INHERITANCE OF EARLINESS IN FIVE EARLY MATURING PEANUT, (*Arachis hypogaea* L.), LINES

A Thesis

by

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INHERITANCE OF EARLINESS IN FIVE EARLY MATURING

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ABSTRACT

Inheritance of Earliness in Five Early Maturing

Peanut, (*Arachis hypogaea* L.), Lines.

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Five early maturing spanish peanut lines were crossed in complete diallel and parent, F_1, and F_2 generations were evaluated. Dates of emergence and occurrence of first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers were recorded. Number of full-size pods and number of mature pods based on internal pericarp color were counted after digging.

Progenies differed among parental combinations in number of days to specified flower numbers, number of full-size pods, number of mature pods, and percent mature pods. Reciprocal differences were not apparent.

Segregates were found in all crosses that flowered earlier and produced more full-size and mature pods than the parents. Number of full-size pods, number of mature pods, percent mature pods, and days from planting to the twenty-fifth flower were highly correlated. Correlation of days from planting to specified number of flowers and number of full-size pods was higher than

for days from emergence or first flower to specified flower numbers and number of full-size pods. Selection for earliness on the basis of flower number would not have been effective in this study.

Important differences in the heritabilities of traits used as indicators of relative maturity were not apparent. Averaged over crosses the heritability of days from planting to twenty-five flowers was higher than for days from planting to first flower. Heritability estimates for number of full-size and mature pods tended to be highest in crosses involving Tx851856.

Parental lines did not differ (P=0.05) in general combining ability (GCA) for neither number of mature pads (NUMP) nor weight of mature seeds (WTMS) based on F_1 data. TxAG-1 crosses produced the most mature pods and Tx851856 crosses had the heaviest mature seeds (WTMS). These traits are characteristics of the two parental lines. Chico had good GCA for both NUMP and WTMS.

Differences in specific combining ability (SCA) for NUMP or WTMS were not statistically significant (P=0.05).

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DEDICATION

To my parents,

my relatives,

my friends,

and al 1 Senegalese peanut fat-mers.

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INTRODUCTION

The development of productive, acceptable, early maturing cultivars is a priority objective in many plant breeding programs. Earliness reduces the duration of crop risk: allows greater flexibility in planting time within growing seasons: facilitates irrigation water conservation and reduces irrigation expense: and is important in areas with short rainy seasons and subsistence farming, such as occurs in the Sahel. The capability of a variety to mature a reasonable quantity of fruit during the short seasons in some areas becomes even more important than good yield performance when seasons are favorable.

The cultivars Sn 55-437, Sn 73-30, and TS 32-l are cultivated widely in the peanut growing regions of West Africa where the rainy seasons are very short. These cultivars, which are classif ied as 120 day varieties in Texas, normally require 90 days for acceptable maturation in those regions of West Africa (7). The length of the rainy season in regions of Africa has often been inadequate for these cultivars to mature. Poor yields and poor quality have been the result. Earlier maturing varieties adapted to these regions are needed.

Germplasm that matures earlier than Sn 55-437 and TS 32-1 and suitable for use as parents is limited. Chico has been used as a source of earliness in several breeding programs with limited success (e.g.4,16). Two breeding lines, TxAG-1 and TxAG-2, which

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Thesis format follows Crop Science style.

mature approximately 30 days earlier than Starr in Texas, were released by the Texas Agricultural Experiment Station as germplasm lines for earliness (22). Another breeding line, designated Tx851856, reportedly from North Vietnam, has matured simultaneously with Chico in Texas tests (O.D. Smith, persona1 communication).

The purpose of this study is to ascertain whether or not the genetic factors providing earliness in Chico, Sn 55-437, TxAG-1, TxAG-2, and Tx851856 are the same or different: the relative merit of each as a parent for earliness: and if segregates earlier than these breeding lines might be developed through recombination among crosses of these lines.

LITERATURE REVIEW

The growth duration of U.S. peanut cultivars ranges from 95-100 days for Chico to more than 150 days for Southeastern Runner (2).

Typically, the growth duration of the fastigiata subspp. is shorter than the hypogaea subspp., and the descriptive reference of "early spanish" is common within the industry. The yield of Chico in Texas is markedly inferior to commercial cultivars such as Starr and Tamnut 74. The yields of TxAG-1, TxAG-2, and Tx851856 have also been inferior to Starr in Texas tests.

Definition of when a variety is "mature" is subjective because of the indeterminate nature of the crop. Peanuts harvested at any time include some immature fruits. Since immature peanut kernels lower both quality and yield, peanut plants should be harvested when the frequency and quantity of mature seeds are maximal.

Many studies on methods of estimating peanut maturity have been published (11,14,16,18,19,24,26). Miller and Burns (16) studied the internal pericarp color of peanut pods, and stated that as the peanuts mature, the veins near the internal hull surface change from white to brown. The darkening of the veins is apparently caused by the ageing of the vein cells and consequently color development. Gilman and Smith (11) used peanut genotypes differing in botanical type and geographical source to establish parameters for making reliable maturity determinations on the basis of internal pericarp color (IPC). They compared the IPC

(16), kernel density (KD), and arginine maturity index (AMI) methods of estimating peanut maturity.

The AMI method, developed by Young and Mason (26) is based on a colorimetric reaction in which 50g samples of freshly harvested or dry-cured peanuts were homogenized in a Waring Blendor at high speed in 500 ml of 3N $HClO_4$ for 9 minutes. Classification of maturity was based on the free arginine content of the samples measured colorimetrically. They concluded that the immature peanuts which are usually quite small were extremely high in free argfnine. They concluded that arginine content was a sensitive, rapid means of determining the amount of immaturity in a sample of peanuts.

Holaday and coworkers (14) reported results of a 3-year study which was based on the measurement of the pigments extracted from peanut pods with methanol. The percent of light transmitted through the methanolic extracts was measured and compared with the days after planting, yield, dollar return per acre, and meteorological data recorded during the growing period of Florunner peanut. Both the Holaday and AMI methods are destructive and not adapted to use where seed supply is very limited.

Pattee and coworkers (18) based their method on the changing seed-hull ratio during maturation of the fruit. The ratio was obtained by dividing the weight of seeds by the weight of the hulls. The ratio or maturity index was determined from fresh (FMI) as well as air-dried pods (DMI), and these ratios correlated well with a physiological maturity index. This method might be acceptable for estimating states of maturation within a line but is not suited for comparing among selections where pod shape, shell thickness, and factors other than proportion of mature pods affect the seed-hull ratio.

