variance is large compared with the amount of additive and dominance variance. Thus, it may be concluded that, depending on the environment, fairly rapid advances may be made due to selection for increased marketable pepper fruit weight.

Number of Cull Pepper Fruit per Plant

First harvest

An analysis of variance table based on a fixed model using individual plant data from F_1 plots is presented in Table 44. There was no significant difference among crosses for number of cull pepper fruit produced in the first harvest. Direction of dominance values were generally positive. Eighty percent of the F_1 population means were significantly different from their associated midparent means. This strongly suggests that this trait is controlled by dominant gene action. There was no significant low-parent heterosis (Table 45).

No significant differences were found among general combining ability effects. However, highly significant differences were observed among specific combining ability effects (Table 46). This suggests that some combinations produced significantly fewer culls than others. General and specific combining ability estimates and their associated variances are presented in Tables 47 and 48. 'Fordhook' had the highest general combining ability of all the parents of this study for number of cull pepper fruit per plant in this harvest. Parent and F_1 means for number of cull pepper fruit per plant, first harvest, are listed in Table 49. A Duncan's Multiple Range test shows that 'Fordhook' produced significantly more cull pepper fruit than three other parents. The F_1 population 'Delaware Belle' x 'Fordhook' produced significantly more cull pepper fruit than did other F_1 populations.

Table 44. Analysis of variance of individual plant data for the trait number of cull pepper fruit, first harvest

Source	Degrees of freedom	Mean square	Expectations		F^a
			Random model	Fixed model	
Replications	3	3.37	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	12.96
Cross	9	0.42	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	1.61
Cross*Replications	23	0.01	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	0.04
Error	120	0.26	σ^2_e	σ^2_e	
Total[b]	155				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 155 due to missing data.

Table 45. Number of plants, mean, standard deviation, midparent mean, direction of dominance, low-parent heterosis, and standard deviation of low-parent heterosis for the traits number of cull pepper fruit per plant, first harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	Low-parent heterosis (L')	Standard deviation of L'
Fordhook x Fordhook	9	0.33	0.50	--	--	--	--
Golden Calwonder x Golden Calwonder	13	0.00	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	3	0.00	0.00	--	--	--	--
Pip x Pip	11	0.18	0.60	--	--	--	--
Delaware Belle x Delaware Belle	8	0.00	0.00	--	--	--	--
Golden Calwonder x Fordhook	22	0.32	0.65	0.16	0.16**	--	--
Calwonder 300 x Fordhook	10	0.30	0.48	0.16	0.14*	--	--
Calwonder 300 x Golden Calwonder	17	0.18	0.39	0.00	0.18**	--	--
Pip x Fordhook	13	0.00	0.00	0.25	-0.25**	1.00	0.63
Pip x Golden Calwonder	17	0.29	0.85	0.09	0.20**	--	--
Pip x Calwonder 300	12	0.00	0.00	0.09	-0.09	0.00	--
Delaware Belle x Fordhook	19	0.53	0.70	0.16	0.37**	--	--
Delaware Bell x Golden Calwonder	23	0.13	0.34	0.00	0.13**	--	--
Delaware Belle x Calwonder 300	4	0.00	0.00	0.00	0.00	0.00	--
Delaware Belle x Pip	19	0.21	0.53	0.09	0.12*	--	--

*Significant at the 5 percent level.

**Significant at the 1 percent level.

Table 46. Analysis of variance for general and specific combining ability for the trait number of cull pepper fruit, first harvest

Source	Degrees of freedom	Mean square	F[a]
GCA	4	0.030	1.07
SCA	5	0.028	93.33**
Error	28	0.0003	

[a]Random model assumed

**Significant at the 1 percent level.

Heritability estimates were produced to determine what percentage of the phenotypic variability was genetic. These estimates can be generated from mean plant data, provided that a random model is assumed for the GCA-SCA analysis of variance. Based on data from Table 46, the genotypic variance was estimated as $\sigma^2_G = 2\sigma^2_g + \sigma^2_s = 0.03$, and the phenotypic variance was estimated as $\sigma^2_p = \sigma^2_G + \sigma^2_e = 0.26$. An estimate of 0.002 was produced for the additive genetic variance, $\sigma^2_a = 2\sigma^2_g$. From the estimates above, broad and narrow sense heritabilities were calculated as 11 and 1 percent, respectively.

Second harvest

Table 50 suggests there are highly significant differences between crosses for this trait. Direction of dominance values are primarily positive. However, no significant differences between F_1 means and their respective midparent means were found. It appears that this trait is

Table 47. Estimates of general combining ability and its associated variance for the trait number of cull pepper fruit, first harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.12	1.22
Golden Calwonder	0.04	-0.07
Calwonder 300	-0.10	0.73
Pip	-0.09	0.61
Delaware Belle	0.03	-0.19

[a] $\sigma^2 g_i$ = 0.01, S.E. = 0.01.

[b] Multiply by 10^{-2} for actual values.

Table 48. Estimates of specific combining ability and its associated variance for the trait number of cull pepper fruit, first harvest

	Specific combining ability (s_{ij})[a]				
Parent	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	σ^2_{sca} [b]
Fordhook	-0.04	0.09	-0.22	0.19	2.47
Golden Calwonder		0.04	0.15	-0.14	0.84
Calwonder 300			0.00	-0.12	0.13
Pip				0.08	1.91
Delaware Belle					1.88

[a] $\sigma^2 s_{ij}$ = 0.03, S.E. = 0.02.

[b] Multiply by 10^{-2} for actual values.

Table 49. Parent and F_1 means for the trait number of cull pepper fruit per plant, first harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent mean[b]
Male parent	Fordhook		0.32 ab	0.30 ab	0.08 b	0.53 a	0.33 a
	Golden Calwonder			0.18 ab	0.29 ab	0.13 b	0.00 b
	Calwonder 300				0.00 b	0.00 b	0.00 b
	Pip					0.21 ab	0.18 ab
	Delaware Belle						0.00 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 50. Analysis of variance of individual plant data for the trait number of cull pepper fruit, second harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.06	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	0.06
Cross	9	3.34	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	3.37**
Cross*Replications	27	2.15	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	2.17
Error	206	0.99	σ^2_e	σ^2_e	
Total[b]	245				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 245 due to missing data.

**Significant at the 1 percent level.

Table 51. Number of plants, mean, standard deviation, midparent mean, direction of dominance, low-parent heterosis, and standard deviation of low-parent heterosis for the trait number of cull pepper fruit per plant, second harvest

Cross	Number of plants (n)	Mean ($\bar{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{X}$-mp)	Low-parent heterosis (L')	Standard deviation of L'
Fordhook x Fordhook	27	1.22	1.22	--	--	--	--
Golden Calwonder x Colden Calwonder	22	0.59	0.96	--	--	--	--
Calwonder 300 x Calwonder 300	7	0.43	0.53	--	--	--	--
Pip x Pip	16	0.19	0.40	--	--	--	--
Delaware Belle x Delaware Belle	20	0.25	0.55	--	--	--	--
Golden Calwonder x Fordhook	25	1.08	1.44	0.90	0.18	-0.83	1.25
Calwonder 300 x Fordhook	27	0.48	1.15	0.82	-0.34	-0.12	2.30
Calwonder 300 x Golden Calwonder	21	1.09	1.44	0.51	0.58	-1.53	1.96
Pip x Fordhook	27	0.63	0.97	0.70	-0.07	-2.31	6.05
Pip x Golden Calwonder	22	0.59	1.10	0.39	0.20	-2.10	5.45
Pip x Calwonder 300	20	0.20	0.41	0.31	-0.11	-0.05	5.06
Delaware Belle x Fordhook	28	1.18	1.28	0.73	0.45	-3.72	8.67
Delaware Belle x Golden Calwonder	26	0.65	1.02	0.42	0.23	-1.60	3.49
Delaware Belle x Calwonder 300	25	0.12	0.33	0.34	-0.22	0.52	5.44
Delaware Belle x Pip	25	0.40	0.64	0.22	0.18	-1.10	3.68

Table 52. Parent and F_1 means for the trait number of cull pepper fruit per plant, second harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		1.08 ab	0.48 bc	0.63 abc	1.18 a	1.22 a
	Golden Calwonder			1.09 ab	0.59 abc	0.65 abc	0.59 b
	Calwonder 300				0.20 c	0.12 c	0.43 b
	Pip					0.40 c	0.19 b
	Delaware Belle						0.25 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

controlled by additive gene action. No significant low-parent heterosis was observed for this trait (Table 51).

No significant differences were observed for either general or specific combining ability estimates. Parent and F_1 means for number of cull pepper fruit, second harvest, are listed in Table 52. 'Fordhook' produced significantly more cull pepper fruit than did the other parental cultivars. Among F_1 population means, 'Delaware Belle' x 'Fordhook' produced significantly more cull pepper fruit than did other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data provided that a random model is assumed for the GCA-SCA analysis of variance. Based on these assumptions, the genotypic variance was estimated as 0.08. The phenotypic variance estimate was 0.99 and the additive genetic variance was estimated as 0.08. From these estimates, both broad and narrow sense heritability estimates were calculated as 8 percent.

Third harvest

Using individual plant data from F_1 plots, an analysis of variance based on a fixed model was performed (Table 53). Significant differences were found between crosses in the third harvest. Direction of dominance values were generally negative, suggesting that the F_1 populations produced fewer culls than did their respective parent populations. However, no significant differences were found between F_1 population means and their respective midparent means. Additive gene action appears to control this trait. No apparent low-parent heterosis was observed (Table 54).

Table 53. Analysis of variance of individual plant data for the trait number of cull pepper fruit, third harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.19	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	1.05
Cross	8	0.49	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	2.72*
Cross*Replications	14	0.78	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	4.33
Error	48	0.18	σ^2_e	σ^2_e	
Total[b]	73				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 73 due to missing data.

*Significant at the 5 percent level.

Table 54. Number of plants, mean, standard deviation, midparent mean, direction of dominance, low-parent heterosis, and standard deviation of low-parent heterosis for the trait number of cull pepper fruit per plant, third harvest

Cross	Number of plants (n)	Mean ($\bar{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{X}$-mp)	Low-plant heterosis (L')	Standard deviation of L'
Fordhook x Fordhook	17	0.82	1.13	--	--	--	--
Golden Calwonder x Golden Calwonder	1	0.00	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	1	1.00	0.00	--	--	--	--
Pip x Pip	1	0.00	0.00	--	--	--	--
Delaware Belle x Delaware Belle	3	0.00	0.00	--	--	--	--
Golden Calwonder x Fordhook	6	0.83	1.33	0.41	0.42	--	--
Calwonder 300 x Fordhook	12	0.00	0.00	0.91	-0.91	1.00	1.20
Calwonder 300 x Golden Calwonder	2	0.00	0.00	0.50	-0.50	0.00	--
Pip x Fordhook	7	0.28	0.49	0.41	-0.13	--	--
Pip x Golden Calwonder	6	0.17	0.41	0.00	0.17	--	--
Pip x Calwonder 300	0	0.00	0.00	0.50	-0.50	0.00	--
Delaware Belle x Fordhook	17	0.23	0.75	0.41	-0.18	--	--
Delaware Belle x Golden Calwonder	8	0.00	0.00	0.00	0.00	0.00	--
Delaware Belle x Calwonder 300	6	0.00	0.00	0.50	-0.50	0.00	--
Delaware Belle x Pip	10	0.00	0.00	0.00	0.00	0.00	--

No significant differences were observed for either general or specific combining ability effects. Parent and F_1 means for number of cull pepper fruit per plant, third harvest, are listed in Table 55. No significant difference was observed among parent means. The data suggest that the 'Golden Calwonder' x 'Fordhook' population produced significantly more cull pepper fruit than other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. Based on these assumptions, the genotypic, phenotypic, and additive genetic variances were estimated as 0.05, 0.45, and 0.04, respectively. Both broad and narrow sense heritability estimates were calculated as 11 and 9 percent, respectively.

Total harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots suggests that significant differences exist between F_1 population means for total number of cull pepper fruit (Table 56). Various parent and F_1 population statistics are presented in Table 57. Generally, the direction of dominance values are positive, suggesting that the F_1 populations produced more culls than their respective parent populations. No significant differences were found between F_1 population means and their respective midparent means. This suggests that gene action is basically additive. No significant low-parent heterosis was observed for this trait.

No significant differences were found among general or specific combining ability estimates. Parent and F_1 means for total number of cull

Table 55. Parent and F_1 means for the trait number of cull pepper fruit per plant, third harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		0.83 a	0.00 b	0.28 b	0.23 b	0.82 a
	Golden Calwonder			0.00 b	0.17 b	0.00 b	0.00 a
	Calwonder 300				--	0.00 b	1.00 a
	Pip					0.00 b	0.00 a
	Delaware Belle						0.00 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 56. Analysis of variance of individual plant data for the trait total number of cull pepper fruit

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	1.91	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	1.44
Cross	9	6.27	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	4.71**
Cross*Replications	27	1.48	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.11
Error	225	1.33	σ^2_e	σ^2_e	
Total[b]	264				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 264 due to missing data.

**Significant at the 1 percent level.

Table 57. Number of plants, mean, standard deviation, midparent mean, direction of dominance, low-parent heterosis, and standard deviation of low-parent heterosis for the trait total number of cull pepper fruit per plant

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	Low-plant heterosis (L')	Standard deviation of L'
Fordhook x Fordhook	28	1.78	1.29	--	--	--	--
Golden Calwonder x Golden Calwonder	25	0.52	0.92	--	--	--	--
Calwonder 300 x Calwonder 300	10	0.40	0.52	--	--	--	--
Pip x Pip	19	0.26	0.56	--	--	--	--
Delaware Belle x Delaware Belle	23	0.22	0.52	--	--	--	--
Golden Calwonder x Fordhook	28	1.39	1.66	1.15	0.24	-1.67	1.77
Calwonder 300 x Fordhook	27	0.59	1.18	1.09	-0.50	-0.47	2.64
Calwonder 300 x Golden Calwonder	27	0.96	1.53	0.46	0.50	-1.40	2.40
Pip x Fordhook	27	0.70	1.03	1.02	-0.32	-1.69	7.24
Pip x Golden Calwonder	25	0.76	1.33	0.39	0.37	-1.92	9.05
Pip x Calwonder 300	23	0.17	0.39	0.33	-0.16	0.35	13.79
Delaware Belle x Fordhook	28	1.68	1.39	1.00	0.68	-6.64	224.13
Delaware Belle x Golden Calwonder	28	0.71	1.05	0.37	0.34	-2.23	17.14
Delaware Belle x Calwonder 300	25	0.12	0.33	0.31	-0.19	0.45	21.19
Delaware Belle x Pip	27	0.52	0.75	0.24	0.28	-1.36	7.72

pepper fruit per plant are presented in Table 58. A Duncan's Multiple Range test revealed that 'Fordhook' produced significantly more cull pepper fruit than the other parent populations. The F_1 population 'Delaware Belle' x 'Fordhook' produced significantly more cull pepper fruit than other F_1 populations.

Heritability estimates were produced to determine what percentage of the phenotypic variability was genetic. These estimates may be calculated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 0.25, 1.58, and 0.18, respectively. Broad and narrow sense heritability estimates were calculated as 16 and 11 percent, respectively.

Discussion

It has been shown that 'Fordhook' consistently produced more cull pepper fruit than did the other parents. The hybrid population with the most cull pepper fruit was 'Delaware Belle' x 'Fordhook'.

Additive gene action is the primary control for this trait. In Table 57, the direction of dominance values are generally positive, however, none of the F_1 means differed significantly from its midparent mean. In addition, there was no significant low-parent heterosis for this trait.

No significant differences were found between either general or specific combining ability estimates. The overall mean ($\overline{X}$) for number of cull pepper fruit for individual F_1 plants was 0.78.

Heritability estimates for number of cull pepper fruit varied from 8 to 11 percent for broad sense heritability, and from 1 to 9 percent for

Table 58. Parent and F_1 means for the trait total number of cull pepper fruit per plant

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		1.39 ab	0.59 cd	0.70 cd	1.68 a	1.78 a
	Golden Calwonder			0.96 bc	0.76 bcd	0.71 cd	0.52 b
	Calwonder 300				0.17 d	0.12 d	0.40 b
	Pip					0.52 cd	0.26 b
	Delaware Belle						0.22 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

narrow sense heritability. Broad and narrow sense heritability estimates for total number of cull pepper fruit were 16 and 11 percent, respectively. Using the narrow sense heritability estimate, the response to selection, R, can be determined (5). The response to selection represents the difference between the mean of the original population and the mean of the selected population. The expected response to selection is given by the relationship

$$R = (h^2)(i)(\sigma_p),$$

where

h^2 is narrow sense heritability,

i is the selection intensity, and

σ_p is the phenotypic standard deviation.

Table 59 provides a comparison of R values for two selection intensities. Decreasing the number of cull pepper fruit by established breeding methods may be accomplished at a fairly rapid rate at high selection intensities.

Table 59. Response to selection for total number of cull pepper fruit per plant

Narrow sense heritability	σ_p	Percent saved	i	Response to selection (R)
11.00%	1.26	5%	2.06	0.28
11.00%	1.26	1%	2.66	0.37

Because heritabilities are variance ratios, the estimation of them may be subject to considerable error. In addition, certain model assumptions must be met for analysis of variance components to correctly predict additive and dominance variances. Both the analysis of plot means and the analysis of individual plant data assume a random selection of parental lines (7, 15). In addition, the Griffing diallel analysis assumes there is no epistasis (7). The first assumption, random selection of parental lines, was met. However, because a regression of the covariance on the variance was not performed, it is not certain that the second assumption was met. Therefore, the validity of heritability estimates may be questioned. These estimates do show that the amount of environmental variation is large compared to the amount of additive or dominance variance. It may be concluded that fairly rapid progress due to selection for fewer cull pepper fruit per plant may be expected.

Cull Pepper Fruit Weight per Plant

First harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 60. There was no significant difference between crosses for weight of culls in the first harvest period. Various parent and F_1 population statistics are presented in Table 61. Direction of dominance values were generally positive. Seventy percent of the F_1 population means were significantly different from their associated midparent means. This strongly suggests that this trait is controlled by dominant gene action. There was no significant low-parent heterosis in this harvest.

Table 60. Analysis of variance of individual plant data for the trait cull pepper fruit weight, first harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.37	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	18.50
Cross	9	0.03	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	1.50
Cross*Replications	23	0.01	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	0.50
Error	120	0.02	σ^2_e	σ^2_e	
Total[b]	155				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 155 due to msising data.

Table 61. Number of plants, mean, standard deviation, midparent mean, direction of dominance, low-parent heterosis, and standard deviation of low-parent heterosis for the trait cull pepper fruit weight (lbs.) per plant, first harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	Low-parent heterosis (L')	Standard deviation of L'
Fordhook x Fordhook	9	0.09	0.14	--	--	--	--
Golden Calwonder x Golden Calwonder	13	0.00	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	3	0.00	0.00	--	--	--	--
Pip x Pip	11	0.07	0.24	--	--	--	--
Delaware Belle x Delaware Belle	8	0.00	0.00	--	--	--	--
Golden Calwonder x Fordhook	22	0.09	0.18	0.04	0.05**	--	--
Calwonder 300 x Fordhook	10	0.09	0.15	0.04	0.05**	--	--
Calwonder 300 x Golden Calwonder	17	0.45	0.11	0.00	0.45**	--	--
Pip x Fordhook	13	0.00	0.00	0.08	-0.08**	1.00	--
Pip x Golden Calwonder	17	0.09	0.25	0.03	0.06**	--	--
Pip x Calwonder 300	12	0.00	0.00	0.03	-0.03	0.00	--
Delaware Belle x Fordhook	19	0.15	0.20	0.04	0.11**	--	--
Delaware Belle x Golden Calwonder	23	0.04	0.12	0.00	0.04	--	--
Delaware Belle x Calwonder 300	4	0.00	0.00	0.00	0.00	0.00	--
Delaware Belle x Pip	19	0.09	0.21	0.03	0.06**	--	--

*Significant at the 5 percent level.

**Significant at the 1 percent level.

Table 62. Analysis of variance for general and specific combining ability for the trait cull pepper fruit weight, first harvest

Source	Degrees of freedom	Mean square	F[a]
GCA	4	0.002	0.50
SCA	5	0.004	4.00**
Error	28	0.001	

[a]Random model assumed.

**Significant at the 1 percent level.

No significant differences were found among general combining ability estimates. However, highly significant differences were observed between specific combining ability estimates (Table 62). This suggests that some combinations produced a significantly lower cull weight than others. General and specific combining ability estimates and their associated variances are presented in Tables 63 and 64. Parent and F_1 means for cull pepper fruit weight per plant, first harvest, are listed in Table 65. A Duncan's Multiple Range test shows that no significant differences exist between parents. However, the F_1 population 'Delaware Belle' x 'Fordhook' produced a significantly higher cull pepper fruit weight than did three other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates can be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. Based on data from Table 62, the genotypic variance was

Table 63. Estimates of general combining ability and its associated variance for the trait cull pepper fruit weight, first harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.03	0.06
Golden Calwonder	0.01	-0.02
Calwonder 300	-0.03	0.06
Pip	-0.02	0.01
Delaware Belle	0.01	-0.02

[a] $\sigma^2 g_i$ = -0.001, S.E. = 0.0005.

[b] Multiply by 10^{-2} for actual values.

Table 64. Estimates of specific combining ability and its associated variance for the trait cull pepper fruit weight, first harvest

Parent	Specific combining ability (s_{ij}) [a]				σ^2_{sca} [b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	-0.01	0.03	-0.07	0.05	0.21
Golden Calwonder		0.01	0.04	-0.04	0.04
Calwonder 300			-0.01	-0.04	0.02
Pip				0.04	0.20
Delaware Belle					0.17

[a] $\sigma^2 s_{ij}$ = 0.004, S.E. = 0.006.

[b] Multiply by 10^{-2} for actual values.

Table 65. Parent and F_1 means for the trait cull pepper fruit weight (lbs.) per plant, first harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		0.09 ab	0.09 ab	0.00 b	0.15 a	0.09 a
	Golden Calwonder			0.05 ab	0.09 ab	0.04 ab	0.00 a
	Calwonder 300				0.00 b	0.00 b	0.00 a
	Pip					0.09 ab	0.07 a
	Delaware Belle						0.00 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

estimated as $\sigma^2_G = 2\sigma^2_g + \sigma^2_s = 0.01$, and the phenotypic variance was estimated as $\sigma^2_p = \sigma^2_G + \sigma^2_e = 0.025$. An estimate of -0.002 was produced for the additive genetic variance, σ^2_a. From the estimates above, broad sense heritability was calculated as 4 percent. Since σ^2_g was negative, narrow sense heritability could not be estimated.