Williams and Drexler (24) proposed a method based on color and morphological differences of the mesocarp of fresh Florunner peanut pods. Maturity determination by this method requires removal of a portion of the exocarp or epidermis to expose the mesocarp, which is non-destructive to the remaining pod structure and enclosed seeds.

Oil characteristics of peanut fruits of different maturity classes were determined by Sanders and coworkers (19). Analyses were made on peanut pods separated into maturity classes established by William and Drexler (24). According to that method, color decreased, free fatty acid content decreased, iodine value remained approximately constant, and oven stability of the extracted oil increased with increased maturity.

Bailey and Bear (2) used flower opening and potential for pod development to differentiate the relative earliness of peanut lines. They evaluated earliness of maturity in peanuts by a) the number of days from planting to opening of the first flower; b) first flower to accumulated number of flowers ranging from 15 to 30 per plant; c) opening of flower to maturation of seeds that develop from that flower; and d) maturation of seeds in a pod ta deterioration of the peg by which the pod is attached to the plant. They were able to account for differences in maturity of up to 50 days among the maturity classes.

Hassan and Srivastava (13) studied floral biology and pod development in four peanut cultivars and reported that earlier maturing cultivars began flowering 2 to 3 days sooner than late maturing cultivars. They also reported variety differences in other flowering characteristics but were unable to relate these differences to pod maturing characteristics.

Several reports on breeding for early maturing cultivars have been reported in the literature. Nigam and coworkers (17) stressed early maturing cultivars adapted to the short growing season of the semi-arid tropics, and to fit peanuts into relay or sequential cropping systems. Gibori (9) studied the inheritance of days to first flower in virginia, spanish, and valencia type peanuts. He stated that the length of the period, in days, from emergence to first flower is controlled by several genes which exhibited bidirectional dominance. Gibori and coworkers (10) concluded that bidirectional dominance occurred for the traits total pod yield per plant and number of days from planting to first flower. The genetic control of the length of the period from planting to first flower was studied by Wynne and coworkers (25): the F_1 hybrids were earlier than the early parent, intermediate, or later than the late parent, depending on the botanical types of the parents in each combination. Shakudo and Kawarbata (21) found that the F_1 hybrids flowered later than the mean of their parents. Banks and Kirby (4) bred for earlier maturing spanish peanuts in Oklahoma to escape fall frost damage and for use in double cropping. They developed and released the cultivars Pronto and Spanco which they described as 10 to 24 days earlier than other current U.S. varieties of spanish peanuts in Oklahoma. In Texas, the seeds of Pronto and Spanco are larger than other spanish cultivars and the seeds attain sufficient size to be classified "Sound Mature Kernel" (SMK) at an early date: but the cultivars are not earlier than Starr as measured by the IPC method.

It is evident from this review that several researchers have studied earliness and that no totally effective criterion for screening large populations of peanut lines for earliness has been defined. Both flowering and fruiting traits will be examined in this study to aid the assignment of plants into maturity groups. In the breeding studies cited, the parents used differed considerably in growth duration. We are using parents with short growth duration only, the long range goals being to determine if genotypes earlier than the parents can be developed through recombination.

MATERIALS AND METHODS

Vegetal Material

Five early maturing peanut lines, described in Table 1, were used in this study. Random plants from these lines were crossed, in the greenhouse, in a complete diallel. Some of the F_1 seeds were planted to produce F_2 seeds, and the remainder stored at approximately 28 degrees celsius and 45% relative humidity. Sixteen parent, 30 F_1, and 290 F_2 seeds of each parental combination (except in the cross TxAG-1/TxAG-2 for which we did not have enough seeds) were simultaneously planted under field conditions. The experiment was conducted west of Bryan, Texas on a Patilo sandy loam soil. The experiment was arranged in a randomized split block design with four replications. Replicates one through four were planted on May 19, May 22, May 26, and June 8, respectively. Three to four day intervals between plantings were intended to facilitate data collection and provide some variation in environmental conditions. Rain almost flooded the field following the second planting and the third replicate had to be replanted on June 22 because of persistently wet soil. Proportional components of each population were planted on each date for a total of 720 seeds per planting. Seeds, at planting, were spaced 40 cm apart in rows with 91 cm centers.

Chemicals

Fertilizer and calcium-sulfate were applied according to soil test recommendations. All seeds were treated with fungicide to reduce seedling disease. Weeds were controlled with herbicides

Table 1. Description and characteristics of five parental lines.

1. Chico is an erect spanish type peanut released by the ARS, USDA, and the Georgia, Virginia, and Oklahoma Agricultural Experiment Stations (3) as a garden variety and as a source of earliness. Chico pods are small and slender with thin shells.

2. Sn 55-437 is a spanish type peanut selected in Senegal; its life cycle is about 90-100 days in West Africa (7). It was selected from a probable South American population received from Hungary.

3. TxAG-1 is a germplasm line derived by mutation of Spantex and released by the Texas Agricultural Experiment Station (22). It has a reproductive cycle of 90-110 days.

4. TxAG-2 was released as a germplasm line developed by mutation of Spantex by the Texas Agricultural Experiment Station (22). It matures about 90-110 days after planting varying with environment and location.

5. Tx851856 is an erect spanish type peanut with small leaves and medium size pods. Its reproductive cycle is similar to Chico.

using one pre-plant incorporated application of Trifluralin (1 l/ha), and over the top applications of Bentazon (2 l/ha), and Sethoxydim 0.4 kg a.i./ha plus crop oil 2.3 l/ha. Metachlor was applied pre-emergence and mid-season at a rate of 1 l/ha each application. Cultivation and hand weeding were also used to control weeds as needed throughout the growing season. Recommended disease and insect control practices were followed. Eighteen kg/ha of Ridomil PC (combination of metalaxal and pentachlorobenzene) were applied two times and 4 kg/ha of active ingredient of Quintozene applied one time to control pod rot. Chlorothalonil was used five times at a rate of 2 l/ha to control leaf spot. Chlorpyrifos, 1 kg/600 meter row, and Cyanobenzeneacetate 0.2 kg/ha were also applied to control foliar insect feeders. Water was supplied as needed during the season by sprinkler irrigation.

Traits Measured

Daily record was made on an individual plant basis for days from planting to emergence and flowers one through 25. All entries within a planting were pulled by hand simultaneously, 90 days after planting for replication one, and 90 days after 50% or more of the plants had emerged for the remaining replications. Plants within a cross were identified, bundled, brought to the field laboratory and all pods were picked by hand. Relative maturity was determined on a plant basis using freshly harvested pods classified as follows: pods that were more than two times the diameter of the peg, fleshy pods (torpedo shape and larger), reticular pods, single pods, and full-size pods. After the pods were air dried and hand shelled, the latter class was further divided as fully mature, intermediate, and shrivelled. The mature seeds were counted for each plant and weighed.