Second harvest

Highly significant differences were found between crosses for the trait cull pepper fruit weight, second harvest (Table 66). Direction of dominance values were generally positive, although there was no significant difference between F_1 population means and their respective midparent values. This suggests that additive gene action predominates. No significant low-parent heterosis was observed (Table 67).

Neither general nor specific combining ability effects were significant for this harvest. Parent and F_1 means for cull pepper fruit weight, second harvest, are listed in Table 68. In contrast to the first harvest, 'Fordhook' produced significantly heavier cull fruit than did two other parents. Two F_1 populations, 'Pip' x 'Calwonder 300' and 'Delaware Belle' x 'Calwonder 300', produced significantly less cull weight than did three other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. Based on these assumptions, the genotypic, phenotypic, and additive genetic variances were estimated as 0.01, 0.13, and 0.01,

Table 66. Analysis of variance of individual plant data for the trait cull pepper fruit weight, second harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.05	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	0.38
Cross	9	0.32	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	2.46**
Cross*Replications	27	0.25	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.92
Error	206	0.13	σ^2_e	σ^2_e	
Total[b]	245				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 245 due to missing data.

**Significant at the 1 percent level.

Table 67. Number of plants, mean, standard deviation, midparent mean, direction of dominance, low-parent heterosis, and standard deviation of low-parent heterosis for the trait cull pepper fruit weight (lbs.) per plant, second harvest

Cross	Number of plants (n)	Mean ($\bar{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{X}$-mp)	Low-parent heterosis (L')	Standard deviation of L'
Fordhook x Fordhook	27	0.31	0.34	--	--	--	--
Golden Calwonder x Golden Calwonder	22	0.20	0.34	--	--	--	--
Calwonder 300 x Calwonder 300	7	0.18	0.23	--	--	--	--
Pip x Pip	16	0.09	0.20	--	--	--	--
Delaware Belle x Delaware Belle	20	0.10	0.23	--	--	--	--
Golden Calwonder x Fordhook	25	0.38	0.53	0.25	0.13	-0.90	1.25
Calwonder 300 x Fordhook	27	0.19	0.42	0.24	-0.05	-0.05	1.99
Calwonder 300 x Golden Calwonder	21	0.36	0.47	0.19	0.17	-1.00	1.44
Pip x Fordhook	27	0.23	0.34	0.20	0.03	-1.55	2.85
Pip x Golden Calwonder	22	0.19	0.39	0.14	0.05	-1.11	2.51
Pip x Calwonder 300	20	0.07	0.17	0.13	-0.06	0.22	3.94
Delaware Belle x Fordhook	28	0.37	0.39	0.20	0.17	-2.70	4.93
Delaware Belle x Golden Calwonder	26	0.24	0.41	0.15	0.09	-1.40	2.69
Delaware Belle x Calwonder 300	25	0.06	0.15	0.14	-0.08	0.40	4.30
Delaware Belle x Pip	25	0.16	0.27	0.09	0.07	-0.78	2.56

Table 68. Parent and F_1 means for the trait cull pepper fruit weight (lbs.) per plant, second harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		0.38 a	0.19 ab	0.23 ab	0.37 a	0.31 a
	Golden Calwonder			0.36 a	0.19 ab	0.24 ab	0.20 ab
	Calwonder 300				0.07 b	0.06 b	0.18 ab
	Pip					0.16 ab	0.09 b
	Delaware Belle						0.10 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

respectively. From these estimates, both broad and narrow sense heritability estimates were calculated as 8 percent.

Third harvest

No significant differences were found between crosses for the trait cull pepper fruit weight, third harvest (Table 69). Half of the direction of dominance values were positive. In addition, only one F_1 mean was significantly lower than its associated midparent value for this trait. Gene action appears to be additive with partial dominance for low cull pepper fruit weight. No significant low-parent heterosis was observed (Table 70).

No significant differences were observed for either general or specific combining ability effects. Parent and F_1 means for cull pepper fruit weight per plant, third harvest, are listed in Table 71. No significant difference was observed among parent means. The data suggest that the F_1 population 'Golden Calwonder' x 'Fordhook' produced a heavier cull pepper fruit weight than other F_1 populations.

Heritability estimates were produced to determine what percentage of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. Based on these assumptions, the genotypic, phenotypic, and additive genetic variances were estimated as 0.004, 0.03, and 0.004, respectively. Both broad and narrow sense heritability estimates were calculated as 13 percent.

Table 69. Analysis of variance of individual plant data for the trait cull pepper fruit weight, third harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.01	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	0.50
Cross	8	0.04	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	2.00
Cross*Replications	14	0.05	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	2.50
Error	48	0.02	σ^2_e	σ^2_e	
Total[b]	73				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 73 due to missing data.

Table 70. Number of plants, mean, standard deviation, midparent mean, direction of dominance, low-parent heterosis, and standard deviation of low-parent heterosis for the trait cull pepper fruit weight (lbs.) per plant, third harvest

Cross	Number of plants (n)	Mean ($\bar{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{X}$-mp)	Low-parent heterosis (L')	Standard deviation of L'
Fordhook x Fordhook	17	0.18	0.26	--	--	--	--
Golden Calwonder x Golden Calwonder	1	0.00	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	1	0.50	0.00	--	--	--	--
Pip x Pip	1	0.00	0.00	--	--	--	--
Delaware Belle x Delaware Belle	3	0.00	0.00	--	--	--	--
Golden Calwonder x Fordhook	6	0.22	0.34	0.09	0.13	--	--
Calwonder 300 x Fordhook	12	0.00	0.00	0.34	-0.34*	1.00	1.45
Calwonder 300 x Golden Calwonder	2	0.00	0.00	0.25	-0.25	0.00	--
Pip x Fordhook	7	0.13	0.24	0.09	0.04	--	--
Pip x Golden Calwonder	6	0.05	0.12	0.00	0.05	--	--
Pip x Calwonder 300	0	0.00	0.00	0.25	-0.25	0.00	--
Delaware Belle x Fordhook	17	0.06	0.20	0.09	-0.03	--	--
Delaware Belle x Golden Calwonder	8	0.00	0.00	0.00	0.00	0.00	--
Delaware Belle x Calwonder 300	6	0.00	0.00	0.25	-0.25	0.00	--
Delaware Belle x Pip	10	0.00	0.00	0.00	0.00	0.00	--

*Significant at the 5 percent level.

Table 71. Parent and F_1 means for the trait cull pepper fruit weight (lbs.) per plant, third harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent mean[b]
Male parent	Fordhook		0.22 a	0.00 b	0.13 ab	0.06 b	0.18 a
	Golden Calwonder			0.00 b	0.05 b	0.00 b	0.00 a
	Calwonder 300				--	0.00 b	0.50 a
	Pip					0.00 b	0.00 a
	Delaware Belle						0.00 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Total harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots suggests that highly significant differences exist between F_1 population means for total cull pepper fruit weight (Table 72). Various parent and F_1 population statistics are presented in Table 73. Generally, the direction of dominance values are positive, suggesting that the F_1 populations produced heavier culls than their respective parent populations. No significant differences were found between F_1 population means and their respective midparent means. This suggests that gene action is basically additive. Significant low-parent heterosis was observed for two F_1 populations, 'Pip' x 'Calwonder 300' and 'Delaware Belle' x 'Calwonder 300'. This suggests that those two F_1 populations yielded a significantly lower cull pepper fruit weight than their respective low parent.

No significant differences were found among general or specific combining ability estimates. Parent and F_1 means for total cull pepper fruit weight per plant are presented in Table 74. A Duncan's Multiple Range test revealed that 'Fordhook' produced significantly heavier cull pepper fruit than the other parent populations. The F_1 population 'Delaware Belle' x 'Fordhook' produced significantly heavier cull pepper fruit than other F_1 populations.

Heritability estimates were produced to determine what percentage of the phenotypic variability was genetic. These estimates may be calculated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 0.02, 0.18, and 0.02,

Table 72. Analysis of variance of individual plant data for the trait total cull pepper fruit weight

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.16	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	1.00
Cross	9	0.53	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	3.31**
Cross*Replications	27	0.18	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.12
Error	225	0.16	σ^2_e	σ^2_e	
Total[b]	264				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 264 due to missing data.

**Significant at the 1 percent level.

Table 73. Number of plants, mean, standard deviation, midparent mean, direction of dominance, low-parent heterosis, and standard deviation of low-parent heterosis for the trait total cull pepper fruit weight (lbs.) per plant

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	Low-parent heterosis (L')	Standard deviation of L'
Fordhook x Fordhook	28	0.44	0.34	--	--	--	--
Golden Calwonder x Golden Calwonder	25	0.18	0.32	--	--	--	--
Calwonder 300 x Calwonder 300	10	0.18	0.23	--	--	--	--
Pip x Pip	19	0.11	0.25	--	--	--	--
Delaware Belle x Delaware Belle	23	0.09	0.22	--	--	--	--
Golden Calwonder x Fordhook	28	0.45	0.58	0.31	0.14	-1.50	1.54
Calwonder 300 x Fordhook	27	0.22	0.44	0.31	-0.09	-0.22	1.98
Calwonder 300 x Golden Calwonder	27	0.31	0.48	0.18	0.13	-0.72	1.33
Pip x Fordhook	27	0.26	0.36	0.27	-0.01	-1.36	3.73
Pip x Golden Calwonder	25	0.24	0.45	0.14	0.10	-1.18	3.40
Pip x Calwonder 300	23	0.06	0.16	0.14	-0.08	0.45**	10.23
Delaware Belle x Fordhook	28	0.50	0.40	0.26	0.24	-4.55	67.18
Delaware Belle x Golden Calwonder	28	0.26	0.41	0.13	0.13	-1.89	8.84
Delaware Belle x Calwonder 300	25	0.06	0.15	0.13	-0.07	0.33*	13.68
Delaware Belle x Pip	27	0.21	0.31	0.10	0.11	-1.33	5.48

*Significant at the 5 percent level.

**Significant at the 1 percent level.

Table 74. Parent and F_1 means for the trait total cull pepper fruit weight (lbs.) per plant

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		0.45 ab	0.22 bc	0.26 bc	0.50 a	0.44 a
	Golden Calwonder			0.31 abc	0.24 bc	0.26 bc	0.18 b
	Calwonder 300				0.06 c	0.06 c	0.18 b
	Pip					0.21 bc	0.11 b
	Delaware Belle						0.09 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

respectively. Both broad and narrow sense heritability estimates were calculated as 11 percent.

Discussion

Many conclusions may be drawn from the analyses about the inheritance of cull pepper fruit weight. 'Fordhook' was shown to be the least desirable parent for reduced cull weight. Other parents were not significantly different from one another. 'Pip' x 'Calwonder 300' and 'Delaware Belle' x 'Calwonder 300' were the best hybrids for low cull pepper fruit weight, while 'Delaware Belle' x 'Fordhook' was the worst hybrid.

Gene action was primarily additive. In Table 73, the direction of dominance values were usually positive, but no F_1 means differed significantly from their midparent means. In addition, significant low-parent heterosis was present for this trait, which suggests that some F_1 populations yielded a significantly smaller cull pepper fruit weight than their respective low parent.

No significant differences were found between either general or specific combining ability estimates. The overall mean ($\bar{X}$) for cull pepper fruit weight for individual F_1 plants was 0.25 lbs.

Heritability estimates for cull pepper fruit weight varied from 4 to 13 percent for broad sense heritability, and from 8 to 13 percent for narrow sense heritability. Broad and narrow sense heritability estimates for total cull pepper fruit weight were both 11 percent. Using the narrow sense heritability estimate, the response to selection, R, can be determined (5). The response to selection represents the difference between the mean of the original population and the mean of the selected population.

The expected response to selection is given by the relationship

$$R = (h^2)(i)(\sigma_p),$$

where

h^2 is narrow sense heritability,

i is the selection intensity, and

σ_p is the phenotypic standard deviation.

Table 75 provides a comparison of R values for two selection intensities. Decreasing the cull pepper fruit weight by established breeding methods may be accomplished at a fairly rapid rate if the selection intensity is high.

Table 75. Response to selection for total cull pepper fruit weight (lbs.) per plant

Narrow sense heritability	σ_p	Percent saved	i	Response to selection (R)
11.00%	0.42	5%	2.06	0.09
11.00%	0.42	1%	2.66	0.12

Because heritabilities are variance ratios, the estimation of them may be subject to considerable error. In addition, certain model assumptions must be met for analysis of variance components to correctly predict additive and dominance variances. Both the analysis of plot means and the analysis of individual plant data assume a random selection of parental lines (7, 15). In addition, the Griffing diallel analysis assumes there is no epistasis (7). The first assumption, random selection of parental lines, was met. However, because a regression of the covariance on the

Table 76. Analysis of variance of individual plant data for the trait pepper fruit length, first harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	1.52	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	1.67
Cross	9	8.75	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	9.61**
Cross*Replications	23	1.74	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.91
Error	120	0.91	σ^2_e	σ^2_e	
Total[b]	155				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 155 due to missing data.

**Significant at the 1 percent level.

Table 77. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait pepper fruit length (cm)

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	9	8.72	0.95	--	--	--	--
Golden Calwonder x Golden Calwonder	13	10.28	1.20	--	--	--	--
Calwonder 300 x Calwonder 300	3	9.00	0.70	--	--	--	--
Pip x Pip	11	8.77	1.35	--	--	--	--
Delaware Belle x Delaware Belle	8	9.64	0.51	--	--	--	--
Golden Calwonder x Fordhook	22	10.57	0.90	9.50	1.07**	0.03	0.10
Calwonder 300 x Fordhook	10	8.94	1.21	8.86	0.08	-0.01	0.10
Calwonder 300 x Golden Calwonder	17	9.87	1.22	9.64	0.23	-0.04	0.10
Pip x Fordhook	13	8.84	0.68	8.74	0.10	0.01	0.14
Pip x Golden Calwonder	17	9.58	0.99	9.52	0.06	-0.07	0.14
Pip x Calwonder 300	12	9.61	1.05	8.88	0.73	0.07	0.14
Delaware Belle x Fordhook	19	10.24	1.17	9.18	1.06*	0.06	0.20
Delaware Belle x Golden Calwonder	23	10.95	0.89	9.96	0.99*	0.06	0.14
Delaware Belle x Calwonder 300	4	8.15	0.48	9.32	-1.17	-0.15	0.17
Delaware Belle x Pip	19	10.35	1.14	9.20	1.15*	0.07	0.20

*Significant at the 5 percent level.

**Significant at the 1 percent level.

the variance was not performed, it is not certain that the second assumption was met. Therefore, the validity of heritability estimates may be questioned. These estimates show that the amount of environmental variation is large compared to the amount of additive or dominance variance. It may be concluded that fairly rapid progress due to selection for reduced cull pepper fruit weight per plant may be expected.

Pepper Fruit Length

First harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 76. Highly significant differences were found among crosses. Direction of dominance values were generally positive. Several F_1 population means significantly exceeded their respective midparent means. This suggests that dominant genes were present for pepper fruit length. However, gene action is basically additive (Table 77).

Table 78. Analysis of variance for general and specific combining ability for the trait pepper fruit length, first harvest

Source	Degrees of freedom	Mean square	F^a
GCA	4	0.89	1.37
SCA	5	0.65	10.83**
Error	28	0.06	

[a]Random model assumed.

**Significant at the 1 percent level.

Highly significant differences were observed among specific combining ability estimates (Table 78). This suggests that some combinations produced significantly longer fruit than others. General and specific combining ability estimates and their associated variances are presented in Tables 79 and 80. The parent 'Golden Calwonder' had the best general combining ability of all the parents, which was more than double that of 'Delaware Belle'. Parent and F_1 means for pepper fruit length, first harvest, are presented in Table 81. A Duncan's Multiple Range test revealed that among parent means, 'Golden Calwonder' significantly exceeds two others. The F_1 mean of 'Delaware Belle' x 'Golden Calwonder' significantly surpassed most other F_1 means for pepper fruit length. 'Delaware Belle' x 'Calwonder 300' produced significantly shorter pepper fruit than most other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 78). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 0.75, 1.72, and 0.16, respectively. From these estimates, broad sense heritability was estimated as 44 percent, while narrow sense heritability was estimated as 9 percent.

Second harvest

Significant differences were found among crosses for this trait (Table 82). Half of the direction of dominance values were positive. Two of the F_1 population means were significantly different from their respective midparent means. This indicates that some dominant genes are present.

Table 79. Estimates of general combining ability and its associated variance for the trait pepper fruit length, first harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	-0.08	- 0.35
Golden Calwonder	0.71	49.42
Calwonder 300	-0.76	56.77
Pip	-0.15	1.26
Delaware Belle	0.28	6.85

[a] $\sigma^2 g_i$ = 0.08, S.E. = 0.20.

[b] Multiply by 10^{-2} for actual values.

Table 80. Estimates of specific combining ability and its associated variance for the trait pepper fruit length, first harvest

	Specific combining ability (s_{ij}) [a]				
Parent	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	σ^2_{sca} [b]
Fordhook	0.23	0.07	-0.64	0.33	16.74
Golden Calwonder		0.20	-0.69	0.24	18.42
Calwonder 300			0.81	-1.09	60.50
Pip				0.51	57.59
Delaware Belle					51.35

[a] $\sigma^2 s_{ij}$ = 0.59, S.E. = 0.98.

[b] Multiply by 10^{-2} for actual values.

Table 81. Parent and F_1 means for the trait pepper fruit length (cm), first harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		10.57 ab	8.94 ef	8.84 ef	10.24 bcd	8.72 b
	Golden Calwonder			9.87 cd	9.58 de	10.95 a	10.28 a
	Calwonder 300				9.61 cde	8.15 f	9.00 ab
	Pip					10.35 abc	8.77 b
	Delaware Belle						9.64 ab

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 82. Analysis of variance of individual plant data for the trait pepper fruit length, second harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.42	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	0.54
Cross	9	7.53	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	9.65**
Cross*Replications	27	1.30	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.67
Error	206	0.78	σ^2_e	σ^2_e	
Total[b]	245				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 245 due to missing data.

**Significant at the 1 percent level.

Table 83. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait pepper fruit length (cm), second harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	27	8.95	0.66	--	--	--	--
Golden Calwonder x Golden Calwonder	22	9.75	0.82	--	--	--	--
Calwonder 300 x Calwonder 300	7	9.77	0.78	--	--	--	--
Pip x Pip	16	10.23	1.87	--	--	--	--
Delaware Belle x Delaware Belle	20	10.54	1.03	--	--	--	--
Golden Calwonder x Fordhook	25	10.18	0.94	9.35	0.83*	0.04	0.10
Calwonder 300 x Fordhook	27	9.07	0.72	9.36	-0.29	-0.07	0.07
Calwonder 300 x Golden Calwonder	21	9.72	0.97	9.76	-0.04	-0.01	0.08
Pip x Fordhook	27	9.76	0.55	9.59	0.17	-0.04	0.08
Pip x Golden Calwonder	22	9.80	1.35	9.99	-0.19	-0.04	0.08
Pip x Calwonder 300	20	9.64	0.90	10.00	-0.36	-0.06	0.08
Delaware Belle x Fordhook	28	10.16	0.78	9.74	0.42	-0.04	0.08
Delaware Belle x Golden Calwonder	26	10.65	0.87	10.14	0.51	0.01	0.08
Delaware Belle x Calwonder 300	25	9.34	0.79	10.15	-0.81*	-0.11	0.07
Delaware Belle x Pip	25	10.80	1.14	10.38	0.42	0.02	0.08

*Significant at the 5 percent level.

Table 84. Parent and F_1 means for the trait pepper fruit length (cm), second harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		10.18 bc	9.07 e	9.76 cd	10.16 bc	8.95 c
	Golden Calwonder			9.72 cd	9.80 cd	10.65 ab	9.75 bc
	Calwonder 300				9.64 cd	9.34 de	9.77 abc
	Pip					10.80 a	10.23 ab
	Delaware Belle						10.54 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

However, it appears that additive gene action predominates (Table 83).

Neither GCA nor SCA estimates were significantly different for this harvest. Parent and F_1 means for pepper fruit length, second harvest, are listed in Table 84. Significant differences exist between parental lines. 'Fordhook' was significantly shorter and 'Delaware Belle' was significantly longer than two other cultivars. Among F_1 populations, 'Delaware Belle' x 'Pip' produced significantly longer peppers. In contrast, the population 'Calwonder 300' x 'Fordhook' produced significantly shorter peppers when compared to the other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates can be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. Based on these assumptions, the genotypic, phenotypic, and additive genetic variances were estimated as 0.33, 1.19, and 0.26, respectively. Using these data, both broad and narrow sense heritabilities were estimated as 28 and 22 percent, respectively.

Third harvest

An analysis of variance table based on a fixed model using individual plant data from F_1 plots showed no significant differences among crosses (Table 85). Direction of dominance values were generally negative. One F_1 population mean was significantly different from its midparent mean. However, this was due to the fact that this cross produced no fruit. Therefore, this significance does not indicate the presence of dominance.

Table 85. Analysis of variance of individual plant data for the trait pepper fruit length, third harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	4.73	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	3.64
Cross	8	1.21	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	0.93
Cross*Replications	14	2.59	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.99
Error	48	1.30	σ^2_e	σ^2_e	
Total[b]	73				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 73 due to missing data.

Table 86. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait pepper fruit length (cm), third harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	17	8.18	0.59	--	--	--	--
Golden Calwonder x Golden Calwonder	1	10.20	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	1	8.60	0.00	--	--	--	--
Pip x Pip	1	8.40	0.00	--	--	--	--
Delaware Belle x Delaware Belle	3	10.27	1.01	--	--	--	--
Golden Calwonder x Fordhook	6	8.87	2.15	9.19	-0.32	-0.13	0.14
Calwonder 300 x Fordhook	12	8.69	0.63	8.39	0.30	0.01	0.14
Calwonder 300 x Golden Calwonder	2	9.50	0.85	9.40	0.10	-0.07	0.14
Pip x Fordhook	7	9.28	1.47	8.29	0.99	0.10	0.14
Pip x Golden Calwonder	6	8.90	1.07	9.30	-0.40	-0.13	0.14
Pip x Calwonder 300	0	0.00	0.00	8.50	-8.50**	-1.00	0.10
Delaware Belle x Fordhook	17	9.54	1.33	9.22	0.32	-0.07	0.14
Delaware Belle x Golden Calwonder	8	9.72	1.09	10.23	-0.51	-0.05	0.14
Delaware Belle x Calwonder 300	6	8.82	0.63	9.43	-0.61	-0.14	0.14
Delaware Belle x Pip	10	9.07	1.73	9.33	-0.26	-0.12	0.14

**Significant at the 1 percent level.

Additive gene action appears to control pepper fruit length in the third harvest (Table 86).

Highly significant differences were found among specific combining ability estimates (Table 87). This suggests that some combinations produced significantly longer fruit than others. General and specific combining ability estimates and their associated variances are presented in Tables 88 and 89. Parent and F_1 means for pepper fruit length, third harvest, are presented in Table 90. 'Delaware Belle' was significantly longer than 3 other lines, and 'Fordhook' was significantly shorter than 2 other lines. There was no significant difference among F_1 means for this trait.

Heritability estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 87). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 8.79, 9.88, and 1.14, respectively. From these estimates broad sense heritability was estimated as 89 percent, while narrow sense heritability was estimated as 11 percent.

Table 87. Analysis of variance for general and specific combining ability for the trait pepper fruit length, third harvest

Source	Degrees of freedom	Mean square	F[a]
GCA	4	9.46	1.22
SCA	5	7.74	86.00**
Error	28	0.09	

[a]Random model assumed.

**Significant at the 1 percent level.

Table 88. Estimates of general combining ability and its associated variance for the trait pepper fruit length, third harvest

Parent	General combining ability $(g_i)^a$	σ^2_{gca} [b]
Fordhook	1.14	128.31
Golden Calwonder	1.34	177.91
Calwonder 300	-1.98	390.39
Pip	-1.90	359.35
Delaware Belle	1.40	194.35

[a] $\sigma^2 g_i$ = 0.57, S.E. = 2.19.

[b] Multiply by 10^{-2} for actual values.

Table 89. Estimates of specific combining ability and its associated variance for the trait pepper fruit length, third harvest

	Specific combining ability (s_{ij}) [a]				
Parent	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	σ^2_{sca} [b]
Fordhook	-1.86	1.29	1.80	-1.24	325.91
Golden Calwonder		1.90	1.22	-1.26	334.06
Calwonder 300			-4.36	1.16	850.18
Pip				1.33	846.10
Delaware Belle					203.86

[a] $\sigma^2 s_{ij}$ = 7.65, S.E. = 10.59

[b] Multiply by 10^{-2} for actual values.

Table 90. Parent and F_1 means for the trait pepper fruit length (cm), third harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		8.87 a	8.69 a	9.28 a	9.54 a	8.18 c
	Golden Calwonder			9.50 a	8.90 a	9.72 a	10.20 ab
	Calwonder 300				--	8.82 a	8.60 bc
	Pip					9.07 a	8.40 bc
	Delaware Belle						10.27 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Total harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots suggests that highly significant differences exist between F_1 population means for total pepper fruit length (Table 91). Various parent and F_1 population statistics are presented in Table 92. Generally, the direction of dominance values are positive, suggesting that the F_1 populations produced longer peppers than their respective parent populations. The population 'Golden Calwonder' x 'Fordhook' significantly exceeded its midparent mean, which suggests that partial dominance may be present for longer pepper fruit. However, it appears that additive gene action predominates for this trait. No apparent high-parent heterosis was observed.

No significant differences were found among general or specific combining ability estimates. Parent and F_1 means for total pepper fruit length are presented in Table 93. A Duncan's Multiple Range test showed that 'Delaware Belle' produced longer fruit than 3 other parental lines. In contrast, 'Fordhook' produced shorter fruit than all other parental lines. The F_1 population 'Delaware Belle' x 'Golden Calwonder' produced significantly longer fruit than other F_1 populations, while 'Calwonder 300' x 'Fordhook' produced significantly shorter fruit than other F_1 populations.

Heritability estimates were produced to determine what percentage of the phenotypic variability was genetic. These estimates may be calculated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. From this analysis, the genotypic, phenotypic, and additive

Table 91. Analysis of variance of individual plant data for the trait total pepper fruit length

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	1.64	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	1.53
Cross	9	14.08	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	13.16**
Cross*Replications	27	2.19	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	2.05
Error	436	1.07	σ^2_e	σ^2_e	
Total[b]	475				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 839 to 475 due to missing data.

**Significant at the 1 percent level.

Table 92. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait total pepper fruit length (cm)

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	53	8.67	0.76	--	--	--	--
Golden Calwonder x Golden Calwonder	36	9.95	0.98	--	--	--	--
Calwonder 300 x Calwonder 300	11	9.45	0.81	--	--	--	--
Pip x Pip	28	9.59	1.79	--	--	--	--
Delaware Belle x Delaware Belle	31	10.28	0.98	--	--	--	--
Golden Calwonder x Fordhook	53	10.19	1.20	9.31	0.88**	0.02	--
Calwonder 300 x Fordhook	49	8.95	0.82	9.06	-0.11	-0.05	0.14
Calwonder 300 x Golden Calwonder	40	9.77	1.06	9.70	0.07	-0.02	--
Pip x Fordhook	47	9.43	0.86	9.13	0.30	-0.02	--
Pip x Golden Calwonder	45	9.60	1.20	9.77	-0.17	-0.03	--
Pip x Calwonder 300	32	9.63	0.94	9.52	0.11	0.00	--
Delaware Belle x Fordhook	64	10.02	1.09	9.47	0.55	-0.02	--
Delaware Belle x Golden Calwonder	57	10.64	0.98	10.11	0.53	0.03	--
Delaware Belle x Calwonder 300	35	9.11	0.82	9.86	-0.75	-0.11	--
Delaware Belle x Pip	54	10.32	1.39	9.93	0.39	0.00	--

**Significant at the 1 percent level.

Table 93. Parent and F_1 means for the trait total pepper fruit length (cm)

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		10.19 bc	8.95 g	9.43 ef	10.02 bcd	8.67 c
	Golden Calwonder			9.77 cde	9.60 def	10.64 a	9.95 ab
	Calwonder 300				9.63 def	9.11 fg	9.45 b
	Pip					10.32 ab	9.59 b
	Delaware Belle						10.28 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

genetic variances were estimated as 0.27, 1.41, and 0.18, respectively. Broad and narrow sense heritability estimates were then calculated as 19 and 13 percent, respectively.

Discussion

Many conclusions may be drawn from the analyses about the inheritance of length of fruit in peppers. It was shown that 'Delaware Belle' was the best parent for producing longer fruit, while 'Fordhook' was the best parent for producing shorter fruit. Among F_1 hybrids, 'Delaware Belle' x 'Golden Calwonder' produced longer fruit, while 'Calwonder 300' x 'Fordhook' produced shorter fruit.

The primary gene action seems to be additive with partial dominance for longer fruit. This agrees with the findings of Milkova (16). In Table 92, the direction of dominance values were usually positive, and one F_1 mean was significantly different from its midparent mean. In addition, no high-parent heterosis was observed for this trait.

No significant differences were found between either general or specific combining ability estimates. The overall mean ($\overline{X}$) for pepper fruit length for individual F_1 plants was 9.83 cm.

Heritability estimates for pepper fruit length varied from 28 to 89 percent for broad sense heritability, and from 9 to 22 percent for narrow sense heritability. Broad and narrow sense heritability estimates for total pepper fruit length were 19 and 13 percent, respectively. Using the narrow sense heritability estimate, the response to selection, R, can be determined (5). The response to selection represents the difference between the mean of the original population and the mean of the selected population. The expected response to selection is given by the relationship

$$R = (h^2)(i)(\sigma_p),$$

where

h^2 is narrow sense heritability,

i is the selection intensity, and

σ_p is the phenotypic standard deviation.

Table 94 provides a comparison of R values for two selection intensities. Obviously, increasing fruit length would be a slow process, even at high selection intensities.

Table 94. Response to selection for total pepper fruit length (cm)

Narrow sense heritability	σ_p	Percent saved	i	Response to selection (R)
13.00%	1.19	5%	2.06	0.32
13.00%	1.19	1%	2.66	0.41

Because heritabilities are variance ratios, their estimation may be subject to considerable error. In addition, certain model assumptions must be met for analysis of variance components to correctly predict additive and dominance variances. Both the analysis of plot means and the analysis of individual plant data assume a random selection of parental lines (7, 15). In addition, the Griffing diallel analysis assumes there is no epistasis (7). The first assumption, random selection of parental lines, was met. However, because a regression of the covariance on the variance was not performed, it is not certain that the second assumption was met. Therefore, the validity of heritability estimates may be questioned. The estimates do show that the amount of environmental variation is large compared to the amount of additive and dominance variance. Thus, it may be concluded that progress due to selection for longer fruit will be slow.

Pepper Fruit Diameter

First harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 95. Highly significant differences were found between crosses. Direction of dominance values were generally positive, suggesting that F_1 population means were larger than their midparent means for this trait. No F_1 populations were significantly different from their midparent means, which suggests that additive genes are controlling this trait (Table 96). Significant differences were observed among general combining ability estimates, which suggests that one or more parents produced fruit of significantly larger diameter than was expected. Highly significant differences were observed among specific combining ability estimates, which suggests that some combinations produced fruit of significantly larger diameter than others (Table 97).

General and specific combining ability estimates and their associated variances are presented in Tables 98 and 99. The parents 'Calwonder 300' and 'Pip' were much better general combiners than the other parents. Parent and F_1 means for pepper fruit diameter, first harvest, are

Table 95. Analysis of variance of individual plant data for the trait pepper fruit diameter, first harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	2	0.36	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	0.73
Cross	9	2.81	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	5.73**
Cross*Replications	16	0.37	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	0.75
Error	86	0.49	σ^2_e	σ^2_e	
Total[b]	113				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 113 due to missing data.

**Significant at the 1 percent level.

Table 96. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis, for the trait pepper fruit diameter (cm), first harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	8	7.12	0.84	--	--	--	--
Golden Calwonder x Golden Calwonder	11	7.50	0.56	--	--	--	--
Calwonder 300 x Calwonder 300	3	7.90	0.17	--	--	--	--
Pip x Pip	9	8.24	0.86	--	--	--	--
Delaware Belle x Delaware Belle	8	7.25	0.55	--	--	--	--
Golden Calwonder x Fordhook	16	6.85	0.72	7.31	-0.46	-0.09	0.06
Calwonder 300 x Fordhook	6	8.15	0.73	7.51	0.64	0.03	0.04
Calwonder 300 x Golden Calwonder	11	7.95	0.67	7.70	0.25	0.01	0.04
Pip x Fordhook	13	7.81	0.81	7.68	0.13	-0.05	0.04
Pip x Golden Calwonder	11	8.22	0.58	7.87	0.35	0.00	0.04
Pip x Calwonder 300	11	8.39	0.67	8.07	0.32	0.02	0.04
Delaware Belle x Fordhook	12	7.39	0.71	7.18	0.21	0.02	0.06
Delaware Belle x Golden Calwonder	18	7.38	0.67	7.37	0.01	-0.02	0.06
Delaware Belle x Calwonder 300	4	7.97	0.53	7.57	0.40	0.01	0.04
Delaware Belle x Pip	12	7.80	0.61	7.74	0.06	-0.05	0.04

Table 97. Analysis of variance for general and specific combining ability for the trait pepper fruit diameter, first harvest

Source	Degrees of freedom	Mean square	F^a
GCA	4	0.39	5.57*
SCA	5	0.07	7.00**
Error	28	0.01	

[a]Random model assumed.

*Significant at the 5 percent level.

**Significant at the 1 percent level.

listed in Table 100. The parental line 'Pip' produced a significantly larger fruit diameter than 3 other parents. Among F_1 populations, 'Pip' x 'Golden Calwonder' and 'Pip' x 'Calwonder 300' produced significantly larger fruit diameters than 3 other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 97). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 0.28, 0.76, and 0.22, respectively. From these estimates, broad sense heritability was estimated as 37 percent, while narrow sense heritability was estimated as 29 percent.

Second harvest

Significant differences were found among crosses for this trait (Table 101). Half of the direction of dominance values were positive, even

Table 98. Estimates of general combining ability and its associated variance for the trait pepper fruit diameter, first harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	-0.32	9.79
Golden Calwonder	-0.25	5.80
Calwonder 300	0.43	18.04
Pip	0.35	11.80
Delaware Belle	-0.21	3.96

[a] $\sigma^2 g_i$ = 0.11, S.E. = 0.09.

[b] Multiply by 10^{-2} for actual values.

Table 99. Estimates of specific combining ability and its associated variance for the trait pepper fruit diameter, first harvest

Parent	Specific combining ability (s_{ij}) [a]				
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	σ^2_{sca} [b]
Fordhook	-0.37	0.24	-0.02	0.12	5.84
Golden Calwonder		-0.02	0.33	0.05	7.16
Calwonder 300			-0.19	-0.05	2.09
Pip				-0.14	4.37
Delaware Belle					-0.03

[a] $\sigma^2 s_{ij}$ = 0.06, S.E. = 0.21.

[b] Multiply by 10^{-2} for actual values.

Table 100. Parent and F_1 means for the trait pepper fruit diameter (cm), first harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		6.85 d	8.15 ab	7.81 abc	7.39 bcd	7.12 b
	Golden Calwonder			7.95 abc	8.22 a	7.38 cd	7.50 b
	Calwonder 300				8.39 a	7.97 abc	7.90 ab
	Pip					7.80 abc	8.24 a
	Delaware Belle						7.25 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 101. Analysis of variance of individual plant data for the trait pepper fruit diameter, second harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	1.38	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	2.42
Cross	9	5.60	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	9.82**
Cross*Replications	27	1.33	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	2.33
Error	206	0.57	σ^2_e	σ^2_e	
Total[b]	245				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 245 due to missing data.

**Significant at the 1 percent level.

Table 102. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait pepper fruit diameter (cm), second harvest

Cross	Number of plants (n)	Mean ($\bar{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{X}$-mp)	High parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	27	7.20	0.58	--	--	--	--
Golden Calwonder x Golden Calwonder	22	8.51	0.66	--	--	--	--
Calwonder 300 x Calwonder 300	7	8.70	1.03	--	--	--	--
Pip x Pip	16	9.23	0.49	--	--	--	--
Delaware Belle x Delaware Belle	20	8.20	0.91	--	--	--	--
Golden Calwonder x Fordhook	25	7.42	0.74	7.85	-0.43	-0.13	0.10
Calwonder 300 x Fordhook	27	8.47	0.74	7.95	0.52	-0.03	0.10
Calwonder 300 x Golden Calwonder	21	8.51	0.65	8.60	-0.09	-0.02	0.10
Pip x Fordhook	27	8.22	0.85	8.21	0.01	-0.11	0.10
Pip x Golden Calwonder	22	8.63	0.91	8.87	-0.24	-0.06	0.10
Pip x Calwonder 300	20	8.90	0.83	8.96	-0.06	-0.03	0.10
Delaware Belle x Fordhook	28	7.84	0.74	7.70	0.14	-0.04	0.10
Delaware Belle x Golden Calwonder	26	8.16	1.01	8.35	-0.19	-0.04	0.10
Delaware Belle x Calwonder 300	25	8.90	0.67	8.45	0.45	0.02	0.10
Delaware Belle x Pip	25	8.76	0.95	8.71	0.05	-0.05	0.10

though none of the F_1 population means were significantly different from their midparent means. This suggests that gene action is primarily additive. No significant high-parent heterosis was observed for this harvest (Table 102).

Table 103. Analysis of variance for general and specific combining ability for the trait pepper fruit diameter, second harvest

Source	Degrees of freedom	Mean square	F[a]
GCA	4	0.47	15.67**
SCA	5	0.03	0.60
Error	28	0.05	

[a]Random model assumed.

**Significant at the 1 percent level.

The analysis of variance for general and specific combining ability is presented in Table 103. Highly significant differences were observed between GCA estimates, which suggests that one or more parents produced fruit of significantly larger diameter than was expected. General and specific combining ability estimates and their associated variances are presented in Tables 104 and 105. The parent 'Calwonder 300' was the best general combiner of all the parents in this study. Parent and F_1 means for pepper fruit diameter, second harvest, are presented in Table 106. The mean fruit diameter of the parent 'Pip' was significantly larger than that of the 3 other parental lines. In contrast, the mean

Table 104. Estimates of general combining ability and its associated variance for the trait pepper fruit diameter, second harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	-0.52	26.40
Golden Calwonder	-0.27	6.65
Calwonder 300	0.42	17.00
Pip	0.33	10.25
Delaware Belle	0.04	- 0.48

[a] $\sigma^2 g_i$ = 0.15, S.E. = 0.11.

[b] Multiply by 10^{-2} for actual values.

Table 105. Estimates of specific combining ability and its associated variance for the trait pepper fruit diameter, second harvest

Parent	Specific combining ability (s_{ij}) [a]				
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	σ^2_{sca} [b]
Fordhook	-0.17	0.20	0.04	-0.06	0.87
Golden Calwonder		-0.02	0.19	0.00	0.58
Calwonder 300			-0.23	0.06	1.63
Pip				0.01	1.42
Delaware Belle					-1.36

[a] $\sigma^2 s_{ij}$ = -0.02, S.E. = 0.69.

[b] Multiply by 10^{-2} for actual values.

Table 106. Parent and F_1 means for the trait pepper fruit diameter (cm), second harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		7.42 d	8.47 ab	8.22 bc	7.84 c	7.20 c
	Golden Calwonder			8.51 ab	8.63 ab	8.16 bc	8.51 b
	Calwonder 300				8.90 a	8.90 a	8.70 ab
	Pip					8.76 a	9.23 a
	Delaware Belle						8.20 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

fruit diameter of the parent 'Fordhook' was significantly smaller than that of all other parental lines. Significant differences were present between F_1 populations for fruit diameter. The population 'Golden Calwonder' x 'Fordhook' produced a significantly smaller mean fruit diameter than all other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 103). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 0.28, 0.84, and 0.30, respectively. From these estimates, broad sense heritability was estimated as 33 percent, while narrow sense heritability was estimated as 36 percent.

Third harvest

Significant differences were found between crosses for this harvest (Table 107). Direction of dominance values were mostly negative, which means that F_1 population means were smaller than their midparent means for this trait. One F_1 population mean was significantly different from its midparent mean. However, this was because that particular cross produced no fruit. Therefore, this significance does not indicate the presence of dominance. These data suggest that additive gene action controls the trait pepper fruit diameter in this harvest. No significant high-parent heterosis was observed (Table 108).

Highly significant differences were found among specific combining ability estimates, suggesting that some combinations produced fruit of significantly larger diameters than others (Table 109). General and specific

Table 107. Analysis of variance of individual plant data for the trait pepper fruit diameter, third harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.17	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_c + ac\phi(b)$	0.27
Cross	8	1.67	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	2.65*
Cross*Replications	14	0.70	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_c + c\phi(bv)$	1.11
Error	48	0.63	σ^2_e	σ^2_e	
Total[b]	73				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 73 due to missing data.

*Significant at the 5 percent level.

Table 108. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait pepper fruit diameter (cm), third harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	17	6.56	0.60	--	--	--	--
Golden Calwonder x Golden Calwonder	1	8.10	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	1	9.30	0.00	--	--	--	--
Pip x Pip	1	9.00	0.00	--	--	--	--
Delaware Belle x Delaware Belle	3	7.67	0.85	--	--	--	--
Golden Calwonder x Fordhook	6	6.60	0.61	7.33	-0.73	-0.18	0.07
Calwonder 300 x Fordhook	12	7.67	0.63	7.93	-0.26	-0.17	0.05
Calwonder 300 x Golden Calwonder	2	8.05	0.07	8.70	-0.65	-0.13	0.05
Pip x Fordhook	7	7.28	1.16	7.78	-0.50	-0.19	0.14
Pip x Golden Calwonder	6	7.48	0.73	8.55	-1.07	-0.17	0.14
Pip x Calwonder 300	0	0.00	0.00	9.15	-9.15**	-1.00	0.04
Delaware Belle x Fordhook	17	7.29	1.02	7.11	0.18	-0.05	0.08
Delaware Belle x Golden Calwonder	8	7.15	0.54	7.88	-0.73	-0.12	0.07
Delaware Belle x Calwonder 300	6	8.43	0.79	8.48	-0.05	-0.09	0.06
Delaware Belle x Pip	10	7.69	0.42	8.33	-0.64	-0.14	0.14

**Significant at the 1 percent level.

Table 109. Analysis of variance for general and specific combining ability for the trait pepper fruit diameter, third harvest

Source	Degrees of freedom	Mean square	F[a]
GCA	4	4.17	0.57
SCA	5	7.28	364.00**
Error	28	0.02	

[a]Random model assumed.

**Significant at the 1 percent level.

combining ability estimates and their associated variances are presented in Tables 110 and 111. 'Delaware Belle' had the best general combining ability of all the parental lines in this study. Parent and F_1 means for pepper fruit diameter, third harvest, are presented in Table 112. The parental mean of 'Fordhook' was significantly smaller than that of every other cultivar. The F_1 population mean of 'Delaware Belle' x 'Calwonder 300' was significantly larger than that of 4 other F_1 populations.

Heritability estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 109). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 5.18, 5.75, and -2.08, respectively. From these estimates, broad sense heritability was calculated as 90 percent. Narrow sense heritability could not be estimated, since σ^2_g was negative.

Table 110. Estimates of general combining ability and its associated variance for the trait pepper fruit diameter, third harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.59	34.22
Golden Calwonder	0.74	54.17
Calwonder 300	-0.97	93.50
Pip	-1.53	233.50
Delaware Belle	1.17	136.30

[a]$\sigma^2 g_i$ = -1.04, S.E. = 0.96.

[b]Multiply by 10^{-2} for actual values.

Table 111. Estimates of specific combining ability and its associated variance for the trait pepper fruit diameter, third harvest

Parent	Specific combining ability (s_{ij}) [a]				
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	σ^2_{sca} [b]
Fordhook	-1.50	1.28	1.45	-1.24	249.48
Golden Calwonder		1.51	1.51	-1.53	303.57
Calwonder 300			-4.26	1.46	805.12
Pip				1.29	805.01
Delaware Belle					254.34

[a]$\sigma^2 s_{ij}$ = 7.26, S.E. = 8.54.

[b]Multiply by 10^{-2} for actual values.