Statistical and Genetic Analyses

Statistical analyses

Data was analyzed using the general linear mode1 procedures. Population and generation means and variances were estimated. Homogeneity of variances among replications were tested by Bartlett°s formula (5). Coefficients of correlation between traits were computed using SAS procedures (20).

Genetic analyses

Broad sense heritability, defined as the proportion of the total variance expressed among individuals that can be attributed to genetic differences among them (8), was estimated using the method described by Allard (1)

$H=V_G/V_P$ where

H= broad sense heritability

V_G= genetic variance

V_P= total phenotypic variance

V_G was estimated by substracting the environmental variance, which was considered to be the average of the variances of F_1, P_1, and P_2 from V_P; where P_1 and P_2 are the female and male parents of a given cross.

V_P is the variance of the F_2 generation of the same cross.

Sprague and Tatum (24) defined "general combining ability"

(GCA) as the average performance of a parental line in hybrid combination and "specific combining ability" (SCA) as those cases in which certain combinations do relatively better or worse than would be expected on the basis of the average performance of the lines. Combining abilities were compared according to Griffing's method I model 1 (12) (parents, one set of F_1's and reciprocal F_1's are included). The mathematical model for the combining ability analysis is summarized below

Y_{ijk} = U + gi + gj + sij + rij + 1/bcx(sum Of eijkl) where

Y_{ij} = value of the i^{th} line and the j^{th} line

U = population mean

g_i = GCA effect for the i^{th} parent

g_j = GCA effect for the j^{th} parent

s_{ij} = SCA effect for the cross between the i^{th} parent and the j^{th} parent such that $s_{ij}=s_{ji}xr_{ij}$

r_{ij} = reciprocal cross between the i^{th} and j^{th} parents

e_{ijkl} = the environmental effect associated with the ijkl th individual observation.

RESULTS

Rain and low temperatures occurred for about a month after planting started. Rainfall totalled 14.2 mm the day following the first planting date (Appendix figures 1 and 2). The second planting emerged relatively fast, although the soil was wet and rather cool. The third and fourth planting dates coincided with heavy rains that saturated the soil for two weeks. Both the germination rate and flowering pattern were affected by the varied growing conditions.

Planting Date Effects

Emergence

The rate of emergence varied considerably among replications as indicated by Figures 1 through 4. Emergence occurred 6 to 22 days after planting with most plants emerging between 6 and 14 days after planting for replication one (Figure 1). Most of the plants from the second planting emerged between 6 and 11 days after planting (Figure 2). The third and fourth plantings suffered the most from the weather. Germination and/or hypocotyl growth was slowed, some seeds rotted, and less than 25% of the seeds of replication three emerged. Consequently, it was replanted June 22 when conditions were more favorable for emergence. With the near optimal moisture and warm temperatures, emergence was almost complete within seven days (Figure 3). Emergence in replication four was very slow, mostly 14 to 20 days after planting (dap), as shown in Figure 4; however, most of the seeds did emerge. In every replication there were a few plants

Figure 1. Number of days from planting to emergence for replication 1.

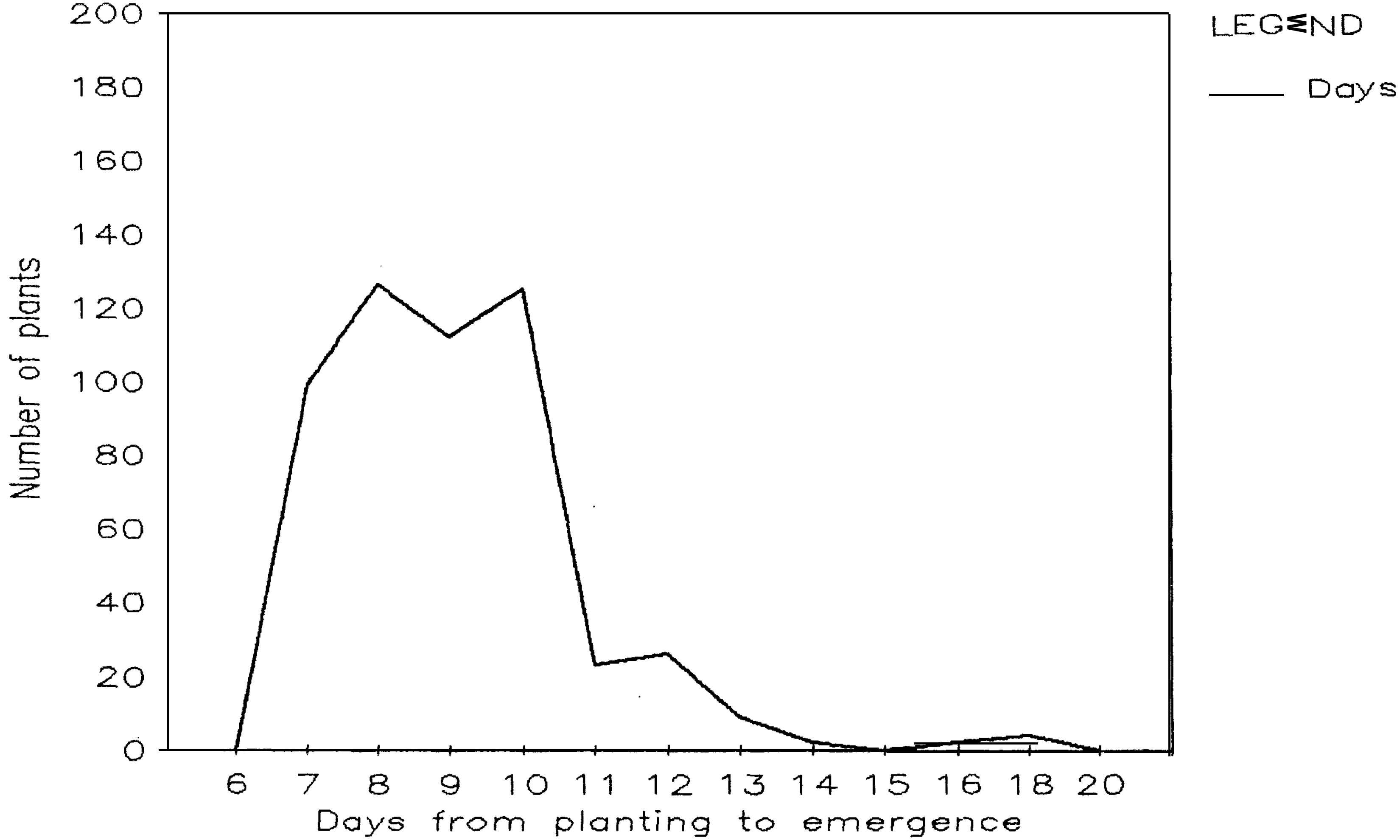

Figure 2.Number of days from planting to emergence for replication 2.