Table 112. Parent and F_1 means for the trait pepper fruit diameter (cm), third harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		6.60 b	7.67 ab	7.28 b	7.29 b	6.56 b
	Golden Calwonder			8.05 ab	7.48 ab	7.15 b	8.10 a
	Calwonder 300				--	8.43 a	9.30 a
	Pip					7.69 ab	9.00 a
	Delaware Belle						7.67 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 113. Analysis of variance of individual plant data for the trait total pepper fruit diameter

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	1.29	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_b + ac\phi(b)$	1.98
Cross	9	10.74	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	16.52**
Cross*Replications	27	1.52	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	2.34
Error	394	0.65	σ^2_e	σ^2_e	
Total[b]	433				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 839 to 433 due to missing data.

**Significant at the 1 percent level.

Table 114. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait total pepper fruit diameter (cm)

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	52	6.98	0.68	--	--	--	--
Golden Calwonder x Golden Calwonder	34	8.17	0.77	--	--	--	--
Calwonder 300 x Calwonder 300	11	8.54	0.92	--	--	--	--
Pip x Pip	26	8.88	0.78	--	--	--	--
Delaware Belle x Delaware Belle	31	7.91	0.91	--	--	--	--
Golden Calwonder x Fordhook	47	7.12	0.78	7.57	-0.45*	-0.13	--
Calwonder 300 x Fordhook	45	8.22	0.78	7.76	0.46	-0.04	--
Calwonder 300 x Golden Calwonder	34	8.30	0.68	8.35	-0.05	-0.03	--
Pip x Fordhook	47	7.97	0.93	7.93	0.04	-0.10	--
Pip x Golden Calwonder	39	8.33	0.88	8.52	-0.19	-0.06	--
Pip x Calwonder 300	31	8.72	0.80	8.71	0.01	-0.02	--
Delaware Belle x Fordhook	57	7.58	0.85	7.44	0.14	-0.04	0.14
Delaware Belle x Golden Calwonder	52	7.73	0.94	8.04	-0.31	-0.05	--
Delaware Belle x Calwonder 300	35	8.71	0.73	8.22	0.49	0.02	--
Delaware Belle x Pip	47	8.29	0.92	8.39	-0.10	-0.07	--

*Significant at the 5 percent level.

Total harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 113. Highly significant differences were found between crosses. Half of the direction of dominance values were positive. One F_1 mean was significantly different from its mid-parent mean, which suggests that partial dominance may be present. However, additive gene action predominates for this trait. No significant high-parent heterosis was observed (Table 114).

Table 115. Analysis of variance for general and specific combining ability for the trait total pepper fruit diameter

Source	Degrees of freedom	Mean square	F^a
GCA	4	0.53	17.67**
SCA	5	0.03	0.60
Error	28	0.05	

[a]Random model assumed.

**Significant at the 1 percent level.

Significant differences were observed between general combining ability estimates (Table 115). This suggests that one or more parents produced fruit of significantly larger diameter than was expected. General and specific combining ability estimates and their associated variances are presented in Tables 116 and 117. The parent 'Calwonder 300' had the best general combining ability. Parent and F_1 means for total pepper fruit

Table 116. Estimates of general combining ability and its associated variance for the trait total pepper fruit diameter

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	-0.50	24.33
Golden Calwonder	-0.30	8.33
Calwonder 300	0.52	26.37
Pip	0.31	8.94
Delaware Belle	-0.03	- 0.58

[a] $\sigma^2 g_i$ = 0.17, S.E. = 0.12.

[b] Multiply by 10^{-2} for actual values.

Table 117. Estimates of specific combining ability and its associated variance for the trait total pepper fruit diameter

Parent	Specific combining ability (s_{ij}) [a]				
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	σ^2_{sca} [b]
Fordhook	-0.18	0.10	0.06	0.00	-0.14
Golden Calwonder		-0.02	0.22	-0.04	1.09
Calwonder 300			-0.21	0.11	0.55
Pip				-0.09	1.80
Delaware Belle					-0.94

[a] $\sigma^2 s_{ij}$ = -0.02, S.E. = 2.54.

[b] Multiply by 10^{-2} for actual values.

Table 118. Parent and F_1 means for the trait total pepper fruit diameter (cm)

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		7.12 e	8.22 b	7.97 bc	7.58 d	6.98 d
	Golden Calwonder			8.30 ab	8.33 ab	7.73 cd	8.17 bc
	Calwonder 300				8.72 a	8.71 a	8.54 ab
	Pip					8.29 b	8.88 a
	Delaware Belle						7.91 c

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

diameter are listed in Table 118. Among parental populations, 'Pip' produced fruit of significantly larger diameter than 3 other parents, while 'Fordhook' produced fruit of significantly smaller diameter than all other parents of this study. Two F_1 populations, 'Pip' x 'Calwonder 300' and 'Delaware Belle' x 'Calwonder 300' produced fruit of significantly larger diameter than 6 other F_1 populations. In contrast, 'Golden Calwonder' x 'Fordhook' produced fruit of significantly smaller diameter than every other F_1 population.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 115). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 0.32, 1.03, and 0.34, respectively. From these estimates, broad sense heritability was estimated as 31 percent, while narrow sense heritability was estimated as 33 percent.

Discussion

It has been shown that 'Pip' consistently produced fruit of larger diameter, and that 'Fordhook' consistently produced fruit of smaller diameter than the other parents in this study. The F_1 populations with the largest fruit diameter were 'Pip' x 'Calwonder 300' and 'Delaware Belle' x 'Calwonder 300'. In contrast, 'Golden Calwonder' x 'Fordhook' produced the smallest fruit diameter among F_1 populations.

Gene action was largely additive with partial dominance for smaller fruit diameter. In Table 114, half of the direction of dominance values were negative, and one F_1 mean was significantly smaller than its midparent mean. In addition, there was no significant high-parent heterosis for the trait pepper fruit diameter.

Significant differences were found between general combining ability estimates, which suggests that one or more parents produced fruit of significantly larger diameter than was expected (Table 115). Analyses of mean plant data provide estimates of the general and specific combining abilities of each line and cross (Tables 116 and 117). The values obtained can be interpreted as follows. The overall mean ($\overline{X}$) for pepper fruit diameter for individual F_1 plants was 8.03 cm. The mean for any cross (parents i and j) is predicted as follows:

$$\overline{X}_{ij} = \overline{X} + g_i + g_j + s_{ij},$$

where g_i and g_j are the general combining abilities of the two lines, and s_{ij} is specific combining ability (24). 'Calwonder 300' and 'Pip' can be expected to increase the overall mean. In contrast, 'Fordhook', 'Golden Calwonder', and 'Delaware Belle' can be expected to decrease the overall mean.

Heritability estimates for pepper fruit diameter varied from 33 to 90 percent for broad sense heritability, and from 29 to 36 percent for narrow sense heritability. Legg and Lippert (12) found a broad sense heritability of 90.79 percent. Broad and narrow sense heritability estimates for total pepper fruit diameter were 31 and 33 percent, respectively. Using the narrow sense heritability estimate, the response to selection, R, can be determined (5). The response to selection represents the difference between the mean of the original population and the mean of the selected population. The expected response to selection is given by the relationship

$$R = (h^2)(i)(\sigma_p),$$

where

h^2 is narrow sense heritability,

i is the selection intensity, and

σ_p is the phenotypic standard deviation.

Table 119 provides a comparison of R values for two selection intensities. Evidently, increasing fruit diameter would be a slow process, even at high selection intensities.

Table 119. Response to selection for total pepper fruit diameter (cm)

Narrow sense heritability	σ_p	Percent saved	i	Response to selection (R)
33.00%	1.01	5%	2.06	0.69
33.00%	1.01	1%	2.66	0.89

Because heritabilities are variance ratios, their estimation may be subject to considerable error. In addition, certain model assumptions must be met for analysis of variance components to correctly predict additive and dominance variances. Both the analysis of plot means and the analysis of individual plant data assume a random selection of parental lines (7, 15). In addition, the Griffing diallel analysis assumes there is no epitasis (7). The first assumption, random selection of parental lines, was met. However, because a regression of the covariance on the variance was not performed, it is not certain that the second assumption was met. Therefore, the validity of heritability estimates may be questioned. These estimates do show that the amount of environmental variation is large compared with the amount of genetic variance. It may be concluded that progress in increasing pepper fruit diameter as a result of selection will be slow.

Number of Pepper Lobes per Fruit

First harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 120. Highly significant differences were found between crosses. Direction of dominance values were generally positive, although no significant differences were found between F_1 population means and their respective midparent means. This suggests that gene action is primarily additive. No significant high-parent heterosis was observed in this harvest period (Table 121).

Significant differences were observed among specific combining ability estimates (Table 122). This suggests that some combinations produced significantly more pepper lobes than others. General and specific combining ability estimates and their associated variances are presented in Tables 123 and 124. Parent and F_1 means for number of pepper lobes per fruit, first harvest, are listed in Table 125. 'Pip' produced significantly more lobes than 3 other parents. The populations 'Pip' x 'Fordhook' and 'Delaware Belle' x 'Calwonder 300' produced significantly more lobes than

Table 120. Analysis of variance of individual plant data for the trait number of pepper lobes, first harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.45	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	1.36
Cross	9	1.40	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	4.24**
Cross*Replications	23	0.49	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.48
Error	120	0.33	σ^2_e	σ^2_e	
Total[b]	155				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 155 due to missing data.

**Significant at the 1 percent level.

Table 121. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait number of pepper lobes per fruit, first harvest

Cross	Number of plants (n)	Mean ($\bar{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	9	3.05	0.84	--	--	--	--
Golden Calwonder x Golden Calwonder	13	2.84	0.31	--	--	--	--
Calwonder 300 x Calwonder 300	3	2.67	0.58	--	--	--	--
Pip x Pip	11	3.41	0.66	--	--	--	--
Delaware Belle x Delaware Belle	8	2.81	0.37	--	--	--	--
Golden Calwonder x Fordhook	22	2.60	0.69	2.94	-0.34	-0.15	0.14
Calwonder 300 x Fordhook	10	3.18	0.58	2.86	0.32	0.04	0.14
Calwonder 300 x Golden Calwonder	17	2.83	0.55	2.75	0.08	0.00	0.14
Pip x Fordhook	13	3.33	0.47	3.23	0.10	-0.02	0.14
Pip x Golden Calwonder	17	2.98	0.56	3.12	-0.14	-0.13	0.14
Pip x Calwonder 300	12	3.12	0.61	3.04	0.08	-0.08	0.14
Delaware Belle x Fordhook	19	2.47	0.68	2.93	-0.46	-0.19	0.14
Delaware Belle x Golden Calwonder	23	2.88	0.63	2.82	0.06	0.01	0.14
Delaware Belle x Calwonder 300	4	3.62	0.48	2.74	0.88	0.29	0.17
Delaware Belle x Pip	19	3.16	0.50	3.11	0.05	-0.07	0.14

Table 122. Analysis of variance for general and specific combining ability for the trait number of pepper lobes, first harvest

Source	Degrees of freedom	Mean square	F[a]
GCA	4	0.13	1.30
SCA	5	0.10	5.00**
Error	28	0.02	

[a]Random model assumed.

**Significant at the 1 percent level.

several other F_1 populations. In contrast, 'Delaware Belle' x 'Fordhook' produced significantly fewer lobes than most other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 122). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 0.10, 0.41, and 0.02, respectively. Broad and narrow sense heritabilities were then estimated as 24 and 5 percent, respectively.

Second harvest

No significant differences were found between crosses during the second harvest (Table 126). Direction of dominance values were negative, which suggests that F_1 population means for number of pepper lobes were smaller than their respective midparent means. No F_1 population means were

Table 123. Estimates of general combining ability and its associated variance for the trait number of pepper lobes, first harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	-0.16	2.21
Golden Calwonder	-0.26	6.41
Calwonder 300	0.23	4.94
Pip	0.17	2.54
Delaware Belle	0.02	-0.31

[a] $\sigma^2 g_i$ = 0.01, S.E. = 0.03.

[b] Multiply by 10^{-2} for actual values.

Table 124. Estimates of specific combining ability and its associated variance for the trait number of pepper lobes, first harvest

Parent	Specific combining ability (s_{ij}) [a]				σ^2_{sca} [b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	0.01	0.10	0.30	-0.40	7.80
Golden Calwonder		-0.15	0.05	0.10	0.30
Calwonder 300			-0.30	0.36	7.53
Pip				-0.05	5.29
Delaware Belle					9.20

[a] $\sigma^2 s_{ij}$ = 0.08, S.E. = 0.26.

[b] Multiply by 10^{-2} for actual values.

Table 125. Parent and F_1 means for the trait number of pepper lobes per fruit, first harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		2.60 cd	3.18 ab	3.33 a	2.47 d	3.05 ab
	Golden Calwonder			2.83 bcd	2.98 abc	2.88 bc	2.85 b
	Calwonder 300				3.12 ab	3.62 a	2.67 b
	Pip					3.16 ab	3.41 a
	Delaware Belle						2.81 b

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

significantly different from their midparent means. This suggests that additive gene action predominates (Table 127).

Neither GCA nor SCA estimates were significantly different in this harvest period. Parent and F_1 means for number of pepper lobes per fruit, second harvest, are presented in Table 128. There were no significant differences between parental lines. The F_1 population 'Golden Calwonder' x 'Fordhook' produced significantly fewer lobes than 4 other F_1 populations.

Heritability estimates may be generated from mean plant data if a random model is assumed for GCA-SCA analysis of variance. Based on these assumptions, the genotypic, phenotypic, and additive genetic variances were estimated as 0.00, 0.23, and 0.00. Since both σ^2_g and σ^2_s were zero, neither broad sense nor narrow sense heritability could be estimated.

Third harvest

No significant differences were found between crosses for this harvest period (Table 129). Direction of dominance values were generally negative, which means that F_1 population means were smaller than their respective midparent means for this trait. One F_1 mean was significantly different from its midparent mean. This occurred because that particular cross produced no fruit. Therefore, dominant gene action is absent and additive gene action predominates for this trait (Table 130).

Highly significant differences were observed between SCA estimates (Table 131). This suggests that some combinations produced more pepper lobes than others. General and specific combining ability estimates and their associated variances are presented in Tables 132 and 133. Parent and F_1 means for number of pepper lobes per fruit, third harvest, are

Table 126. Analysis of variance of individual plant data for the trait number of pepper lobes, second harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.43	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	1.95
Cross	9	0.39	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	1.77
Cross*Replications	27	0.29	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.32
Error	206	0.22	σ^2_e	σ^2_e	
Total[b]	245				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 245 due to missing data.

Table 127. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait number of pepper lobes per fruit, second harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	27	3.17	0.30	--	--	--	--
Golden Calwonder x Golden Calwonder	22	3.08	0.45	--	--	--	--
Calwonder 300 x Calwonder 300	7	3.21	0.70	--	--	--	--
Pip x Pip	16	3.10	0.69	--	--	--	--
Delaware Belle x Delaware Belle	20	3.21	0.59	--	--	--	--
Golden Calwonder x Fordhook	25	2.82	0.54	3.12	-0.30	-0.11	0.14
Calwonder 300 x Fordhook	27	3.16	0.40	3.19	-0.03	-0.01	0.14
Calwonder 300 x Golden Calwonder	21	2.97	0.39	3.14	-0.17	-0.07	0.14
Pip x Fordhook	27	3.12	0.42	3.13	-0.01	-0.01	0.14
Pip x Golden Calwonder	22	3.17	0.52	3.09	0.08	0.02	0.14
Pip x Calwonder 300	20	3.04	0.53	3.15	-0.11	-0.05	0.14
Delaware Belle x Fordhook	28	2.87	0.46	3.19	-0.32	-0.10	0.14
Delaware Belle x Golden Calwonder	26	3.08	0.40	3.14	-0.06	-0.04	0.14
Delaware Belle x Calwonder 300	25	3.16	0.50	3.21	-0.05	-0.01	0.14
Delaware Belle x Pip	25	3.07	0.59	3.15	-0.08	-0.04	0.14

Table 128. Parent and F_1 means for the trait number of pepper lobes per fruit, second harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male Parent	Fordhook		2.82 b	3.16 a	3.12 a	2.87 ab	3.17 a
	Golden Calwonder			2.97 ab	3.17 a	3.08 ab	3.08 a
	Calwonder 300				3.04 ab	3.16 a	3.21 a
	Pip					3.07 ab	3.10 a
	Delaware Belle						3.21 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 129. Analysis of variance of individual plant data for the trait number of pepper lobes, third harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.56	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	2.00
Cross	8	0.35	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	1.25
Cross*Replications	14	0.28	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.00
Error	48	0.28	σ^2_e	σ^2_e	
Total[b]	73				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 73 due to missing data.

Table 130. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait number of pepper lobes per fruit, third harvest

Cross	Number of plants (n)	Mean ($\bar{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\bar{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	17	3.23	0.36	--	--	--	--
Golden Calwonder x Golden Calwonder	1	3.00	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	1	4.00	0.00	--	--	--	--
Pip x Pip	1	4.00	0.00	--	--	--	--
Delaware Belle x Delaware Belle	3	3.17	1.04	--	--	--	--
Golden Calwonder x Fordhook	6	3.33	0.41	3.11	0.22	0.03	0.14
Calwonder 300 x Fordhook	12	3.42	0.47	3.61	-0.19	-0.14	0.10
Calwonder 300 x Golden Calwonder	2	3.25	0.35	3.50	-0.25	-0.19	0.10
Pip x Fordhook	7	3.21	0.39	3.61	-0.40	-0.20	0.10
Pip x Golden Calwonder	6	3.00	0.00	3.50	-0.50	-0.25	0.10
Pip x Calwonder 300	0	0.00	0.00	4.00	-4.00**	-1.00	0.06
Delaware Belle x Fordhook	17	3.04	0.77	3.20	-0.16	-0.06	0.14
Delaware Belle x Golden Calwonder	8	3.37	0.52	3.08	0.29	0.06	0.14
Delaware Belle x Calwonder 300	6	3.33	0.52	3.58	-0.25	-0.17	0.10
Delaware Belle x Pip	10	3.60	0.47	3.58	0.02	-0.10	0.10

**Significant at the 1 percent level, due to missing F_1 data.

Table 131. Analysis of variance for general and specific combining ability for the trait number of pepper lobes, third harvest

Source	Degrees of freedom	Mean square	F[a]
GCA	4	1.03	0.88
SCA	5	1.17	117.00**
Error	28	0.01	

[a]Random model assumed.

**Significant at the 1 percent level.

listed in Table 134. No significant differences were found between parents. The F_1 population 'Delaware Belle' x 'Pip' produced significantly more pepper lobes than 2 other F_1 populations.

Heritability estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 131). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 1.06, 1.33, and -0.10, respectively. From these estimates, broad sense heritability was estimated as 80 percent. Narrow sense heritability could not be estimated since σ^2_g was negative.

Total harvest

Highly significant differences were found between crosses for total number of pepper lobes (Table 135). Direction of dominance values were generally negative, suggesting that the F_1 population means were smaller than their respective midparent means for this trait. Two F_1 means were

Table 132. Estimates of general combining ability and its associated variance for the trait number of pepper lobes, third harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.39	14.94
Golden Calwonder	0.38	14.17
Calwonder 300	-0.61	36.94
Pip	-0.67	44.62
Delaware Belle	0.51	25.74

[a] $\sigma^2 g_i$ = -0.05, S.E. = 0.24.

[b] Multiply by 10^{-2} for actual values.

Table 133. Estimates of specific combining ability and its associated variance for the trait number of pepper lobes, third harvest

Parent	Specific combining ability (s_{ij}) [a]				σ^2_{sca} [b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	-0.40	0.67	0.53	-0.82	51.40
Golden Calwonder		0.52	0.33	-0.47	24.67
Calwonder 300			-1.68	0.47	124.75
Pip				0.80	127.74
Delaware Belle					57.80

[a] $\sigma^2 s_{ij}$ = 1.16, S.E. = 0.49.

[b] Multiply by 10^{-2} for actual values.

Table 134. Parent and F_1 means for the trait number of pepper lobes per fruit, third harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		3.33 ab	3.42 ab	3.21 ab	3.04 b	3.23 a
	Golden Calwonder			3.25 ab	3.00 b	3.37 ab	3.00 a
	Calwonder 300				--	3.33 ab	4.00 a
	Pip					3.60 a	4.00 a
	Delaware Belle						3.17 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 135. Analysis of variance of individual plant data for the trait total number of pepper lobes

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.15	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	0.52
Cross	9	1.49	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	5.14**
Cross*Replications	27	0.32	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.10
Error	436	0.29	σ^2_e	σ^2_e	
Total[b]	475				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 839 to 475 due to missing data.

**Significant at the 1 percent level.

Table 136. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait total number of pepper lobes per fruit

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	53	3.17	0.45	--	--	--	--
Golden Calwonder x Golden Calwonder	36	2.99	0.41	--	--	--	--
Calwonder 300 x Calwonder 300	11	3.14	0.71	--	--	--	--
Pip x Pip	28	3.25	0.69	--	--	--	--
Delaware Belle x Delaware Belle	31	3.11	0.60	--	--	--	--
Golden Calwonder x Fordhook	53	2.79	0.62	3.08	-0.29*	-0.12	0.14
Calwonder 300 x Fordhook	49	3.23	0.46	3.15	0.08	0.02	0.14
Calwonder 300 x Golden Calwonder	40	2.92	0.47	3.06	-0.14	-0.07	0.14
Pip x Fordhook	47	3.19	0.43	3.21	-0.02	-0.02	0.14
Pip x Golden Calwonder	45	3.08	0.50	3.12	-0.04	-0.05	0.14
Pip x Calwonder 300	32	3.07	0.55	3.19	-0.12	-0.05	0.14
Delaware Belle x Fordhook	64	2.80	0.65	3.14	-0.34**	-0.12	0.14
Delaware Belle x Golden Calwonder	57	3.04	0.54	3.05	-0.01	-0.02	0.14
Delaware Belle x Calwonder 300	35	3.24	0.51	3.12	0.12	0.03	0.14
Delaware Belle x Pip	54	3.20	0.57	3.18	0.02	-0.01	0.14

*Significant at the 5 percent level.

**Significant at the 1 percent level.

significantly smaller than their midparent means. This suggests that partial dominance for fewer pepper lobes may be present. However, additive gene action controls this trait (Table 136).

SCA estimates were significantly different (Table 137). GCA and SCA estimates and their associated variances are presented in Tables 138 and 139. Parent and F_1 means for total number of pepper lobes per fruit are presented in Table 140. No significant differences were observed between parent means. The F_1 populations 'Golden Calwonder' x 'Fordhook' and 'Delaware Belle' x 'Fordhook' produced significantly fewer lobes than most other F_1 populations.