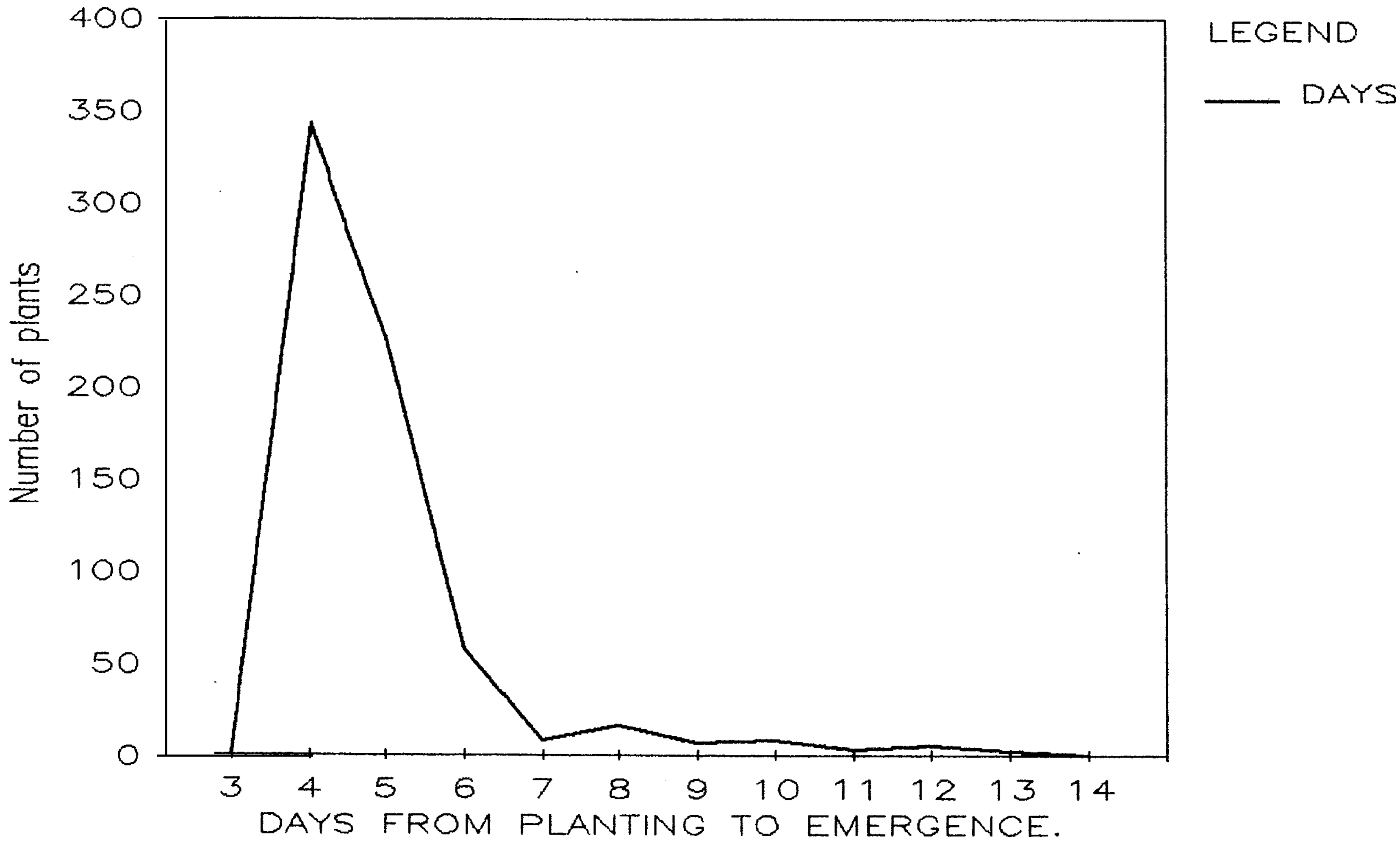

Figure 3. Number of days from planting to emergence for replication 3.