Table 137. Analysis of variance for general and specific combining ability for the trait total number of pepper lobes

Source	Degrees of freedom	Mean square	F[a]
GCA	4	0.03	1.00
SCA	5	0.03	3.00*
Error	28	0.01	

[a]Random model assumed.

*Significant at the 5 percent level.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 137). Based on these assumptions, the genotypic, phenotypic, and additive genetic variances were estimated as 0.02, 0.31, and

Table 138. Estimates of general combining ability and its associated variance for the trait total number of pepper lobes

Parent	General combining ability (g_i)[a]	σ^2_{gca}[b]
Fordhook	-0.07	0.22
Golden Calwonder	-0.13	1.42
Calwonder 300	0.08	0.37
Pip	0.11	0.94
Delaware Belle	0.02	-0.23

[a] $\sigma^2 g_i$ = 0.00, S.E. = 0.00.

[b] Multiply by 10^{-2} for actual values.

Table 139. Estimates of specific combining ability and its associated variance for the trait total number of pepper lobes

Parent	Specific combining ability (s_{ij})[a]				σ^2_{sca}[b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	-0.06	0.17	0.10	-0.21	2.22
Golden Calwonder		0.09	0.05	0.10	0.14
Calwonder 300			-0.17	0.09	1.80
Pip				0.02	0.72
Delaware Belle					1.42

[a] $\sigma^2 s_{ij}$ = 0.02, S.E. = 0.62.

[b] Multiply by 10^{-2} for actual values.

Table 140. Parent and F_1 means for the trait total number of pepper lobes per fruit

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent mean[b]
Male parent	Fordhook		2.79 c	3.23 a	3.19 a	2.80 c	3.17 a
	Golden Calwonder			2.92 bc	3.08 ab	3.04 ab	2.99 a
	Calwonder 300				3.07 ab	3.24 a	3.14 a
	Pip					3.20 a	3.25 a
	Delaware Belle						3.11 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

0.00, respectively. From these estimates, broad sense heritability was estimated as 6 percent. Narrow sense heritability could not be estimated since σ^2_g was zero.

Discussion

Many conclusions may be drawn from the analyses about the inheritance of number of lobes in peppers. No significant difference was found between parents for this trait. Most F_1 populations were not significantly different, but 'Golden Calwonder' x 'Fordhook' and 'Delaware Belle' x 'Fordhook' produced significantly fewer lobes than other F_1 populations.

Additive gene action is predominant, with partial dominance for fewer lobes. In Table 136, the direction of dominance values were usually negative, and two F_1 means were significantly different from their midparent means. In addition, no significant high-parent heterosis was present for this trait.

Significant differences were found between specific combining ability estimates (Table 137). The overall mean ($\overline{X}$) for number of pepper lobes for individual F_1 plants was 3.04.

Heritability estimates for number of pepper lobes varied from 24 to 80 percent for broad sense heritability. The only narrow sense heritability estimate produced was 5 percent for the first harvest. The broad sense heritability estimate for total number of pepper lobes was 6 percent. Using the narrow sense heritability estimate, the response to selection, R, can be determined (5). The response to selection represents the difference between the mean of the original population and the mean of the selected population. The expected response to selection is given by the relationship

$$R = (h^2)(i)(\sigma_p),$$

where

h^2 is narrow sense heritability,

i is the selection intensity, and

σ_p is the phenotypic standard deviation.

Table 141 provides a comparison of R values for two selection intensities. Obviously, increasing the number of pepper lobes would be a very slow process, if at all possible, even at high selection intensities.

Table 141. Response to selection for total number of pepper lobes

Narrow sense heritability	σ_p	Percent saved	i	Response to selection (R)
5.00%	0.56	5%	2.06	0.06
5.00%	0.56	1%	2.66	0.07

Because heritabilities are variance ratios, their estimation may be subject to considerable error. In addition, certain model assumptions must be met for analysis of variance components to correctly predict additive and dominance variances. Both the analysis of plot means and the analysis of individual plant data assume a random selection of parental lines (7, 15). In addition, the Griffing diallel analysis assumes there is no epistasis (7). The first assumption, random selection of parental lines, was met. However, because a regression of the covariance on the variance was not performed, it is not certain that the second assumption was met. Therefore, the validity of heritability estimates may be questioned. These estimates do show that the amount of environmental variation is large compared to the amount of additive and dominance variance. It may be concluded that very little progress would be expected from selection for a greater number of pepper lobes.

Pepper Fruit Wall Thickness

First harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 142. There was no significant difference between crosses for pepper fruit wall thickness, first harvest. Direction of dominance values were generally positive, which means that the F_1 population means were larger than their midparent means for this trait. One F_1 population mean was significantly larger than its midparent mean, suggesting that partial dominance for thicker fruit walls may be present. However, additive genes appear to control this trait. No significant high-parent heterosis was observed in this harvest period (Table 143).

No significant differences between general or specific combining ability estimates were observed. No significant difference was observed between parent or F_1 population means when a Duncan's Multiple Range test was applied.

Table 142. Analysis of variance of individual plant data for the trait pepper fruit wall thickness, first harvest

Source	Degrees of freedom	Mean square	Expectations		F[a]
			Random model	Fixed model	
Replications	2	0.01	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	0.50
Cross	9	0.01	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	0.50
Cross*Replications	16	0.02	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.00
Error	86	0.02	σ^2_e	σ^2_e	
Total[b]	113				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 113 due to missing data.

Table 143. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait pepper fruit wall thickness (cm), first harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	8	0.62	0.10	--	--	--	--
Golden Calwonder x Golden Calwonder	11	0.65	0.14	--	--	--	--
Calwonder 300 x Calwonder 300	3	0.47	0.06	--	--	--	--
Pip x Pip	9	0.52	0.12	--	--	--	--
Delaware Belle x Delaware Belle	8	0.56	0.14	--	--	--	--
Golden Calwonder x Fordhook	16	0.62	0.10	0.63	-0.01	-0.05	0.14
Calwonder 300 x Fordhook	6	0.60	0.11	0.54	0.06	-0.03	0.14
Calwonder 300 x Golden Calwonder	11	0.61	0.13	0.56	0.05	-0.06	0.14
Pip x Fordhook	13	0.55	0.11	0.57	-0.02	-0.11	0.14
Pip x Golden Calwonder	11	0.58	0.15	0.58	0.00	-0.11	0.14
Pip x Calwonder 300	11	0.59	0.10	0.49	0.10*	0.13	0.20
Delaware Belle x Fordhook	12	0.59	0.13	0.59	0.00	-0.05	0.14
Delaware Belle x Golden Calwonder	18	0.64	0.15	0.60	0.04	-0.01	0.14
Delaware Belle x Calwonder 300	4	0.50	0.08	0.51	-0.01	-0.11	0.17
Delaware Belle x Pip	12	0.61	0.14	0.54	0.07	0.09	0.20

*Significant at the 5 percent level.

Table 144. Analysis of variance of individual plant data for the trait pepper fruit wall thickness, second harvest

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.02	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	2.00
Cross	9	0.02	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	2.00*
Cross*Replications	27	0.01	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.00
Error	206	0.01	σ^2_e	σ^2_e	
Total[b]	245				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 245 due to missing data.

*Significant at the 5 percent level.

Table 145. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait pepper fruit wall thickness (cm), second harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	27	0.78	0.10	--	--	--	--
Golden Calwonder x Golden Calwonder	22	0.76	0.07	--	--	--	--
Calwonder 300 x Calwonder 300	7	0.68	0.11	--	--	--	--
Pip x Pip	16	0.81	0.11	--	--	--	--
Delaware Belle x Delaware Belle	20	0.86	0.07	--	--	--	--
Golden Calwonder x Fordhook	25	0.78	0.08	0.77	0.01	0.00	0.10
Calwonder 300 x Fordhook	27	0.83	0.12	0.73	0.10**	0.06	0.10
Calwonder 300 x Golden Calwonder	21	0.72	0.07	0.72	0.00	-0.05	0.10
Pip x Fordhook	27	0.81	0.06	0.79	0.02	0.00	0.10
Pip x Golden Calwonder	22	0.74	0.08	0.78	-0.04	-0.09	0.10
Pip x Calwonder 300	20	0.77	0.10	0.74	0.03	-0.05	0.10
Delaware Belle x Fordhook	28	0.80	0.07	0.82	-0.02	-0.07	0.07
Delaware Belle x Golden Calwonder	26	0.78	0.09	0.81	-0.03	-0.09	0.07
Delaware Belle x Calwonder 300	25	0.78	0.09	0.77	0.01	-0.09	0.07
Delaware Belle x Pip	25	0.77	0.10	0.83	-0.06**	-0.10	0.07

**Significant at the 1 percent level.

Heritability estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. Based on these assumptions, the genotypic, phenotypic, and additive genetic variances were estimated as 0.00, 0.02, and 0.00, respectively. Since σ^2_g and σ^2_s were both zero, heritability estimates could not be produced.

Second harvest

A significant difference was found between crosses when an analysis of variance was performed using individual plant data from F_1 plots (Table 144). Direction of dominance values were generally positive. Two F_1 population means were significantly different from their midparent means, suggesting that dominant genes may be present for this trait. However, additive gene action predominates. No significant high-parent heterosis was observed (Table 145).

Table 146. Analysis of variance for general and specific combining ability for the trait pepper fruit wall thickness, second harvest

Source	Degrees of freedom	Mean square	F[a]
GCA	4	0.002	1.00
SCA	5	0.002	6.67**
Error	28	0.0003	

[a]Random model assumed.

**Significant at the 1 percent level.

Significant differences were found between SCA estimates (Table 146). This suggests that some combinations produced fruit with significantly thicker walls than other combinations. General and specific combining ability estimates and their associated variances are presented in Tables 147 and 148. Parent and F_1 means for pepper fruit wall thickness, second harvest, are presented in Table 149. A Duncan's Multiple Range Test revealed that the parent 'Delaware Belle' significantly exceeded 3 other parents for pepper fruit wall thickness, while 'Calwonder 300' produced significantly thinner pepper fruit walls than every other parent in this study. The F_1 population, 'Calwonder 300' x 'Fordhook', produced significantly thicker pepper fruit walls than most other F_1 populations, while 'Calwonder 300' x 'Golden Calwonder' produced significantly thinner pepper fruit walls than most other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates can be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 146). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 0.002, 0.009, and 0.00, respectively. Using these estimates, broad sense heritability was estimated as 22 percent. Narrow sense heritability could not be estimated since $\sigma^2{}_g$ was zero.

Third harvest

No significant difference was found between crosses when an analysis of variance was performed using individual plant data from F_1 plots (Table 150). Direction of dominance values were generally negative, which means

Table 147. Estimates of general combining ability and its associated variance for the trait pepper fruit wall thickness, second harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.04	0.16
Golden Calwonder	-0.03	0.09
Calwonder 300	0.00	0.00
Pip	-0.01	0.01
Delaware Belle	0.01	0.01

[a] $\sigma^2 g_i$ = 0.00, S.E. = 0.0004.

[b] Multiply by 10^{-2} for actual values.

Table 148. Estimates of specific combining ability and its associated variance for the trait pepper fruit wall thickness, second harvest

Parent	Specific combining ability (s_{ij}) [a]				σ^2_{sca} [b]
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	
Fordhook	0.00	0.02	0.01	-0.02	0.03
Golden Calwonder		-0.02	0.00	0.03	0.04
Calwonder 300			0.01	0.00	0.03
Pip				0.00	0.01
Delaware Belle					0.04

[a] $\sigma^2 s_{ij}$ =0.002, S.E. = 0.005.

[b] Multiply by 10^{-2} for actual values.

Table 149. Parent and F_1 means for the trait pepper fruit wall thickness (cm), second harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
	Fordhook		0.78 abc	0.83 a	0.81 ab	0.80 abc	0.78 b
	Golden Calwonder			0.72 d	0.74 cd	0.78 bc	0.76 b
Male parent	Calwonder 300				0.77 bcd	0.78 bc	0.68 c
	Pip					0.77 bcd	0.81 ab
	Delaware Belle						0.86 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Table 150. Analysis of variance of individual plant data for the trait pepper fruit wall thickness, third harvest

Source	Degrees of freedom	Mean square	Expectations		F^a
			Random model	Fixed model	
Replications	3	0.01	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	1.00
Cross	8	0.01	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	1.00
Cross*Replications	14	0.01	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + \phi(bv)$	1.00
Error	48	0.01	σ^2_e	σ^2_e	
Total[b]	73				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 279 to 73 due to missing data.

Table 151. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait pepper fruit wall thickness (cm), third harvest

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	17	0.78	0.11	--	--	--	--
Golden Calwonder x Golden Calwonder	1	0.80	0.00	--	--	--	--
Calwonder 300 x Calwonder 300	1	0.70	0.00	--	--	--	--
Pip x Pip	1	0.80	0.00	--	--	--	--
Delaware Belle x Delaware Belle	3	0.90	0.10	--	--	--	--
Golden Calwonder x Fordhook	6	0.75	0.15	0.79	-0.04	-0.06	0.10
Calwonder 300 x Fordhook	12	0.79	0.08	0.74	0.05	0.01	0.10
Calwonder 300 x Golden Calwonder	2	0.70	0.00	0.75	-0.05	-0.12	0.10
Pip x Fordhook	7	0.71	0.13	0.79	-0.08	-0.11	0.10
Pip x Golden Calwonder	6	0.78	0.04	0.80	-0.02	-0.02	0.10
Pip x Calwonder 300	0	0.00	0.00	0.75	-0.75**	-1.00	0.06
Delaware Belle x Fordhook	17	0.73	0.10	0.84	-0.11*	-0.19	0.14
Delaware Belle x Golden Calwonder	8	0.77	0.05	0.85	-0.08	-0.14	0.14
Delaware Belle x Calwonder 300	6	0.85	0.05	0.80	0.05	-0.05	0.14
Delaware Belle x Pip	10	0.75	0.08	0.85	-0.10	-0.17	0.14

*Significant at the 5 percent level.

**Significant at the 1 percent level.

that the F_1 population means were smaller than their midparent means in this harvest period. Two F_1 means were significantly smaller than their midparent means, suggesting that partial dominance for thinner pepper fruit walls may be present. It should be noted that one of those significant differences was due to the fact that the F_1 cross 'Pip' x 'Calwonder 300' produced no fruit. Therefore, the presence of dominant genes would not be indicated in that case. Additive genes appeared to control this trait during the third harvest period. No significant high-parent heterosis was observed (Table 151).

Table 152. Analysis of variance for general and specific combining ability for the trait pepper fruit wall thickness, third harvest

Source	Degrees of freedom	Mean square	F^a
GCA	4	0.055	0.95
SCA	5	0.058	193.33**
Error	28	0.0003	

[a]Random model assumed.

**Significant at the 1 percent level.

Highly significant differences were observed between SCA estimates (Table 152). This suggests that some combinations produced fruit with significantly thicker walls than other combinations. General and specific combining ability estimates and their associated variances are presented in Tables 153 and 154. Parent and F_1 means for pepper fruit wall thickness

Table 153. Estimates of general combining ability and its associated variance for the trait pepper fruit wall thickness, third harvest

Parent	General combining ability (g_i) [a]	σ^2_{gca} [b]
Fordhook	0.08	0.64
Golden Calwonder	0.09	0.81
Calwonder 300	-0.13	1.69
Pip	-0.16	2.56
Delaware Belle	0.12	1.44

[a] $\sigma^2 g_i$ = 0.00, S.E. = 0.01.

[b] Multiply by 10^{-2} for actual values.

Table 154. Estimates of specific combining ability and its associated variance for the trait pepper fruit wall thickness, third harvest

Parent	Specific combining ability (s_{ij}) [a]				
	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	σ^2_{sca} [b]
Fordhook	-0.10	0.16	0.11	-0.16	2.44
Golden Calwonder		0.06	0.17	-0.12	1.90
Calwonder 300			-0.39	0.18	7.12
Pip				0.11	6.84
Delaware Belle					2.82

[a] $\sigma^2 s_{ij}$ = 0.06, S.E. = 0.01.

[b] Multiply by 10^{-2} for actual values.

Table 155. Parent and F_1 means for the trait pepper fruit wall thickness (cm), third harvest

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent mean[b]
Male parent	Fordhook		0.75 ab	0.79 ab	0.71 b	0.73 b	0.78 a
	Golden Calwonder			0.70 b	0.78 ab	0.77 ab	0.80 a
	Calwonder 300				--	0.85 a	0.70 a
	Pip					0.75 ab	0.80 a
	Delaware Belle						0.90 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

third harvest, are presented in Table 155. No significant differences existed between parent means. The F_1 population 'Delaware Belle' x 'Calwonder 300' produced significantly thicker pepper fruit walls than 3 other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates may be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance (Table 152). From this analysis, the genotypic, phenotypic, and additive genetic variances were estimated as 0.056, 0.065, and -0.002, respectively. Using these estimates, broad sense heritability was estimated as 86 percent. Narrow sense heritability could not be estimated, since ${\sigma^2}_g$ was negative.

Total harvest

An analysis of variance based on a fixed model using individual plant data from F_1 plots is presented in Table 156. A highly significant difference existed between crosses for total pepper fruit wall thickness. Direction of dominance values were generally negative, suggesting that F_1 population means were smaller than their midparent means for this trait. Two F_1 means significantly surpassed their respective midparent means, suggesting that partial dominance for thicker fruit walls may be present. However, additive genes appear to control fruit wall thickness in peppers. No significant high-parent heterosis was observed (Table 157).

No significant differences between general or specific combining ability estimates were observed. Parent and F_1 means for total pepper fruit wall thickness are presented in Talbe 158. A Duncan's Multiple

Table 156. Analysis of variance of individual plant data for the trait total pepper fruit wall thickness

Source	Degrees of freedom	Mean square	Expectations: Random model	Expectations: Fixed model	F[a]
Replications	3	0.11	$\sigma^2_e + c\sigma^2_{bv} + ac\sigma^2_b$	$\sigma^2_e + ac\phi(b)$	11.00
Cross	9	0.03	$\sigma^2_e + c\sigma^2_{bv} + bc\sigma^2_v$	$\sigma^2_e + bc\phi(v)$	3.00**
Cross*Replications	27	0.01	$\sigma^2_e + c\sigma^2_{bv}$	$\sigma^2_e + c\phi(bv)$	1.00
Error	394	0.01	σ^2_e	σ^2_e	
Total[b]	433				

[a]Based on a fixed model.

[b]Degrees of freedom reduced from 839 to 433 due to missing data.

**Significant at the 1 percent level.

Table 157. Number of plants, mean, standard deviation, midparent mean, direction of dominance, high-parent heterosis, and standard deviation of high-parent heterosis for the trait total pepper fruit wall thickness (cm)

Cross	Number of plants (n)	Mean ($\overline{X}$)	Standard deviation	Midparent mean (mp)	Direction of dominance ($\overline{X}$-mp)	High-parent heterosis (H')	Standard deviation of H'
Fordhook x Fordhook	52	0.75	0.11	--	--	--	--
Golden Calwonder x Golden Calwonder	34	0.73	0.11	--	--	--	--
Calwonder 300 x Calwonder 300	11	0.63	0.13	--	--	--	--
Pip x Pip	26	0.71	0.17	--	--	--	--
Delaware Belle x Delaware Belle	31	0.79	0.16	--	--	--	--
Golden Calwonder x Fordhook	47	0.72	0.12	0.74	-0.02	-0.04	--
Calwonder 300 x Fordhook	45	0.79	0.13	0.69	0.10**	0.05	--
Calwonder 300 x Golden Calwonder	34	0.68	0.10	0.68	0.00	-0.07	--
Pip x Fordhook	47	0.72	0.14	0.73	-0.01	-0.04	--
Pip x Golden Calwonder	39	0.70	0.12	0.72	-0.02	-0.04	--
Pip x Calwonder 300	31	0.71	0.13	0.67	0.04	0.00	--
Delaware Belle x Fordhook	57	0.73	0.12	0.77	-0.04	-0.07	--
Delaware Belle x Golden Calwonder	52	0.73	0.13	0.76	-0.03	-0.07	--
Delaware Belle x Calwonder 300	35	0.76	0.13	0.71	0.05*	-0.04	--
Delaware Belle x Pip	47	0.72	0.13	0.75	-0.03	-0.09	--

*Significant at the 5 percent level.

**Significant at the 1 percent level.

Table 158. Parent and F_1 means for the trait total pepper fruit wall thickness (cm)

		Female parent[a]					
		Fordhook	Golden Calwonder	Calwonder 300	Pip	Delaware Belle	Parent[b] mean
Male parent	Fordhook		0.72 bc	0.79 a	0.72 bc	0.73 bc	0.75 ab
	Golden Calwonder			0.68 c	0.70 bc	0.73 bc	0.73 abc
	Calwonder 300				0.71 bc	0.76 ab	0.63 c
	Pip					0.72 bc	0.71 bc
	Delaware Belle						0.79 a

[a]Duncan's Multiple Range Test of F_1 means; values with the same letter are not significantly different at the 5 percent level.

[b]Duncan's Multiple Range Test of parent means; values with the same letter are not significantly different at the 5 percent level.

Range Test indicated that the parent 'Delaware Belle' produced significantly thicker pepper fruit walls than 2 other parents, while 'Calwonder 300' produced significantly thinner pepper fruit walls than 2 other parents. The F_1 population 'Calwonder 300' x 'Fordhook' produced significantly thicker pepper fruit walls than 8 other F_1 populations.

Heritability estimates were produced to determine how much of the phenotypic variability was genetic. These estimates can be generated from mean plant data if a random model is assumed for the GCA-SCA analysis of variance. Based on these assumptions, genetic variances were estimated as 0.001, 0.017, and 0.0008, respectively. Using these estimates, broad sense heritability was estimated as 6 percent, while narrow sense heritability was estimated as 5 percent.

Discussion

It has been shown that the parent 'Delaware Belle' produced significantly thicker pepper fruit walls than other parents. On the other hand, 'Calwonder 300' produced significantly thinner pepper fruit walls than other parents. 'Calwonder 300' x 'Fordhook' produced the thickest pepper fruit walls among F_1 populations.

Additive gene action is predominant with partial dominance for thicker fruit walls. Milkova (16) found similar results. In Table 157, the direction of dominance values were usually negative, suggesting that F_1 population means were smaller than their midparent means for this trait. In addition, no significant high-parent heterosis was observed.

No significant differences between general or specific combining ability were observed. The overall mean ($\overline{X}$) for pepper fruit wall thickness for individual F_1 plants was 0.73 cm.

Heritability estimates for pepper fruit wall thickness varied from 22 to 86 percent for broad sense heritability. Narrow sense heritability for individual harvests could not be estimated, since σ^2_g was either zero or negative. Broad and narrow sense heritability estimates for total pepper fruit wall thickness were 6 and 5 percent, respectively. Using the narrow sense heritability estimate, the response to selection, R, can be determined (5). The response to selection represents the difference between the mean of the original population and the mean of the selected population. The expected response to selection is given by the relationship

$$R = (h^2)(i)(\sigma_p),$$

where h^2 is narrow sense heritability,

i is the selection intensity, and

σ_p is the phenotypic standard deviation.

Table 159 provides a comparison of R values for two selection intensities. It is evident that progress due to selection for increased pepper fruit wall thickness will be very slow.

Table 159. Response to selection for total pepper fruit wall thickness (cm)

Narrow sense heritability	σ_p	Percent saved	i	Response to selection (R)
5.00%	0.13	5%	2.06	0.01
5.00%	0.13	1%	2.66	0.02

Because heritabilities are variance ratios, their estimation may be subject to considerable error. In addition, certain model assumptions must be met for analysis of variance components to correctly predict additive and dominance variances. Both the analysis of plot means and the analysis of individual plant data assume a random selection of parental lines (7, 15). In addition, the Griffing diallel analysis assumes there is no epistasis (7). The first assumption, random selection of parental lines was met. However, because a regression of the covariance on the variance was not performed, it is not certain that the second assumption was met. Therefore, the validity of heritability estimates may be questioned. The low total estimates of heritability do show that the amount of environmental variation is large compared to the amount of additive and dominance variance. Thus, very little progress may be expected due to selection for greater pepper fruit wall thickness.

CONCLUSIONS

The results of this study provide information about the inheritance of eight quantitative characters in peppers. They are number of marketable pepper fruit per plant, marketable pepper fruit weight per plant, number of cull pepper fruit per plant, cull pepper fruit weight per plant, pepper fruit length, pepper fruit diameter, number of pepper lobes per fruit, and pepper fruit wall thickness.

For number of marketable pepper fruit per plant:

1) Gene action seems to be primarily additive with partial dominance for a large number of marketable fruit.
2) No high-parent heterosis was present.
3) Heritability estimates were very low (0.43 to 13 percent). This suggests that there is great environmental influence on the number of marketable fruit produced in peppers. However, the predicted response to selection was moderate, indicating that progress from selecting for an increased number of marketable fruit per pepper plant should be a fairly rapid process.

For marketable pepper fruit weight per plant:

1) Gene action seems to be partial dominance for heavier fruit, with additive genes playing a smaller role.
2) No high-parent heterosis was present.
3) Heritability estimates were very low (0 to 7 percent). This suggests that there is a lot of environmental influence on marketable fruit weight in peppers. However, the predicted response to

selection was fairly large, indicating that progress due to selection for heavier fruit will be a fairly rapid process.

For number of cull pepper fruit per plant:

1) Gene action is additive.
2) No low-parent heterosis was present.
3) Heritability estimates were low (1 to 9 percent). This is an indication of a large environmental influence on the number of cull pepper fruit. The predicted response to selection was fairly large, suggesting that progress due to selection for fewer cull pepper fruit per plant may be a moderate to rapid process.

For cull pepper fruit weight per plant:

1) Gene action is additive.
2) Significant low-parent heterosis was present, suggesting that some F_1 populations yielded a significantly smaller cull pepper fruit weight than their respective low parent.
3) Narrow sense heritability ranged from 8 to 13 percent. It is evident that the environment plays a major role in conditioning the cull pepper fruit weight. The predicted response to selection was relatively large, suggesting that fairly rapid advances may be made as a result of selection for decreased cull pepper fruit weight.

For pepper fruit length:

1) Gene action is primarily additive with partial dominance for longer fruit.
2) High-parent heterosis was not observed.

3) Narrow sense heritability ranged from 9 to 22 percent. This suggests that there is a great deal of environmental influence on length of fruit. Furthermore, the predicted response to selection was small, suggesting that there will be slow progress in a selection program for longer pepper fruit.

For pepper fruit diameter:

1) Gene action is largely additive with partial dominance for smaller fruit diameter.
2) No high-parent heterosis was present.
3) Heritability estimates were moderate to low (29 to 36 percent). This means that the environment plays a major role in conditioning the diameter of pepper fruit. In addition, the predicted response to selection was small, suggesting that there will be slow progress in selecting for larger fruit diameter.

For number of pepper lobes per fruit:

1) Gene action is predominantly additive with partial dominance for fewer lobes.
2) No high-parent heterosis was present.
3) Narrow sense heritability was 5 percent. Evidently, the environment has a great deal of influence on the inheritance of number of pepper lobes. In addition, the response to selection was very small, suggesting that progress due to selection for a greater number of lobes will be very slow.

For pepper fruit wall thickness:

1) Gene action is primarily additive with partial dominance for thicker fruit walls.
2) No high-parent heterosis was present.
3) Narrow sense heritability could not be estimated for individual harvests, since the variance component estimates for GCA (σ^2_g) were either zero or negative. However, the total narrow sense heritability estimate was 5 percent. This suggests that environmental influence on the inheritance of pepper fruit wall thickness is very great. Furthermore, the response to selection was extremely low, indicating that advances in selection for thicker fruit walls will be very slow.

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APPENDIX

DATA FIELD KEY

VARIABLE NAME	FIELD
POPULATION CODE	A
REPLICATION	B
PLANT NUMBER	C
JULIAN HARVEST DATE	D
NUMBER OF MARKETABLE PEPPER FRUIT	E
MARKETABLE PEPPER FRUIT WEIGHT	G
NUMBER OF CULL PEPPER FRUIT	H
CULL PEPPER FRUIT WEIGHT	H
NUMBER OF FRUIT SAMPLED	I
PEPPER FRUIT LENGTH CM	J
PEPPER FRUIT DIAMETER CM	K
NUMBER OF LOBES	L
PEPPER FRUIT WALL THICKNESS CM	M

A	B	C	D	E	F	G	H	I	J	K	L	M
1	1	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	1	2	204	1	0.3	0	0.0	1	9.3	6.5	3.0	0.6
1	1	3	204	1	0.3	0	0.0	1	10.2	7.2	3.0	0.6
1	1	4	204	2	0.6	0	0.0	2	9.0	6.6	3.0	0.5
1	1	5	204	1	0.4	0	0.0	1	11.0	7.3	3.0	0.8
1	1	6	204	4	1.0	0	0.0	4	9.3	6.8	3.5	0.5
1	1	7	204	2	0.6	0	0.0	2	10.5	6.7	2.5	0.6
1	2	1	204	1	0.4	0	0.0	1	9.9	7.0	3.0	0.7
1	2	2	204	2	0.7	0	0.0	2	10.5	8.0	3.0	0.5
1	2	3	204	2	0.6	0	0.0	2	10.7	6.5	2.5	0.6
1	2	4	204	1	0.4	0	0.0	1	11.4	7.0	3.0	0.8
1	2	5	204	1	0.3	0	0.0	1	10.4	7.0	3.0	0.6
1	2	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	2	7	204	1	0.2	0	0.0	1	9.8	6.6	3.0	0.6
1	3	1	204	1	0.4	0	0.0	1	10.5	7.7	3.0	0.7
1	3	2	204	2	0.8	0	0.0	2	10.2	7.8	3.0	0.7
1	3	3	204	0	0.0	1	0.3	1	10.4	5.3	1.0	0.6
1	3	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	3	5	204	0	0.0	1	0.2	1	11.0	5.6	1.0	0.5
1	3	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	3	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	4	1	204	3	1.0	0	0.0	3	10.8	.	2.3	.
1	4	2	204	1	0.2	0	0.0	1	10.2	.	3.0	.
1	4	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	4	4	204	0	0.0	2	0.6	2	13.0	.	1.5	.
1	4	5	204	3	1.0	0	0.0	3	10.9	.	3.0	.
1	4	6	204	1	0.4	2	0.5	1	11.8	.	2.0	.
1	4	7	204	1	0.4	1	0.3	1	11.7	.	2.0	.
2	1	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	2	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	2	2	204	1	0.3	0	0.0	1	8.2	7.9	3.0	0.5
2	2	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	2	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	2	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	2	6	204	1	0.3	0	0.0	1	8.7	7.2	3.0	0.5
2	2	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	3	1	204	2	0.8	1	0.2	2	9.1	8.2	3.3	0.7
2	3	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	3	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	3	4	204	1	0.5	0	0.0	1	12.0	8.6	3.0	0.7
2	3	5	204	2	0.9	0	0.0	2	8.5	9.3	3.5	0.7
2	3	6	204	1	0.3	0	0.0	1	7.5	7.7	4.0	0.5

A	B	C	D	E	F	G	H	I	J	K	L	M
2	3	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	2	204	1	0.4	0	0.0	1	9.5	.	2.0	.
2	4	3	204	0	0.0	1	0.4	1	9.0	.	3.0	.
2	4	4	204	1	0.4	0	0.0	1	8.3	.	4.0	.
2	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	6	204	0	0.0	1	0.3	1	8.6	.	3.0	.
2	4	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	3	204	1	0.3	0	0.0	1	8.6	6.8	4.0	0.4
3	1	4	204	1	0.3	0	0.0	1	8.3	8.5	3.0	0.5
3	1	5	204	2	0.7	0	0.0	2	9.8	7.4	2.5	0.7
3	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	2	204	1	0.4	0	0.0	1	10.1	8.0	3.0	0.8
3	2	3	204	1	0.5	0	0.0	1	9.0	9.0	3.0	0.7
3	2	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	5	204	1	0.4	0	0.0	1	10.4	7.8	3.0	0.6
3	2	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	7	204	1	0.5	0	0.0	1	11.0	8.0	3.0	0.6
3	3	1	204	1	0.5	0	0.0	1	12.3	9.0	2.0	0.8
3	3	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	5	204	1	0.4	0	0.0	1	11.2	7.9	3.0	0.6
3	3	6	204	1	0.3	0	0.0	1	11.1	7.6	3.0	0.5
3	3	7	204	1	0.3	0	0.0	1	9.2	7.5	3.0	0.5
3	4	1	204	0	0.0	1	0.2	1	8.7	.	2.0	.
3	4	2	204	3	0.9	0	0.0	3	10.0	.	3.3	.
3	4	3	204	0	0.0	1	0.4	1	9.2	.	2.0	.
3	4	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	5	204	3	0.8	0	0.0	3	8.5	.	3.3	.
3	4	6	204	0	0.0	1	0.2	1	8.8	.	3.0	.
3	4	7	204	1	0.2	0	0.0	1	11.6	.	2.0	.
4	1	1	204	3	0.8	0	0.0	3	9.4	6.5	3.3	0.5
4	1	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	5	204	2	0.6	0	0.0	2	9.0	7.9	3.0	0.6
4	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	7	204	1	0.5	0	0.0	1	9.8	8.0	3.0	0.9
4	2	1	204	1	0.3	0	0.0	1	8.6	8.5	3.0	0.5
4	2	2	204	1	0.3	0	0.0	1	8.2	9.2	4.0	0.5
4	2	3	204	1	0.4	0	0.0	1	9.2	7.4	3.0	0.5
4	2	4	204	1	0.3	0	0.0	1	9.3	7.0	3.0	0.5
4	2	5	204	1	0.3	0	0.0	1	7.8	8.9	4.0	0.5

A	B	C	D	E	F	G	H	I	J	K	L	M
4	2	6	204	1	0.3	0	0.0	1	7.5	7.1	4.0	0.5
4	2	7	204	1	0.4	0	0.0	1	8.8	8.1	4.0	0.6
4	3	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	3	2	204	1	0.3	0	0.0	1	8.7	8.2	3.0	0.5
4	3	3	204	2	0.6	0	0.0	2	9.0	8.0	3.0	0.5
4	3	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	3	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	3	6	204	2	0.6	0	0.0	2	9.6	6.8	3.0	0.5
4	3	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	1	204	1	0.5	0	0.0	1	10.7	8.5	3.0	0.8
5	1	2	204	1	0.5	0	0.0	1	10.8	8.5	3.0	0.7
5	1	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	4	204	1	0.2	0	0.0	1	9.6	8.0	3.0	0.4
5	1	5	204	2	1.0	0	0.0	2	9.1	9.2	4.0	0.6
5	1	6	204	1	0.4	0	0.0	1	12.2	7.9	2.0	0.7
5	1	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	2	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	2	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	2	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	2	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	2	5	204	1	0.3	0	0.0	1	9.3	7.8	3.0	0.5
5	2	6	204	1	0.3	0	0.0	1	9.4	8.5	3.0	0.5
5	2	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	1	204	1	0.3	0	0.0	1	7.5	8.6	2.0	0.4
5	3	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	3	204	1	0.5	0	0.0	1	9.6	8.5	3.0	0.8
5	3	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	5	204	2	0.5	0	0.0	2	8.9	7.0	2.5	0.5
5	3	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	7	204	2	0.6	0	0.0	2	9.0	7.9	3.0	0.5
5	4	1	204	0	0.0	2	0.6	2	9.2	.	2.5	.
5	4	2	204	0	0.0	3	0.9	3	9.3	.	3.7	.
5	4	3	204	1	0.3	0	0.0	1	9.5	.	4.0	.
5	4	4	204	2	0.5	0	0.0	2	9.5	.	3.0	.
5	4	5	204	2	0.7	0	0.0	2	10.0	.	3.0	.
5	4	6	204	1	0.3	0	0.0	1	9.3	.	3.0	.
5	4	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	1	204	1	0.4	0	0.0	1	8.3	9.0	4.0	0.5
6	1	2	204	1	0.5	0	0.0	1	10.1	8.2	3.0	0.7
6	1	3	204	1	0.4	0	0.0	1	10.3	8.2	2.0	0.8
6	1	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
6	1	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	2	1	204	1	0.4	0	0.0	1	10.7	7.3	3.0	0.6
6	2	2	204	1	0.4	0	0.0	1	10.2	8.2	3.0	0.6
6	2	3	204	.	.	.	.	.	.	.	.	.
6	2	4	204	1	0.3	0	0.0	1	8.2	8.0	3.0	0.5
6	2	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	2	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	2	7	204	1	0.3	0	0.0	1	8.7	8.2	3.0	0.5
6	3	1	204	1	0.5	0	0.0	1	10.6	9.0	3.0	0.6
6	3	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	3	3	204	1	0.5	0	0.0	1	10.3	7.9	4.0	0.7
6	3	4	204	2	0.6	0	0.0	2	8.9	8.5	2.5	0.5
6	3	5	204	1	0.4	0	0.0	1	8.2	9.8	4.0	0.5
6	3	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	3	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	2	204	1	0.6	0	0.0	1	10.8	.	3.0	.
6	4	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	1	1	204	1	0.4	0	0.0	1	10.2	7.5	2.0	0.5
7	1	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	1	3	204	0	0.0	1	0.2	1	11.4	5.7	1.0	0.4
7	1	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	1	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	1	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	2	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	2	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	2	3	204	2	0.7	0	0.0	2	11.1	8.0	2.5	0.6
7	2	4	204	1	0.4	0	0.0	1	9.0	7.5	3.0	0.6
7	2	5	204	2	0.6	2	0.4	2	8.2	7.3	3.5	0.7
7	2	6	204	2	0.7	0	0.0	2	11.7	6.9	2.0	0.5
7	2	7	204	1	0.4	0	0.0	1	9.0	8.3	3.0	0.5
7	3	1	204	2	0.7	0	0.0	2	11.1	7.0	2.5	0.9
7	3	2	204	2	0.6	0	0.0	2	10.1	7.7	3.0	0.6
7	3	3	204	2	0.7	1	0.3	2	11.0	7.0	2.0	0.7
7	3	4	204	1	0.4	0	0.0	1	10.7	7.5	3.0	0.5
7	3	5	204	1	0.4	0	0.0	1	11.8	8.3	2.0	0.6
7	3	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	3	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	4	1	204	2	0.7	0	0.0	2	10.4	.	2.5	.
7	4	2	204	0	0.0	1	0.2	1	8.8	.	1.0	.
7	4	3	204	0	0.0	1	0.3	1	8.9	.	3.0	.

A	B	C	D	E	F	G	H	I	J	K	L	M
7	4	4	204	4	1.4	0	0.0	4	11.3	.	2.5	.
7	4	5	204	0	0.0	2	0.7	2	10.1	.	2.5	.
7	4	6	204	0	0.0	1	0.4	1	11.3	.	3.0	.
7	4	7	204	0	0.0	1	0.3	1	8.5	.	3.0	.
8	1	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	1	2	204	1	0.3	0	0.0	1	9.8	9.0	3.0	0.5
8	1	3	204	1	0.2	0	0.0	1	11.0	6.8	2.0	0.5
8	1	4	204	2	0.7	0	0.0	2	11.6	6.9	3.0	0.8
8	1	5	204	2	0.7	0	0.0	2	11.4	7.0	3.0	0.7
8	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	1	7	204	0	0.0	1	0.3	1	11.5	6.9	1.0	0.7
8	2	1	204	1	0.3	0	0.0	1	11.0	7.0	3.0	0.4
8	2	2	204	1	0.4	0	0.0	1	12.5	7.9	2.0	0.7
8	2	3	204	1	0.4	0	0.0	1	11.7	7.8	3.0	0.7
8	2	4	204	2	0.7	0	0.0	2	10.8	7.0	3.5	0.6
8	2	5	204	3	1.1	0	0.0	3	11.0	7.4	2.7	0.8
8	2	6	204	3	1.1	0	0.0	3	9.9	7.8	3.3	0.7
8	2	7	204	1	0.3	0	0.0	1	10.7	6.5	3.0	0.5
8	3	1	204	2	0.6	0	0.0	2	10.3	7.1	3.5	0.8
8	3	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	3	3	204	1	0.3	0	0.0	1	12.9	6.7	2.0	0.5
8	3	4	204	3	1.0	0	0.0	3	11.4	7.8	2.7	0.8
8	3	5	204	4	1.3	0	0.0	4	10.5	7.6	3.5	0.4
8	3	6	204	1	0.4	0	0.0	1	10.6	8.6	3.0	0.5
8	3	7	204	1	0.5	0	0.0	1	12.3	7.0	3.0	0.9
8	4	1	204	1	0.4	0	0.0	1	9.5	.	4.0	.
8	4	2	204	3	0.9	0	0.0	3	10.4	.	3.0	.
8	4	3	204	0	0.0	1	0.4	1	11.0	.	3.0	.
8	4	4	204	3	0.7	0	0.0	3	10.2	.	3.0	.
8	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	4	6	204	1	0.5	1	0.3	1	9.8	.	3.0	.
8	4	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	4	204	1	0.3	0	0.0	1	7.9	8.2	3.0	0.4
9	2	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
9	3	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	4	204	2	0.6	0	0.0	2	8.5	7.7	3.5	0.5
9	3	5	204	1	0.4	0	0.0	1	7.6	8.6	4.0	0.5
9	3	6	204	1	0.4	0	0.0	1	8.6	7.4	4.0	0.6
9	3	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	1	1	204	1	0.5	0	0.0	1	10.8	8.0	3.0	0.8
10	1	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	1	3	204	1	0.4	0	0.0	1	12.3	7.5	3.0	0.5
10	1	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	1	5	204	1	0.5	0	0.0	1	11.7	8.6	3.0	0.7
10	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	1	7	204	1	0.3	0	0.0	1	11.6	7.6	3.0	0.5
10	2	1	204	1	0.4	0	0.0	1	10.3	7.8	4.0	0.7
10	2	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	3	1	204	1	0.5	0	0.0	1	8.8	8.3	4.0	0.7
10	3	2	204	2	0.6	0	0.0	2	9.3	7.9	3.0	0.5
10	3	3	204	3	0.9	0	0.0	3	9.6	6.7	3.0	0.5
10	3	4	204	1	0.4	0	0.0	1	9.4	8.0	3.0	0.5
10	3	5	204	1	0.4	0	0.0	1	9.9	8.5	2.0	0.5
10	3	6	204	1	0.3	0	0.0	1	10.0	6.7	3.0	0.5
10	3	7	204	1	0.5	0	0.0	1	11.9	8.0	3.0	0.9
10	4	1	204	0	0.0	1	0.5	1	10.5	.	3.0	.
10	4	2	204	2	0.6	0	0.0	2	11.8	.	4.0	.
10	4	3	204	0	0.0	2	0.7	2	10.2	.	3.0	.
10	4	4	204	0	0.0	1	0.5	1	10.5	.	3.0	.
10	4	5	204	2	0.7	0	0.0	2	8.8	.	4.0	.
10	4	6	204	1	0.5	0	0.0	1	8.5	.	3.0	.
10	4	7	204	1	0.5	0	0.0	1	10.8	.	3.0	.
11	1	1	204	1	0.4	1	0.2	1	9.9	8.8	3.5	0.8
11	1	2	204	2	0.6	0	0.0	2	8.0	6.6	3.5	0.6
11	1	3	204	2	0.5	0	0.0	2	8.5	6.7	3.0	0.7
11	1	4	204	1	0.3	0	0.0	1	7.7	7.7	4.0	0.6
11	1	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	1	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	2	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
11	2	2	204	0	0.0	1	0.3	1	7.7	7.0	3.0	0.5
11	2	3	204	2	0.6	0	0.0	2	8.3	6.5	3.5	0.5
11	2	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	2	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	2	6	204	1	0.4	0	0.0	1	8.9	7.5	3.0	0.7
11	2	7	204	1	0.3	0	0.0	1	9.1	6.2	3.0	0.6
11	3	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	3	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	3	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	3	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	3	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	3	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	3	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	4	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	4	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	4	3	204	0	0.0	1	0.3	1	10.4	.	1.0	.
11	4	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	4	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	4	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	1	1	204	1	0.4	0	0.0	1	12.9	7.2	2.0	0.7
12	1	2	204	2	0.6	0	0.0	2	9.6	7.8	3.0	0.5
12	1	3	204	1	0.5	0	0.0	1	9.9	8.0	3.0	0.9
12	1	4	204	1	0.4	0	0.0	1	10.6	6.6	3.0	0.7
12	1	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	1	6	204	1	0.2	0	0.0	1	10.2	6.8	3.0	0.4
12	1	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	1	204	1	0.3	0	0.0	1	8.0	7.2	3.0	0.5
12	2	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	4	204	1	0.4	0	0.0	1	10.2	7.1	3.0	0.7
12	2	5	204	1	0.5	0	0.0	1	10.6	7.8	3.0	0.8
12	2	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	1	204	2	0.7	0	0.0	2	9.8	7.7	2.5	0.7
12	3	2	204	1	0.4	0	0.0	1	10.6	7.8	3.0	0.6
12	3	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	7	204	1	0.5	0	0.0	1	11.9	8.5	3.0	0.7
12	4	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	6	204	2	0.6	0	0.0	2	10.2	.	2.5	.
12	4	7	204	1	0.3	0	0.0	1	9.1	.	3.0	.