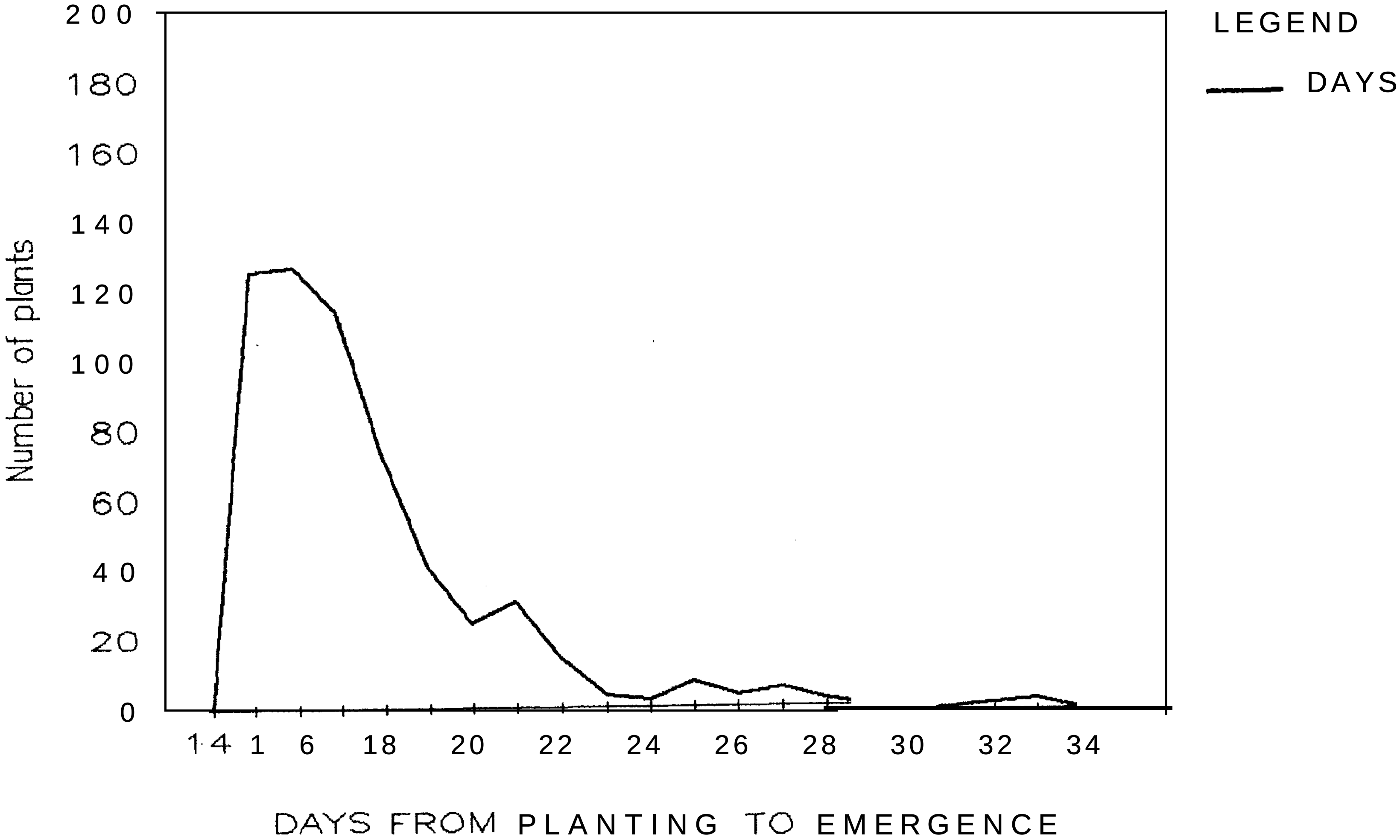

Figure 4. Number of days from planting to emergence for replcation 4.

that emerged very late, up to 71 dap in repl ication two.

Anal yses of emergence data for the five parental lines confirmed the differences among repl icat ions. Mean separat ion using the Wal ler-Duncan method, i nd i cated a c l e a r difference among replications as shown in Table 2. The differences can be attributed logically to the environmental variations, particulary mo isture, temperature, and soil compaction from the rains imme-diately after planting.

Table 2. Mean number of days from planting to emergence for five parental lines over replications.

Replication	Mean
1	10.4 b*
2	9.2 c
3	5.9 d
4	19.1 a

* Means followed by the same letter are not signlficantly different at the 0.05 probablity level and k=100 (Waller-Duncan test).

Outlayers. The extremely s low emergence of occasional p 1 ants in every population caused much variabil ity in the emergence and flowering data. Seed immaturity, dormancy, genetic disorders, and possibly other factors, independently and in combination, are assumed to be the cause of the stragglers. Analyses of the data from the parents showed the variation was not normally distributed. Since the variation of interest focuses on those genotypes which reproduce faster and in greater quantities, plants slower than the 95 percentile were arbitrarily deleted from all analyses. After this adjustment normality was approached.

Homogeneity of variance. Since the days from planting to emergence and flowering, and the time span required for the designated number of flowers were different among replications, examination was made as to the homogeneity of the variances among the four replications. Comparisons were made using the parents for the variables days from planting to emergence (DEMR); days to first (DONE), fifth (DFIVE), and tenth (DTEN) flowers, and number of mature pods (NUMP). The test described by Bartlett (5) indicated that the variances for emergence and flowering were not homogeneous among replications ($P=0.05$). Consequently, analyses were made and data are presented by replication. For NUMP, the variances were homogeneous among replications two, three, and four. The variance associated with the low NUMP of replication one was not homogeneous with the other replications.

Population Effects

Parents

Number of days from planting to a given number of flowers was compared for the five parental varieties using the Waller-Duncan test. Table 3 summarizes that comparison.

Chico began producing flowers earlier than the other varieties followed closely by Sn 55-437, which was in the same

Table 3. Mean number of days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers for four replications of the parental lines.

	Flower number					
Variety	ONE	FIVE	TEN	FIFT	TWEN	TW5
Chico	33.6 b*	38.3 b	42.5 c	47.0a	49.5a	51.9a
Sn55-437	35.1 ab	41.7ab	44.8 bc	47.1a	49.1a	50.6a
TxAG-1	38.9a	43.8a	47.1ab	49.1a	50.7a	52.2a
TxAG-2	37.6ab	43.5a	46.4ab	49.6a	51.3a	52.9a
Tx851856	36.4ab	44.9a	48.9a	51.1a	52.8a	54.2a

* Means within columns followed by the same letter are not significantly different at the 0.05 level and k=100 (Waller-Duncan test).

statistical group as Chico in each comparison through 25 flowers. TxAG-1, the only parent to initiate flowering slower (P=0.05) than Chico averaged 5.3 days later than Chico. Differences In flowering among parental lines was most apparent at the 10 flower stage. Chico produced 10 flowers earlier than all three Tx selections, and Sn 55-437 was earlier than Tx851856. All parents were in the same statistical group at the 15, 20, and 25 flower stages.

Parent means by replication, excluding the very slow emerging plants, for the variables of interest are shown in Table 4. Replication (planting date) differences are apparent for all variables, and consistency among parents in the relative rate of

Table 4. Means and standard deviations for number of days from planting to emergence to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers and means and standard deviations of number of full-size pods and number of mature pods for the parental lines within the 4 replications.

	Chico	TxAG-2	TxAG-1	Sn55-437	Tx851856
Replication 1					
DEMR	10.4-J	9.3±1.6	9.8±2.3	9.8±3.7	10.9±2.5
DONE	35.5±6.6	40.8±4.9	45.9±1.1	37.3±10.8	39.0±2.6
DFIVE	42.4±8.6	50.9±6.7	52.5±1.2	47.6±10.3	52.3±4.8
DTEN	48.6+6.0	56.2±3.6	57.0±1.7	50.7±9.9	57.3±3.9
DFIFT	56.6±5.0	59.7±2.8	58.8±1.8	54.5±10.4	59.6±3.5
DTWEN	59.8±4.9	61.2±2.5	60.2±1.7	56.2±10.4	61.8±3.3
DTW5	62.8+4.1	63.2±2.4	61.6±1.3	57.4±10.4	63.2±3.4
FULL	18.7±9.4	16.8±7.7	30.8±8.6	13.2±5.9	14.2±3.5
NUMP	1.0±0.5	2.2+1.8	2.4±1.7	0.5±0.5	0.9±0.3
%MP	5.3	12.9	7.7	3.8	6.5
Replication 2					
DEMR	8.8±2.0	9.4±0.7	9.1±0.6	8.6±0.7	9.4±1.8
DONE	38.2±3.8	44.4±9.7	44.2±4.3	44.4±5.0	40.4±9.1
DFIVE	46.7±2.7	49.1±8.3	50.5±3.0	53.9±2.9	52.0±5.9
DTEN	51.3±6.0	53.1±6.4	55.5±2.1	57.2±2.6	55.4±4.8
DFIFT	55.8±7.8	56.8±8.8	57.5±2.1	58.6±3.0	58.5±5.1
DTWEN	59.2±6.0	59.5±8.8	58.6±2.0	60.5±3.3	59.7±4.9
DTW5	61.3±5.8	61.4±9.9	60.2±2.2	62.0±3.3	61.6±4.9
FULL	40.3±29.5	20.8±7.0	36.1±4.0	24.5±12.1	24.2±13.7
NUMP	6.7±5.3	6.0±4.7	9.7±3.3	3.5±4.5	5.1±3.5
%MP	16.5	28.7	27.0	14.3	21.1