A	B	C	D	E	F	G	H	I	J	K	L	M
13	1	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	1	204	1	0.3	0	0.0	1	8.3	7.7	3.0	0.4
13	2	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	3	204	1	0.3	0	0.0	1	9.0	8.0	2.0	0.5
13	2	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	7	204	1	0.4	0	0.0	1	9.7	8.0	3.0	0.5
13	4	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	7	204	.	.	.	.	.	.	.	.	.
14	1	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	3	204	1	0.3	0	0.0	1	6.8	9.0	4.0	0.5
14	1	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	7	204	1	0.3	0	0.0	1	9.5	7.2	3.0	0.5
14	2	1	204	1	0.3	0	0.0	1	10.0	9.0	3.0	0.5
14	2	2	204	1	0.3	0	0.0	1	6.3	9.5	4.0	0.4
14	2	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	4	204	2	0.8	0	0.0	2	8.7	8.6	3.5	0.5
14	2	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	6	204	2	0.9	0	0.0	2	8.8	8.3	4.0	0.8
14	2	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	1	204	2	0.6	0	0.0	2	9.6	7.5	3.0	0.6
14	3	2	204	1	0.3	0	0.0	1	7.8	8.0	4.0	0.5
14	3	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	6	204	1	0.3	0	0.0	1	10.6	7.1	2.0	0.4

A	B	C	D	E	F	G	H	I	J	K	L	M
14	3	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	2	204	1	0.5	0	0.0	1	9.9	.	4.0	.
14	4	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	4	204	0	0.0	2	0.8	2	8.5	.	3.0	.
14	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	1	204	1	0.3	0	0.0	1	9.3	7.4	3.0	0.5
15	1	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	6	204	1	0.3	0	0.0	1	9.4	7.0	3.0	0.5
15	1	7	204	1	0.3	0	0.0	1	9.7	7.7	3.0	0.5
15	2	1	204	2	0.5	0	0.0	2	9.5	6.9	2.5	0.5
15	2	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	3	204	1	0.3	0	0.0	1	9.4	7.0	2.0	0.5
15	3	4	204	1	0.5	0	0.0	1	10.4	8.3	3.0	0.9
15	3	5	204	1	0.4	0	0.0	1	10.4	6.5	3.0	0.6
15	3	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	7	204	2	0.5	0	0.0	2	9.0	7.2	3.0	0.5
15	4	1	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	2	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	3	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	4	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	5	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	6	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	7	204	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	1	1	225	4	1.7	0	0.0	4	10.1	8.0	3.0	0.7
1	1	2	225	0	0.0	3	1.2	3	9.0	6.5	2.0	0.6
1	1	3	225	2	0.6	2	0.6	2	8.5	6.1	3.0	0.8
1	1	4	225	1	0.4	0	0.0	1	9.3	8.1	3.0	0.7
1	1	5	225	5	2.1	0	0.0	5	9.8	8.2	3.0	0.8
1	1	6	225	3	1.0	0	0.0	3	9.7	6.8	3.0	0.7
1	1	7	225	4	1.7	0	0.0	4	10.1	7.9	3.5	0.8
1	2	1	225	4	1.7	0	0.0	4	10.0	8.2	3.0	0.7
1	2	2	225	1	0.5	0	0.0	1	10.4	7.7	3.0	0.8
1	2	3	225	1	0.6	0	0.0	1	10.5	7.9	3.0	0.9
1	2	4	225	0	0.0	2	0.6	2	10.1	6.3	2.5	0.9
1	2	5	225	0	0.0	1	0.4	1	10.7	6.4	3.0	0.8

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	6	225	0	0.0	2	0.9	2	9.8	7.3	1.0	0.8
1	2	7	225	1	0.6	4	1.7	1	10.9	8.3	2.0	0.7
1	3	1	225	1	0.6	0	0.0	1	12.2	9.0	3.0	0.7
1	3	2	225	3	1.0	0	0.0	3	10.5	7.4	3.0	0.8
1	3	3	225	0	0.0	0	0.0	0	9.6	6.9	3.0	0.9
1	3	4	225	3	1.1	0	0.0	3	12.3	7.3	3.0	0.8
1	3	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	3	6	225	5	1.8	4	1.2	5	10.2	7.0	3.0	0.7
1	3	7	225	1	0.5	4	1.5	1	9.5	8.0	2.0	0.8
1	4	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	4	2	225	4	1.0	2	0.5	4	9.9	6.6	3.0	0.8
1	4	3	225	4	1.4	2	0.5	4	8.6	7.2	3.0	0.9
1	4	4	225	6	2.5	0	0.0	5	10.0	8.0	3.0	0.9
1	4	5	225	1	0.3	1	0.3	1	11.2	7.3	3.5	0.8
1	4	6	225	1	0.4	0	0.0	1	11.5	7.2	3.0	0.8
1	4	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	1	225	1	0.4	0	0.0	1	8.1	8.0	3.0	1.0
2	1	2	225	2	0.9	0	0.0	2	8.8	9.1	3.5	0.9
2	1	3	225	4	1.6	0	0.0	4	9.0	8.5	3.0	0.8
2	1	4	225	2	0.8	0	0.0	2	8.3	8.3	3.0	0.8
2	1	5	225	6	2.0	0	0.0	5	9.6	7.7	3.0	0.8
2	1	6	225	4	1.8	0	0.0	4	9.3	8.3	3.0	0.9
2	1	7	225	6	2.7	0	0.0	5	8.6	8.8	3.5	0.9
2	2	1	225	2	0.8	2	0.8	2	9.3	8.8	2.5	0.7
2	2	2	225	2	0.9	0	0.0	2	8.8	8.5	4.0	0.8
2	2	3	225	5	1.5	1	0.3	5	8.6	8.2	3.0	0.7
2	2	4	225	4	1.5	0	0.0	4	9.7	7.7	3.0	0.7
2	2	5	225	3	1.1	3	1.2	3	8.0	7.0	3.0	0.7
2	2	6	225	2	1.0	0	0.0	2	10.8	8.0	3.0	0.9
2	2	7	225	6	2.5	1	0.5	5	9.1	7.7	3.0	0.8
2	3	1	225	2	0.8	0	0.0	2	10.0	8.9	3.0	0.7
2	3	2	225	1	0.6	0	0.0	1	9.1	9.2	4.0	0.8
2	3	3	225	3	1.6	0	0.0	3	9.0	9.5	3.3	1.0
2	3	4	225	2	0.8	0	0.0	2	7.5	8.4	3.0	0.7
2	3	5	225	2	0.9	0	0.0	2	8.4	8.8	3.0	0.8
2	3	6	225	6	2.6	0	0.0	5	8.6	10.0	3.0	0.9
2	3	7	225	3	1.4	0	0.0	3	10.0	10.0	3.0	0.8
2	4	1	225	5	2.4	0	0.0	5	10.2	9.1	3.0	1.0
2	4	2	225	2	1.1	0	0.0	2	9.0	8.5	4.0	1.0
2	4	3	225	4	2.1	1	0.6	4	9.3	8.8	3.0	0.8
2	4	4	225	3	1.3	0	0.0	3	9.2	7.6	3.0	1.1
2	4	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	6	225	2	0.9	0	0.0	2	9.3	7.8	4.0	0.7
2	4	7	225	0	0.0	5	1.7	5	9.3	7.6	2.6	0.7
3	1	1	225	1	0.6	0	0.0	1	9.9	9.8	3.0	0.8
3	1	2	225	6	2.2	0	0.0	5	9.2	8.3	3.0	0.8
3	1	3	225	2	0.9	0	0.0	2	10.1	7.9	3.0	0.7
3	1	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
3	1	5	225	1	0.5	0	0.0	1	12.1	8.0	3.0	0.8
3	1	6	225	5	2.1	4	1.3	5	9.1	8.1	3.0	0.7
3	1	7	225	1	0.4	0	0.0	1	8.2	8.7	3.0	0.8
3	2	1	225	0	0.0	3	0.9	3	8.7	7.0	2.0	0.8
3	2	2	225	2	0.7	0	0.0	2	9.4	8.8	3.0	0.7
3	2	3	225	1	0.5	1	0.4	1	9.7	8.3	3.0	0.7
3	2	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	5	225	3	1.5	0	0.0	3	11.4	8.7	3.0	0.6
3	2	6	225	3	1.4	0	0.0	3	9.0	9.9	3.0	0.8
3	2	7	225	1	0.7	1	0.5	1	10.2	8.5	3.0	0.6
3	3	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	2	225	4	1.5	0	0.0	4	9.3	8.7	3.0	0.7
3	3	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	4	225	0	0.0	3	1.1	3	10.8	7.8	2.0	0.6
3	3	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	6	225	2	1.2	0	0.0	2	11.0	8.5	3.0	0.8
3	3	7	225	3	1.4	0	0.0	3	9.6	8.3	3.3	0.6
3	4	1	225	1	0.4	3	0.6	1	9.0	8.2	3.0	0.8
3	4	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	3	225	3	1.4	2	0.7	3	9.2	9.4	3.0	0.7
3	4	4	225	2	0.9	3	1.0	2	9.2	8.5	3.0	0.7
3	4	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	6	225	3	1.1	3	1.1	3	10.3	8.5	3.0	0.7
3	4	7	225	2	0.9	0	0.0	2	8.8	8.8	4.0	0.7
4	1	1	225	1	0.5	0	0.0	1	9.8	8.5	3.0	0.8
4	1	2	225	2	0.6	0	0.0	2	9.3	8.3	3.0	0.8
4	1	3	225	2	0.8	0	0.0	2	9.2	8.9	3.5	0.8
4	1	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	5	225	5	2.2	0	0.0	5	9.6	8.9	3.0	0.8
4	1	6	225	6	3.0	0	0.0	5	10.0	8.3	4.0	0.9
4	1	7	225	3	1.2	0	0.0	3	8.7	8.5	3.0	0.8
4	2	1	225	1	0.4	1	0.5	1	9.5	8.7	2.5	0.8
4	2	2	225	5	2.3	0	0.0	5	9.0	9.4	3.0	0.8
4	2	3	225	4	2.2	0	0.0	4	10.4	9.2	3.0	0.8
4	2	4	225	1	0.5	0	0.0	1	9.0	9.0	4.0	0.8
4	2	5	225	3	1.5	0	0.0	3	9.2	8.5	3.7	0.8
4	2	6	225	5	2.2	1	0.6	5	10.0	8.6	3.0	0.9
4	2	7	225	2	0.9	1	0.5	2	9.7	8.9	3.0	0.8
4	3	1	225	1	0.4	1	0.4	1	10.2	7.6	2.0	0.7
4	3	2	225	2	1.0	0	0.0	2	9.8	8.8	3.5	0.8
4	3	3	225	2	0.9	0	0.0	2	9.5	8.6	3.5	0.8
4	3	4	225	5	2.1	0	0.0	5	9.7	9.1	3.0	0.8
4	3	5	225	1	0.4	2	0.6	1	9.4	8.8	3.0	0.8
4	3	6	225	3	1.4	0	0.0	3	10.3	8.2	3.3	0.9
4	3	7	225	6	2.6	0	0.0	5	9.6	7.5	3.5	0.9
4	4	1	225	1	0.5	2	0.7	1	10.6	6.5	3.0	0.7
4	4	2	225	0	0.0	3	1.2	3	10.5	6.6	2.7	0.9
4	4	3	225	2	0.9	2	0.7	2	11.0	7.7	3.0	0.8

A	B	C	D	E	F	G	H	I	J	K	L	M
4	4	4	225	3	1.2	3	0.8	3	10.5	6.6	3.0	0.8
4	4	5	225	1	0.6	0	0.0	1	9.8	7.0	3.0	0.9
4	4	6	225	1	0.6	1	0.2	1	9.4	7.1	3.0	0.7
4	4	7	225	3	1.5	0	0.0	3	9.8	8.3	3.0	0.8
5	1	1	225	1	0.5	0	0.0	1	10.7	8.8	3.0	0.7
5	1	2	225	2	1.2	1	0.2	2	10.2	9.1	3.3	0.7
5	1	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	4	225	0	0.0	1	0.2	1	8.5	7.1	4.0	0.7
5	1	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	6	225	2	0.9	0	0.0	2	9.8	8.4	3.0	0.6
5	1	7	225	2	1.0	5	1.8	2	10.6	8.3	3.0	0.7
5	2	1	225	1	0.5	0	0.0	1	7.3	7.2	4.0	0.7
5	2	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	2	3	225	1	0.6	0	0.0	1	10.6	7.6	3.0	0.7
5	2	4	225	1	0.6	0	0.0	1	11.1	8.0	3.0	0.8
5	2	5	225	1	0.6	0	0.0	1	11.6	9.5	3.0	0.8
5	2	6	225	5	2.1	1	0.2	5	10.7	8.0	3.0	0.6
5	2	7	225	6	2.5	0	0.0	5	10.8	8.1	3.0	0.8
5	3	1	225	1	0.5	1	0.5	1	9.6	10.4	2.5	0.8
5	3	2	225	3	1.3	1	0.3	3	10.0	8.4	3.0	0.8
5	3	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	4	225	0	0.0	1	0.3	1	7.0	7.7	3.0	0.9
5	3	5	225	0	0.0	1	0.3	1	7.5	7.8	3.0	0.9
5	3	6	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	7	225	2	1.0	0	0.0	2	10.5	8.5	3.0	0.8
5	4	1	225	3	1.4	0	0.0	3	10.6	9.7	3.0	0.8
5	4	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	4	3	225	1	0.6	0	0.0	1	10.5	9.5	4.0	0.7
5	4	4	225	1	0.6	0	0.0	1	11.0	8.9	4.0	0.7
5	4	5	225	1	0.4	0	0.0	1	9.2	9.6	4.0	0.7
5	4	6	225	0	0.0	1	0.4	1	7.7	9.5	2.0	0.7
5	4	7	225	2	1.0	0	0.0	2	10.2	9.7	3.0	0.8
6	1	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	3	225	1	0.6	0	0.0	1	10.4	10.5	3.0	0.8
6	1	4	225	2	0.9	0	0.0	2	9.2	8.9	4.0	0.7
6	1	5	225	3	1.7	0	0.0	3	10.0	8.1	3.3	0.8
6	1	6	225	5	2.7	0	0.0	5	9.7	9.1	3.0	0.8
6	1	7	225	0	0.0	1	0.6	1	9.9	9.4	2.0	0.7
6	2	1	225	3	1.3	0	0.0	3	10.3	9.1	3.0	0.8
6	2	2	225	2	1.2	0	0.0	2	12.0	9.5	2.5	1.0
6	2	3	225	.	.	.	.	.	.	.	.	.
6	2	4	225	2	1.9	0	0.0	2	9.5	8.2	3.0	0.7
6	2	5	225	3	1.7	1	0.2	3	8.8	8.3	3.0	0.7
6	2	6	225	7	3.2	0	0.0	5	8.5	9.5	3.0	0.7
6	2	7	225	3	1.3	0	0.0	3	9.3	7.5	3.0	0.7
6	3	1	225	1	0.5	0	0.0	1	9.9	9.1	4.0	0.8
6	3	2	225	0	0.0	1	0.3	1	8.5	8.2	4.0	0.6

A	B	C	D	E	F	G	H	I	J	K	L	M
6	3	3	225	0	0.0	1	0.4	1	10.7	7.6	2.0	0.6
6	3	4	225	3	1.4	0	0.0	3	9.5	9.8	3.0	0.8
6	3	5	225	1	0.5	0	0.0	1	9.6	9.4	3.0	0.8
6	3	6	225	6	2.7	0	0.0	5	8.0	8.7	3.0	0.9
6	3	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	1	225	2	0.7	0	0.0	2	10.4	7.7	3.0	0.9
6	4	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	3	225	2	1.1	0	0.0	2	9.8	9.9	3.0	0.8
6	4	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	5	225	3	1.3	0	0.0	3	8.9	9.5	3.0	0.8
6	4	6	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	1	1	225	3	1.5	2	0.9	3	11.2	8.6	2.8	1.0
7	1	2	225	5	1.7	0	0.0	5	10.6	7.2	3.0	0.8
7	1	3	225	1	0.5	3	1.1	1	11.7	7.1	2.0	0.9
7	1	4	225	3	1.1	3	0.9	3	10.5	8.6	2.0	0.8
7	1	5	225	2	0.8	2	0.5	2	10.9	8.2	2.0	0.8
7	1	6	225	4	1.4	1	0.3	4	10.0	6.6	3.0	0.7
7	1	7	225	2	0.6	5	1.4	2	10.4	7.2	2.0	0.8
7	2	1	225	7	2.5	1	0.3	5	9.0	8.2	3.0	0.7
7	2	2	225	8	2.9	1	0.3	5	9.7	7.4	3.0	0.9
7	2	3	225	4	1.8	0	0.0	4	9.5	7.0	3.5	0.8
7	2	4	225	9	2.8	2	0.6	5	8.7	8.0	3.0	0.7
7	2	5	225	4	1.6	1	0.3	4	10.6	7.5	3.0	0.8
7	2	6	225	6	2.6	0	0.0	5	10.5	8.7	3.0	0.8
7	2	7	225	9	3.3	0	0.0	5	9.3	6.5	3.0	0.7
7	3	1	225	4	1.2	2	0.6	4	9.6	8.5	3.0	0.8
7	3	2	225	4	1.4	0	0.0	4	11.2	7.6	3.0	0.7
7	3	3	225	0	0.0	2	0.6	2	9.8	6.4	2.0	0.8
7	3	4	225	4	1.7	2	0.7	4	8.9	7.8	3.0	0.7
7	3	5	225	9	3.0	1	0.4	5	10.5	8.9	3.0	0.8
7	3	6	225	5	2.3	1	0.4	5	10.0	8.3	3.0	0.9
7	3	7	225	5	1.6	3	0.7	5	10.5	7.5	3.0	0.8
7	4	1	225	5	1.8	0	0.0	5	10.0	8.8	3.0	0.8
7	4	2	225	6	2.2	0	0.0	5	10.1	9.0	3.0	0.8
7	4	3	225	5	1.9	0	0.0	5	10.6	8.2	3.0	0.8
7	4	4	225	2	0.8	0	0.0	2	8.8	7.4	4.0	0.9
7	4	5	225	4	1.7	0	0.0	4	9.8	8.4	3.0	0.7
7	4	6	225	6	2.3	1	0.3	5	11.2	7.7	3.0	0.8
7	4	7	225	4	1.6	0	0.0	4	10.8	8.2	3.0	0.8
8	1	1	225	1	0.4	0	0.0	1	9.0	7.7	3.0	0.9
8	1	2	225	3	1.5	0	0.0	3	10.4	8.4	3.0	0.8
8	1	3	225	3	1.5	0	0.0	3	11.0	7.0	3.3	0.8
8	1	4	225	0	0.0	2	0.9	2	11.0	7.8	2.5	0.9
8	1	5	225	1	0.5	1	0.2	1	11.1	6.2	2.0	0.6
8	1	6	225	9	3.3	0	0.0	5	10.4	6.8	3.0	0.8
8	1	7	225	4	1.2	2	0.8	4	11.2	9.2	2.7	0.8
8	2	1	225	5	2.1	0	0.0	5	10.9	7.8	3.0	0.7

A	B	C	D	E	F	G	H	I	J	K	L	M
8	2	2	225	3	1.5	1	0.4	3	10.3	9.9	4.0	0.7
8	2	3	225	3	1.4	0	0.0	3	11.8	8.2	3.0	0.8
8	2	4	225	0	0.0	3	1.5	3	11.0	10.5	3.0	0.6
8	2	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	2	6	225	2	0.9	0	0.0	2	11.4	7.9	3.5	0.6
8	2	7	225	1	0.6	2	0.6	1	11.5	6.8	3.0	0.9
8	3	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	3	2	225	1	0.5	1	0.2	1	12.2	8.3	3.5	0.7
8	3	3	225	4	1.7	0	0.0	4	12.0	8.6	3.0	0.8
8	3	4	225	1	0.5	0	0.0	1	10.4	8.5	3.0	0.8
8	3	5	225	0	0.0	2	0.6	2	9.7	8.4	3.5	0.9
8	3	6	225	5	2.0	3	1.0	5	11.2	7.8	3.0	0.7
8	3	7	225	1	0.5	0	0.0	1	9.9	9.4	3.0	0.9
8	4	1	225	5	1.8	0	0.0	5	9.5	8.1	3.0	0.7
8	4	2	225	2	1.0	0	0.0	2	10.0	9.0	4.0	0.9
8	4	3	225	3	1.4	0	0.0	3	9.3	9.1	3.0	0.8
8	4	4	225	4	1.4	0	0.0	4	10.7	7.0	3.0	0.8
8	4	5	225	2	0.7	0	0.0	2	9.2	7.1	3.0	0.8
8	4	6	225	1	0.5	0	0.0	1	11.4	8.0	3.0	0.7
8	4	7	225	4	1.7	0	0.0	4	10.5	8.7	3.0	0.8
9	1	1	225	4	1.6	0	0.0	4	9.1	8.8	3.0	0.7
9	1	2	225	0	0.0	1	0.5	1	10.8	10.1	2.0	0.7
9	1	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	4	225	1	0.6	0	0.0	1	10.6	9.6	3.0	0.8
9	1	5	225	4	1.4	0	0.0	4	8.4	8.7	3.0	0.7
9	1	6	225	4	1.8	0	0.0	4	10.5	9.6	3.0	0.7
9	1	7	225	4	1.8	0	0.0	4	9.4	8.7	3.5	0.8
9	2	1	225	2	1.0	0	0.0	2	9.0	9.5	3.5	0.7
9	2	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	3	225	3	1.6	0	0.0	3	8.7	8.6	4.0	0.7
9	2	4	225	6	2.7	0	0.0	5	8.6	8.8	3.0	0.9
9	2	5	225	1	0.6	0	0.0	1	8.2	9.0	4.0	0.8
9	2	6	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	7	225	2	1.0	0	0.0	2	9.5	9.4	3.5	0.8
9	3	1	225	1	0.5	0	0.0	1	9.8	9.8	3.0	0.9
9	3	2	225	3	1.4	0	0.0	3	9.9	9.4	3.0	0.8
9	3	3	225	2	1.0	0	0.0	2	8.8	8.9	4.0	1.0
9	3	4	225	4	1.8	0	0.0	4	9.5	9.1	3.0	0.7
9	3	5	225	3	1.5	0	0.0	3	8.7	8.4	3.3	0.8
9	3	6	225	1	0.4	1	0.5	1	8.5	8.4	2.0	0.7
9	3	7	225	4	2.0	0	0.0	4	9.0	10.0	3.0	0.8
9	4	1	225	1	0.5	0	0.0	1	10.4	8.5	3.0	0.9
9	4	2	225	2	1.2	1	0.4	2	10.2	8.1	3.0	0.8
9	4	3	225	3	1.2	0	0.0	3	8.0	8.8	3.0	0.9
9	4	4	225	3	1.5	0	0.0	3	9.7	8.4	3.7	0.7
9	4	5	225	7	2.3	0	0.0	5	8.8	7.2	3.5	0.7
9	4	6	225	4	1.9	0	0.0	4	9.9	8.1	3.0	0.7
9	4	7	225	1	0.4	0	0.0	1	9.5	8.5	3.0	0.7

A	B	C	D	E	F	G	H	I	J	K	L	M
10	1	1	225	1	0.4	0	0.0	1	11.5	8.0	3.0	0.6
10	1	2	225	2	0.7	1	0.3	2	9.8	8.9	2.7	0.8
10	1	3	225	2	0.7	0	0.0	2	9.4	7.0	4.0	0.7
10	1	4	225	2	1.3	0	0.0	2	13.4	9.2	3.0	0.8
10	1	5	225	0	0.0	1	0.4	1	11.9	9.3	3.0	0.9
10	1	6	225	1	0.3	1	0.5	1	11.4	9.2	2.5	0.7
10	1	7	225	3	1.3	0	0.0	3	11.6	8.3	3.0	0.8
10	2	1	225	2	1.1	0	0.0	2	11.1	9.0	3.0	0.7
10	2	2	225	2	0.9	0	0.0	2	11.2	9.3	3.0	0.7
10	2	3	225	1	0.7	1	0.3	1	11.6	8.0	3.0	0.7
10	2	4	225	2	1.3	2	0.8	2	11.0	8.0	3.0	0.7
10	2	5	225	0	0.0	1	0.4	1	13.2	8.2	1.0	0.8
10	2	6	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	7	225	0	0.0	2	1.0	0	9.9	10.1	3.0	0.8
10	3	1	225	1	0.7	0	0.0	1	10.7	9.7	4.0	0.8
10	3	2	225	2	1.1	0	0.0	2	9.3	10.7	4.0	0.9
10	3	3	225	1	0.6	0	0.0	1	10.8	9.5	3.0	0.9
10	3	4	225	1	0.5	0	0.0	1	10.4	8.4	3.0	0.8
10	3	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	3	6	225	5	2.2	0	0.0	5	10.8	8.7	3.0	0.8
10	3	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	4	1	225	1	0.6	0	0.0	1	9.6	9.6	3.0	0.8
10	4	2	225	2	1.2	0	0.0	2	11.0	7.9	3.5	0.9
10	4	3	225	2	1.0	0	0.0	2	10.7	8.5	3.0	0.8
10	4	4	225	0	0.0	1	0.2	1	8.4	7.0	3.0	0.5
10	4	5	225	1	0.3	0	0.0	1	9.6	7.7	3.0	0.7
10	4	6	225	1	0.7	0	0.0	1	10.5	10.3	4.0	0.9
10	4	7	225	2	1.0	0	0.0	2	11.2	8.5	3.0	0.7
11	1	1	225	1	0.5	1	0.2	1	8.3	6.4	4.0	0.8
11	1	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	1	3	225	0	0.0	2	0.5	2	8.4	6.0	4.0	0.8
11	1	4	225	3	1.2	4	1.0	3	8.8	7.6	3.0	0.8
11	1	5	225	2	0.6	3	0.8	2	8.1	7.7	3.3	0.6
11	1	6	225	5	1.7	1	0.2	5	8.8	6.8	3.0	0.8
11	1	7	225	4	1.2	2	0.4	4	8.9	6.9	3.0	0.8
11	2	1	225	4	1.0	0	0.0	4	8.6	7.2	3.0	0.8
11	2	2	225	7	2.5	1	0.3	5	8.7	7.1	3.5	0.8
11	2	3	225	5	1.6	2	0.4	5	8.5	7.4	3.0	1.0
11	2	4	225	5	1.5	1	0.2	5	8.2	7.3	3.0	0.7
11	2	5	225	7	2.6	0	0.0	5	9.2	8.1	3.0	1.0
11	2	6	225	5	1.6	1	0.3	5	8.7	7.5	3.5	0.9
11	2	7	225	6	2.0	0	0.0	5	8.3	7.4	3.3	0.9
11	3	1	225	4	1.2	1	0.2	4	10.3	6.2	3.0	0.7
11	3	2	225	6	1.8	3	0.8	5	8.5	6.7	3.0	0.7
11	3	3	225	5	1.6	1	0.2	5	9.9	7.5	3.0	0.8
11	3	4	225	5	1.7	2	0.6	5	8.1	7.8	3.5	0.8
11	3	5	225	4	1.5	1	0.2	4	9.5	6.3	3.0	0.6
11	3	6	225	6	2.2	0	0.0	5	9.2	7.8	3.5	0.8

A	B	C	D	E	F	G	H	I	J	K	L	M
11	3	7	225	0	0.0	4	1.3	4	8.3	7.8	3.0	0.8
11	4	1	225	5	1.4	2	0.6	5	9.3	6.5	3.0	0.7
11	4	2	225	3	0.8	0	0.0	3	10.1	7.0	3.0	0.7
11	4	3	225	3	1.0	0	0.0	3	9.8	7.6	3.0	0.8
11	4	4	225	5	1.7	1	0.3	5	8.5	7.8	3.0	0.8
11	4	5	225	9	2.8	0	0.0	5	10.0	7.1	3.0	0.7
11	4	6	225	6	2.0	0	0.0	5	9.5	8.0	3.0	0.7
11	4	7	225	3	0.9	0	0.0	3	9.2	6.9	3.0	0.7
12	1	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	1	2	225	2	1.3	1	0.2	2	9.0	9.3	3.3	0.7
12	1	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	1	4	225	1	0.7	1	0.4	1	8.0	8.2	3.0	0.8
12	1	5	225	1	0.4	0	0.0	1	10.5	8.1	3.0	0.6
12	1	6	225	2	0.8	0	0.0	2	10.0	8.7	3.0	0.8
12	1	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	1	225	3	1.2	0	0.0	3	10.6	10.0	3.0	0.7
12	2	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	3	225	1	0.4	0	0.0	1	9.5	7.3	3.0	0.8
12	2	4	225	1	0.4	1	0.2	1	10.3	8.9	2.5	0.8
12	2	5	225	0	0.0	1	0.4	1	9.0	9.3	3.0	0.7
12	2	6	225	4	1.7	1	0.3	4	9.6	8.8	3.0	0.8
12	2	7	225	2	0.7	4	1.3	2	9.7	8.7	3.0	0.7
12	3	1	225	1	0.6	0	0.0	1	9.4	8.3	4.0	0.9
12	3	2	225	0	0.0	2	0.9	2	11.2	9.0	4.0	0.7
12	3	3	225	0	0.0	1	0.5	1	9.0	7.8	2.0	0.7
12	3	4	225	3	1.2	0	0.0	3	9.0	8.2	3.0	0.8
12	3	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	6	225	5	1.9	0	0.0	5	9.8	8.3	3.0	0.8
12	3	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	1	225	4	1.6	0	0.0	4	8.6	8.1	3.0	0.7
12	4	2	225	1	0.4	0	0.0	1	9.4	8.4	4.0	0.7
12	4	3	225	2	0.9	0	0.0	2	10.3	9.4	3.0	0.9
12	4	4	225	4	1.6	0	0.0	4	10.8	8.4	3.0	0.8
12	4	5	225	3	1.1	1	0.2	3	10.6	8.7	3.0	0.8
12	4	6	225	2	0.8	0	0.0	2	9.4	7.4	3.0	0.7
12	4	7	225	1	0.3	0	0.0	1	10.8	7.9	3.0	0.8
13	1	1	225	1	0.6	0	0.0	1	9.6	10.1	4.0	0.8
13	1	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	6	225	2	1.0	0	0.0	2	8.8	8.5	3.5	0.8
13	1	7	225	1	0.3	0	0.0	1	9.2	7.1	3.0	0.6
13	2	1	225	2	1.0	0	0.0	2	9.5	9.1	4.0	0.8
13	2	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
13	2	6	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	5	225	0	0.0	1	0.4	1	10.2	8.5	3.0	0.6
13	3	6	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	2	225	0	0.0	1	0.5	1	11.2	7.9	2.0	0.6
13	4	3	225	0	0.0	1	0.4	1	9.9	9.7	3.0	0.6
13	4	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	6	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	7	225	.	.	.	.	.	.	.	.	.
14	1	1	225	1	0.6	0	0.0	1	12.0	9.5	4.0	0.9
14	1	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	5	225	3	1.6	0	0.0	3	8.8	9.3	3.0	0.9
14	1	6	225	1	0.5	0	0.0	1	8.4	9.4	4.0	0.7
14	1	7	225	5	2.2	0	0.0	5	9.5	9.7	3.6	0.7
14	2	1	225	1	0.6	0	0.0	1	12.0	9.4	3.0	0.8
14	2	2	225	0	0.0	1	0.4	1	8.1	9.8	3.0	0.8
14	2	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	4	225	1	0.4	0	0.0	1	10.0	8.8	3.0	0.7
14	2	5	225	1	0.6	0	0.0	1	10.6	9.0	3.0	0.9
14	2	6	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	1	225	1	0.7	0	0.0	1	12.3	8.9	3.0	0.7
14	3	2	225	3	1.5	0	0.0	3	9.3	9.6	4.0	0.8
14	3	3	225	0	0.0	1	0.7	1	13.9	8.4	1.0	0.8
14	3	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	5	225	1	0.7	0	0.0	1	11.0	10.1	3.0	0.8
14	3	6	225	1	0.7	0	0.0	1	10.8	9.5	3.0	0.8
14	3	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	1	225	0	0.0	1	0.3	1	6.7	8.5	3.0	0.7
14	4	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	3	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	4	225	1	0.4	0	0.0	1	8.8	9.2	3.0	0.8
14	4	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	6	225	1	0.6	0	0.0	1	11.5	8.6	3.0	1.1
14	4	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	2	225	1	0.5	0	0.0	1	10.6	6.4	4.0	0.9
15	1	3	225	1	0.5	1	0.5	1	11.4	8.7	2.0	0.9
15	1	4	225	2	1.2	0	0.0	2	10.6	8.8	4.0	0.8

A	B	C	D	E	F	G	H	I	J	K	L	M
15	1	5	225	3	1.4	0	0.0	3	9.3	8.3	3.7	0.8
15	1	6	225	4	1.8	1	0.3	4	9.5	9.8	3.0	0.8
15	1	7	225	1	0.4	0	0.0	1	9.5	8.8	3.0	0.8
15	2	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	2	225	2	0.7	0	0.0	2	9.5	7.0	3.0	0.8
15	2	3	225	1	0.6	0	0.0	1	12.7	8.0	3.0	0.8
15	2	4	225	2	0.8	0	0.0	2	9.6	8.8	3.0	0.8
15	2	5	225	2	0.8	0	0.0	2	9.3	7.0	4.0	0.8
15	2	6	225	0	0.0	2	0.8	2	12.2	7.5	2.0	0.8
15	2	7	225	1	0.5	0	0.0	1	11.8	8.5	3.0	0.8
15	3	1	225	3	1.8	0	0.0	3	10.8	7.4	4.0	0.9
15	3	2	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	3	225	2	0.9	0	0.0	2	11.4	8.0	3.0	1.0
15	3	4	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	5	225	3	1.6	0	0.0	3	11.3	9.0	3.3	1.0
15	3	6	225	2	1.0	1	0.5	2	9.8	8.1	3.3	1.0
15	3	7	225	1	0.5	0	0.0	1	10.7	8.0	3.0	0.9
15	4	1	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	2	225	3	1.4	0	0.0	3	10.3	10.1	3.0	0.9
15	4	3	225	1	0.5	0	0.0	1	11.0	8.1	3.0	0.8
15	4	4	225	1	0.5	0	0.0	1	9.6	7.8	4.0	0.9
15	4	5	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	6	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	7	225	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	1	2	238	0	0.0	3	0.7	3	7.3	6.5	3.0	0.7
1	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	1	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	2	2	238	1	0.3	0	0.0	1	5.7	6.5	4.0	0.6
1	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	2	6	238	0	0.0	2	0.6	2	9.6	6.0	3.5	0.8
1	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	3	4	238	2	0.7	0	0.0	2	11.1	7.7	3.0	1.0
1	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	3	6	238	4	1.3	0	0.0	4	11.1	6.8	3.0	0.8
1	3	7	238	2	0.5	0	0.0	2	8.4	6.1	3.5	0.6
1	4	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
1	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
1	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	1	238	2	0.7	0	0.0	2	8.0	8.2	4.0	0.8
2	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	3	238	1	0.3	0	0.0	1	8.2	6.5	3.0	0.8
2	1	4	238	5	1.5	0	0.0	5	8.7	7.2	4.0	0.7
2	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	1	7	238	2	0.7	0	0.0	2	8.3	7.7	4.0	0.9
2	2	1	238	5	1.8	0	0.0	5	9.9	7.3	3.0	0.9
2	2	2	238	8	2.5	0	0.0	5	8.0	7.8	3.0	0.7
2	2	3	238	6	1.8	0	0.0	5	8.2	7.2	3.5	0.7
2	2	4	238	5	1.5	0	0.0	5	8.3	7.7	3.0	0.7
2	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	2	6	238	5	1.6	0	0.0	5	9.6	8.0	3.5	0.8
2	2	7	238	2	0.7	0	0.0	2	9.0	8.1	3.0	0.8
2	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	3	2	238	1	0.4	0	0.0	1	9.0	7.4	4.0	0.8
2	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	3	4	238	1	0.5	0	0.0	1	9.1	9.0	3.0	0.9
2	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
2	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	1	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
3	3	3	238	1	0.3	0	0.0	1	10.1	8.0	3.0	0.7
3	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	5	238	2	0.7	0	0.0	2	8.9	8.1	3.5	0.7
3	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
3	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	1	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	2	7	238	1	0.6	0	0.0	1	11.3	9.5	3.0	0.8
4	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	3	3	238	1	0.4	1	0.6	1	9.0	6.4	4.0	0.7
4	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	3	5	238	0	0.0	1	0.3	1	9.0	7.2	3.0	0.6
4	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	3	7	238	1	0.4	0	0.0	1	10.8	7.1	3.0	0.8
4	4	1	238	2	0.4	0	0.0	2	6.8	6.3	3.5	0.5
4	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	3	238	1	0.4	0	0.0	1	8.8	8.1	3.0	0.7
4	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
4	4	6	238	1	0.3	0	0.0	1	9.3	6.4	3.0	0.9
4	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	1	7	238	0	0.0	1	0.3	1	7.0	7.3	3.0	0.7
5	2	1	238	4	1.3	0	0.0	4	10.0	7.6	3.0	0.8

A	B	C	D	E	F	G	H	I	J	K	L	M
5	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	2	4	238	2	0.8	0	0.0	2	9.7	7.5	3.0	0.8
5	2	5	238	2	0.8	0	0.0	2	8.6	7.6	3.0	0.8
5	2	6	238	1	0.5	0	0.0	1	8.8	8.6	3.0	0.8
5	2	7	238	3	0.3	0	0.0	3	9.3	6.3	3.0	0.8
5	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	4	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
5	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	1	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	2	3	238	.	.	.	.	.	.	.	.	.
6	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
6	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
7	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	1	2	238	9	2.7	0	0.0	5	9.8	7.1	3.0	0.8
7	1	3	238	2	0.8	0	0.0	2	10.7	7.2	3.5	0.8
7	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	1	5	238	5	1.8	0	0.0	5	10.7	8.7	3.0	0.8
7	1	6	238	2	0.6	0	0.0	2	11.0	6.7	2.0	0.8
7	1	7	238	2	0.7	0	0.0	2	9.3	7.7	3.5	0.8
7	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	2	2	238	1	0.2	0	0.0	1	7.2	6.0	4.0	0.5
7	2	3	238	2	0.8	0	0.0	2	9.8	7.6	3.5	0.7
7	2	4	238	1	0.3	0	0.0	1	6.7	6.1	4.0	0.7
7	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	2	6	238	2	0.7	0	0.0	2	10.1	7.0	3.0	0.6
7	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	3	1	238	2	0.7	0	0.0	2	9.5	8.4	3.5	0.8
7	3	2	238	1	0.4	0	0.0	1	10.9	8.5	3.0	0.9
7	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	3	4	238	1	0.4	0	0.0	1	11.0	6.6	3.0	0.8
7	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	3	6	238	2	0.6	0	0.0	2	8.3	7.0	3.0	0.7
7	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	4	1	238	1	0.4	0	0.0	1	9.7	7.1	3.0	0.7
7	4	2	238	0	0.0	1	0.2	0	8.5	5.7	1.0	0.6
7	4	3	238	1	0.4	0	0.0	1	10.7	9.5	2.0	0.8
7	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
7	4	7	238	1	0.4	3	0.8	1	8.3	7.0	3.7	0.7
8	1	1	238	1	0.3	0	0.0	1	8.6	6.5	3.0	0.8
8	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	1	4	238	1	0.5	0	0.0	1	10.8	8.2	4.0	0.7
8	1	5	238	1	0.3	0	0.0	1	9.1	6.7	3.0	0.8
8	1	6	238	3	1.0	0	0.0	3	11.0	7.1	3.0	0.8
8	1	7	238	1	0.4	0	0.0	1	10.4	7.4	4.0	0.7
8	2	1	238	1	0.4	0	0.0	1	8.0	6.7	4.0	0.8
8	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
8	3	7	238	1	0.4	0	0.0	1	10.4	7.2	3.0	0.8
8	4	1	238	2	0.7	0	0.0	2	9.5	7.4	3.0	0.8
8	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
8	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	1	4	238	2	0.8	0	0.0	2	9.6	7.8	3.0	0.8
9	1	5	238	1	0.5	0	0.0	1	8.6	7.7	4.0	0.8
9	1	6	238	1	0.4	0	0.0	1	9.3	9.9	3.0	0.9
9	1	7	238	5	1.5	0	0.0	5	8.6	8.4	3.0	0.9
9	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	4	238	C	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	1	238	1	0.5	0	0.0	1	9.0	8.4	3.0	0.9
9	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	3	238	2	0.7	0	0.0	2	7.8	8.4	4.0	0.8
9	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
9	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	1	1	238	1	0.5	0	0.0	1	12.4	8.0	3.0	0.9
10	1	2	238	3	1.0	0	0.0	3	9.0	7.3	3.3	0.8
10	1	3	238	1	0.5	0	0.0	1	9.0	7.5	4.0	0.7
10	1	4	238	1	0.4	0	0.0	1	10.6	7.1	4.0	0.7
10	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	1	6	238	1	0.5	0	0.0	1	9.0	8.1	4.0	0.8
10	1	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	1	238	1	0.3	0	0.0	1	6.5	7.5	3.0	0.6
10	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	3	238	3	1.1	0	0.0	3	8.8	7.5	4.0	0.7
10	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	5	238	3	0.8	0	0.0	3	6.5	7.4	3.7	0.7

A	B	C	D	E	F	G	H	I	J	K	L	M
10	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	3	6	238	1	0.5	0	0.0	1	9.4	8.1	4.0	0.8
10	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	4	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	4	4	238	1	0.4	0	0.0	1	9.5	8.4	3.0	0.8
10	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
10	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	1	1	238	2	0.6	0	0.0	2	8.3	7.3	3.0	0.9
11	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	1	6	238	3	0.9	0	0.0	3	8.3	6.8	3.0	0.8
11	1	7	238	4	1.1	0	0.0	4	7.7	6.5	4.0	0.8
11	2	1	238	2	0.6	0	0.0	2	8.1	8.1	3.0	0.8
11	2	2	238	C	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	2	3	238	5	1.3	2	0.4	5	8.8	7.0	3.0	0.8
11	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	2	5	238	1	0.3	1	0.2	1	8.8	6.9	3.5	0.9
11	2	6	238	1	0.3	0	0.0	1	7.4	5.9	3.0	0.8
11	2	7	238	2	0.5	0	0.0	2	8.6	6.4	3.0	0.6
11	3	1	238	3	0.9	0	0.0	3	7.6	6.5	3.3	0.8
11	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	3	4	238	2	0.5	2	0.4	2	9.4	5.9	3.0	0.6
11	3	5	238	1	0.3	0	0.0	1	8.3	6.7	3.0	0.8
11	3	6	238	C	0.0	2	0.5	2	7.8	6.1	3.0	0.7
11	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	4	1	238	4	0.9	0	0.0	4	7.7	6.8	3.0	0.7
11	4	2	238	3	0.8	1	0.2	3	7.2	6.0	3.0	0.6
11	4	3	238	1	0.4	0	0.0	1	8.9	6.5	4.0	0.9
11	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
11	4	6	238	0	0.0	3	0.6	3	8.1	5.6	3.7	0.9
11	4	7	238	3	0.8	3	0.8	3	8.1	6.6	3.5	0.9
12	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
12	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	1	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
12	4	6	238	1	0.5	0	0.0	1	10.2	8.1	3.0	0.8
12	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	1	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	1	238	0	0.0	1	0.5	1	8.6	9.3	4.0	0.7
13	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
13	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
13	4	7	238	.	.	.	.	.	.	.	.	.
14	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	5	238	2	0.9	0	0.0	2	8.4	9.0	4.0	0.8
14	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	1	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
14	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	1	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	2	238	1	0.5	0	0.0	1	11.2	6.7	4.0	0.9
15	2	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	5	238	2	0.8	0	0.0	2	10.4	8.0	2.0	1.0
15	2	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	2	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0

A	B	C	D	E	F	G	H	I	J	K	L	M
15	3	3	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	3	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	1	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	2	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	3	238	2	0.9	0	0.0	2	9.2	8.3	3.5	0.8
15	4	4	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	5	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	6	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0
15	4	7	238	0	0.0	0	0.0	0	0.0	0.0	0.0	0.0