Table 4. (Continued)

	Chico	TxAG-2	TxAG-1	Sn55-437	Tx851856
Replication 3					
DEMR	6.7±1.6	5.2±0.2	5.5±0.4	5.7±0.6	6.2±0.9
DONE	25.2±1.5	26.4±0.2	26.2±0.9	25.8±0.9	30.0±0.3
DFIVE	28.4+1.8	27.7±0.7	28.4±0.5	28.7±0.9	34.8±2.3
DTEN	31.8+3.2	29.1+1.8	30.4±0.5	31.1±1.0	37.7±2.5
DFIFT	32.4+2.0	30.5±1.5	32.0±0.6	33.9±0.9	39.5±2.3
DTWEN	34.3±1.5	31.1±1.5	33.8±1.0	36.3±1.0	41.0±2.5
DTW5	35.7±1.5	32.8±2.3	35.5±1.6	38.1±1.4	42.1±1.7
FULL	71.1y2.7	60.0t15.3	92.2±16.7	53.4±5.2	36.9±5.2
NUMP	30.8±9.7	26.7±9.7	34.9±3.8	25.6±5.7	22.4±1.8
%MP	43.3	44.6	37.9	47.9	60.6
Replication 4					
DEMR	17.7±1.2	20.0±6.2	18.2±2.6	17.8±2.5	19.5±3.0
DONE	39.7±5.6	44.0±5.4	42.2±5.1	38.9±4.3	41.5±4.4
DFIVE	43.4±8.5	47.1z5.4	47.4±7.4	42.1±6.5	45.3±3.8
DTEN	47.7±6.6	49.4±5.9	50.0±6.9	44.4±6.7	49.8±5.0
DFIFT	50.2±5.6	51.5±5.8	52.2±6.0	46.4±6.4	51.5±5.1
DTWEN	52.7±4.8	52.7±6.2	53.8±5.7	48.2±6.5	53.0±5.6
DTW5	54.7±4.2	54.4±6.0	55.3±5.3	49.7±6.8	55.2±4.2
FULL	46.3'21.7	37.7±9.9	43.4±15.6	37.5±14.5	25.8±14.5
NUMP	24.2±13.6	24.0±7.8	21.2+4.2	16.8±5.3	18.2+10.5
%MP	52.4	63.6	49.0	44.8	70.3

attaining the varied developmental indicators is very low. The replication mean number of days until first flower (DONE) ranged from 25.2 to 39.7 days for Chico. TxAG-1, TxAG-2, and Sn 55-437 required up to five days longer. Tx851856 seemed to show the least environmental effect with a range of only 11.5 days among replications. Chico flowered first in replication one through three and second in replication four. Chico also tended to be among the first to flowers 5, 10, and 15.

TxAG-1, followed by Chico had the highest mean number of full-size (FULL) and mature pods (NUMP). The overall values for the two variables are especially low in replication one. The standard deviations were large compared to the differences among entries so that distinct differences among the parents were not apparent.

Overall, the data indicates that Chico set first flower the earliest followed by Sn 55-437. Although Chico produced flowers faster than the other parental lines it did not produce mature pods faster than the other varieties.

F_1 and F_2 generations

Means of the different variables of F_1 generations and their reciprocals were compared to those of their parents and also to those of F_2 generations and their reciprocals within and among crosses for each replication. The results are given in Tables 5 to 14.

The highest percentage of mature pods (%MP) was produced in replication four while replication one was the lowest. In most of

Table 5. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers: number of full-size pods: number of mature pods; and percent mature pods for the cross Chico/Sn55-437 and its reciprocals by replication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
F_1										
1	16.3	43.7	47.0	51.3	54.7	56.3	57.7	23.3	2.0	8.6
2	9.0	36.0	42.0	46.0	49.0	51.5	54.5	20.0	2.0	10.0
3	5.7	26.7	30.0	31.7	32.3	33.7	34.7	94.0	31.3	33.3
4	15.3	34.0	35.7	36.3	37.0	38.3	39.3	97.0	35.0	36.1
Rec iprocal										
1	8.0	30.3	39.7	48.0	51.7	55.7	61.0	24.0	0.3	1.4
2	12.0	41.5	48.5	50.5	52.5	54.5	56.0	32.0	5.5	17.2
3	6.0	26.0	28.0	30.3	32.0	33.3	34.7	80.3	23.7	29.5
4	18.0	40.0	47.5	49.5	53.0	56.5	56.5	40.5	18.0	44.4
F_2										
1	100 .	35.7	46.6	54.4	57.8	60.5	62.3	18.1	0.8	4.5
2	8.6	40.4	49.7	53.5	56.6	58.5	60.0	26.9	5.2	19.4
3	6.1	24.9	28.1	30.1	31.8	33.3	34.7	57.3	27.4	47.8
4	17.4	36.5	39.1	42.2	44.3	46.6	48.2	45.1	21.8	48.4
Rec i p rocal										
1	8.4	32.1	40.0	46.9	52.3	55.5	57.3	25.5	0.9	3.4
2	10.4	39.3	46.8	53.1	56.0	58.5	60.6	29.4	7.0	23.9
3	5.7	25.0	27.2	28.7	30.0	31.3	31.3	71.9	32.5	45.3
4	17.2	36.4	39.6	41.8	43.8	45.6	48.1	56.5	25.9	45.8

Table 6. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers; number of full-size pods; number of mature pods; and percent mature pods for the cross Chico/Tx851856 and its reciprocals by replication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
F_1										
1	9.3	33.3	35.7	43.3	49.0	54.0	57.7	22.3	1.3	5.9
2	7.7	32.0	36.3	40.7	47.7	50.7	51.7	51.7	5.0	9.7
3	9.0	30.0	34.5	37.0	39.0	40.5	42.5	26.5	16.0	60.4
4	15.0	33.7	34.7	36.3	37.3	38.3	39.7	42.0	30.0	71.4
Reciprocal										
1	8.7	31.7	40.0	53.7	60.3	63.3	65.3	14.0	1.3	9.5
2	9.0	34.5	38.5	46.0	48.5	52.0	54.5	28.5	6.0	21.o
3	5.3	25.7	29.3	32.3	35.0	36.7	38.3	59.0	38.3	64.9
4	18.5	37.0	41.o	43.5	47.0	49.5	52.5	36.5	16.0	43.8
F_2										
1	10.1	32.9	39.5	46.4	50.8	54.6	57.8	19.3	0.4	2.2
2	8.5	34.2	41.3	48.2	51.4	54.1	55.6	37.9	5.4	14.4
3	6.4	27.8	31.0	33.0	34.7	36.0	37.1	61.9	25.0	40.5
4	16.4	34.7	36.8	38.8	40.3	41.7	43.3	46.2	28.4	61.5
Reciprocal										
1	9.2	32.2	39.4	46.5	52.2	56.3	59.4	12.1	0.3	2.8
2	7.9	35.7	44.9	51.5	53.2	54.9	56.3	42.2	6.7	15.8
3	5.4	23.9	26.7	28.6	30.5	32.2	33.7	53.7	29.5	54.9
4	17.5	36.2	38.2	40.1	42.0	43.7	45.0	49.1	24.4	49.6

Table 7. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers: number of full-size pods; number of mature pods; and percent mature pods for the cross Chico/TxAG-1 and its reciprocals by replication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
F_1										
1	10.0	33.3	36.7	43.3	47.3	52.3	55.3	22.0	1.7	7.6
2	9.0	33.0	37.0	42.0	48.0	53.0	56.0	39.0	4.0	10.3
3	5.0	25.3	28.7	30.3	32.0	33.3	34.3	84.0	33.7	40.1
4	17.0	37.3	38.7	40.3	41.7	42.7	45.0	63.7	37.3	58.6
Reciprocal										
1	11.0	37.0	44.0	51.0	55.3	58.0	60.0	34.0	1.7	4.9
2	8.0	33.0	43.0	47.5	50.0	52.0	53.0	47.5	12.0	25.3
3	6.3	30.0	35.7	38.0	39.7	40.7	42.7	62.7	25.7	40.9
4	15.0	36.0	38.0	39.0	42.0	44.0	46.0	95.0	34.0	35.8
F_2										
1	12.0	40.3	47.2	52.9	56.5	59.2	61.6	16.9	0.9	5.7
2	10.8	39.6	46.3	51.6	55.2	57.3	60.0	32.2	6.4	19.8
3	5.4	24.7	27.3	29.7	31.8	33.6	35.4	87.3	32.9	37.7
4	17.2	37.1	40.7	43.1	46.0	48.3	50.2	54.7	34.8	63.6
Reciprocal										
1	11.7	38.9	47.6	54.4	57.0	59.2	60.7	21.0	0.9	4.4
2	9.3	40.3	47.8	53.0	55.8	57.6	59.4	39.7	8.9	22.5
3	5.7	24.7	27.7	29.6	31.4	33.0	34.5	81.3	34.4	42.2
4	17.8	37.6	40.8	43.0	44.9	46.7	48.6	58.6	27.5	46.9

Table 8. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers; number of full-size pods; number of mature pods: and percent mature pods for the cross Chico/TxAG-2 and its reciprocals by replication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
7	9.0	31.3	33.3	37.3	46.3	49.0	55.7	13.7	1.0	7.3
2	9.0	31.0	33.0	37.0	47.0	50.0	52.0	34.0	8.0	23.5
3	5.3	24.0	25.7	28.0	31.3	34.0	36.0	86.7	34.7	40.0
4	28.0	48.5	53.5	54.5	56.5	58.5	59.5	38.5	17.5	45.4
Reciprocal										
1	10.0	32.7	45.7	50.0	60.3	64.0	67.0	16.7	2.7	16.0
2	9.7	33.7	39.7	47.3	51.3	54.0	56.0	49.0	8.7	17.7
3	5.3	24.7	26.3	28.3	30.3	31.7	33.0	65.0	32.3	49.7
4	16.0	33.0	40.0	45.0	47.0	50.0	52.0	21.0	14.0	66.7
F_2										
1	12.4	34.3	40.9	46.1	50.2	55.3	58.6	14.8	1.1	7.3
2	11.1	38.4	44.6	49.5	52.5	54.3	56.3	36.2	5.0	13.8
3	5.6	26.2	29.8	33.0	35.9	38.2	40.5	54.4	23.3	42.8
4	16.6	36.3	39.4	42.6	44.9	47.1	48.8	63.9	25.3	39.6
Reciprocal										
1	8.5	34.4	43.8	53.0	57.4	59.8	61.6	25.6	2.6	10.1
2	8.0	36.4	46.3	53.0	55.2	57.3	59.4	35.2	6.9	19.7
3	5.6	25.3	27.6	29.3	30.9	32.3	33.6	71.3	30.2	42.4
4	17.4	36.8	39.8	42.6	45.0	47.2	48.2	44.4	24.1	54.3

Table 9. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers; number of full-size pods; number of mature pods; and percent mature pods for the cross Sn55-437/Tx851856 and its reciprocals by replication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
F_1										
1	11.0	40.7	50.3	53.3	55.7	57.3	59.3	16.3	0.7	4.1
2	9.3	40.3	50.7	57.3	60.0	63.0	65.7	22.3	6.0	26.9
3	5.3	27.7	31.7	35.3	38.3	39.7	40.7	53.0	22.0	41.5
4	19.5	42.0	47.0	49.0	50.5	51.5	52.5	33.5	20.5	61.2
Reciprocal										
1	9.0	36.5	54.5	58.5	62.0	64.0	66.0	14.0	0.5	3.6
2	9.7	37.0	45.0	50.5	53.5	56.5	58.0	24.0	4.0	16.7
3	6.3	28.0	33.0	35.0	37.0	39.0	40.7	42.7	20.3	47.6
4	16.0	36.0	38.0	39.3	41.0	42.7	44.7	46.7	28.3	60.7
F_2										
1	11.9	42.9	51.2	57.6	60.1	61.9	63.4	12.6	0.9	7.7
2	9.9	46.2	54.6	59.9	61.8	63.6	64.9	22.6	4.8	21.1
3	5.6	30.0	36.0	39.8	42.4	43.9	45.3	49.1	18.9	38.5
4	17.9	38.1	42.3	45.7	47.4	48.9	50.6	36.5	20.5	56.0
Reciprocal										
1	9.3	35.2	45.4	54.0	57.2	60.2	62.4	15.7	0.8	5.0
2	8.5	37.2	45.5	50.2	53.0	55.5	56.8	27.5	9.9	35.9
3	7.9	27.6	30.2	32.8	34.2	35.8	36.6	45.9	25.0	54.8
4	17.0	36.0	38.8	41.3	44.0	45.3	47.2	30.4	18.9	62.2

Table 10. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers; number of full-size pods; number of mature pods and percent mature pods for the cross Sn55-437/TxAG-1 and its reciprocals by replication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
F_1										
1	11.3	44.7	49.0	53.0	56.3	59.3	61.0	17.3	1.0	5.8
2	9.0	41.0	51.0	54.5	56.5	57.5	58.5	30.5	4.5	14.8
3	6.0	27.0	32.3	34.7	36.7	38.3	39.7	62.7	24.3	38.8
4	17.5	37.5	40.5	42.5	45.5	46.5	49.0	63.0	34.5	54.8
Reciprocal										
1	11.0	36.0	43.0	48.7	51.3	52.3	54.0	31.7	4.0	12.6
2	8.7	35.3	38.0	43.0	48.7	51.0	53.3	40.3	7.7	19.0
3	6.3	27.0	31.0	33.3	34.3	36.7	38.0	43.3	19.3	44.6
4	18.0	36.0	38.3	39.3	40.7	41.7	43.3	71.0	27.3	38.5
F_2										
1	10.2	37.4	44.9	52.6	57.0	59.9	61.9	12.1	1.0	8.2
2	8.5	38.3	49.1	53.4	56.1	57.9	59.8	26.6	3.3	12.3
3	6.3	28.6	32.0	34.4	35.9	37.6	39.5	61.5	27.0	44.0
4	17.1	37.4	40.5	42.9	44.7	46.6	48.5	46.6	22.8	48.9
Reciprocal										
1	11.3	41.6	50.9	57.2	60.4	62.3	63.5	15.0	0.7	4.5
2	8.2	37.2	45.6	50.8	53.9	56.1	57.8	26.5	7.1	26.8
3	5.8	26.4	30.0	33.1	35.2	36.7	38.8	58.9	25.1	42.6
4	17.6	37.2	39.9	42.7	45.3	47.6	49.5	44.1	20.8	47.2

Table 11. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers: number of full-size pods; number of mature pods: and percent mature pods for the cross Sn55-437/TxAG-2 and its reciprocals by repl ication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
F_1										
1	9.3	48.0	57.7	60.0	62.0	64.0	65.0	14.0	1.3	9.5
2	10.0	43.7	49.0	55.3	60.0	62.0	62.7	27.0	10.0	37.0
3	5.0	28.3	30.3	33.7	36.0	37.3	39.0	69.0	30.0	43.5
4	18.5	45.0	47.5	50.0	52.5	55.5	58.0	30.0	20.5	68.3
Reciprocal										
1	7.3	32.3	38.0	48.7	54.7	56.0	57.7	28.3	3.3	11.7
2	9.3	34.0	36.7	42.0	49.7	53.0	54.3	22.7	9.7	42.7
3	5.3	25.3	26.3	28.3	29.7	30.7	31.7	67.0	28.0	41.8
4	19.0	38.5	40.0	41.5	42.5	43.5	45.0	81.0	49.0	60.5
F_2										
1	10.4	37.5	47.5	52.6	55.7	58.8	60.6	17.5	2.1	12.2
2	9.6	43.3	50.2	54.2	56.6	58.4	60.2	30.0	12.4	41.3
3	5.8	27.4	31.2	33.7	35.7	37.4	38.7	66.3	22.2	33.4
4	16.8	38.2	41.6	44.9	47.6	49.8	51.2	52.5	29.3	55.8
Reciprocal										
1	10.9	43.2	52.2	56.4	58.6	61.3	62.8	19.5	3.4	17.4
2	10.2	42.1	49.1	53.7	56.2	58.2	59.7	26.1	9.4	36.2
3	5.9	25.3	27.8	29.7	31.2	32.8	34.2	68.3	32.1	46.9
4	18.4	39.8	42.7	45.3	47.1	48.6	50.0	47.0	28.0	59.7

Table 12. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers; number of full-size pods; number of mature pods; and percent mature pods for the cross Tx851856/TxAG-1 and its reciprocals by replication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
F_1										
1	9.3	34.0	41.7	50.7	52.3	55.3	57.3	22.7	0.7	2.9
2	9.7	38.0	43.0	46.3	51.3	53.3	55.0	45.7	11.7	25.5
3	6.0	28.0	33.0	36.3	37.0	39.0	41.0	27.7	12.7	45.8
4	19.0	42.5	47.5	50.5	52.0	53.5	54.5	25.0	17.5	70.0
Reciprocal										
1	7.7	33.0	47.0	52.3	56.7	58.3	59.7	36.3	2.7	7.5
2	10.0	38.3	45.7	51.0	53.0	56.3	58.0	30.3	5.6	18.7
3	5.3	25.0	26.7	28.0	29.7	30.7	33.7	63.3	28.7	45.3
4	20.0	40.0	44.0	49.0	51.0	52.0	54.0	47.0	28.0	59.6
F_2										
1	11.8	37.7	46.7	52.5	55.3	57.1	58.5	15.4	1.1	7-1
2	8.1	37.2	45.8	50.4	53.7	55.3	56.8	25.1	4.8	18.9
3	5.4	26.1	28.7	30.5	31.9	33.2	34.3	63.5	26.8	42.2
4	16.5	35.5	38.8	41.5	44.8	47.3	48.9	33.6	18.7	55.7
Reciprocal										
1	8.2	31.1	39.2	47.1	53.3	58.0	60.2	27.6	1.5	5.5
2	10.5	40.1	47.1	51.1	53.6	55.7	57.3	25.2	4.7	18.5
3	5.3	27.1	30.9	33.6	36.0	36.8	38.5	50.6	26.2	51.8
4	17.3	38.2	41.5	44.0	46.5	47.9	49.2	42.5	24.7	58.0

Table 13. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers; number of full-size pods; number of mature pods: and percent mature pods for the cross Tx851856/TxAG-2 and its reciprocals by replication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
F_1										
1	9.0	32.0	38.3	44.0	54.7	57.7	59.3	30.7	0.3	1.1
2	11.5	41.5	48.5	51.5	53.0	57.0	58.5	27.0	4.5	16.7
3	*	*	*	*	*	*	*	*	*	*
4	17.0	37.3	40.0	41.7	42.7	45.3	46.3	59.7	37.3	62.6
Reciprocal										
1	8.7	40.7	48.7	51.7	58.7	59.7	61.3	24.0	1.0	4.2
2	8.0	41.5	49.5	53.0	55.0	57.0	59.0	29.0	5.0	17.2
3	6.3	30.3	32.0	33.0	36.3	37.7	38.7	55.0	30.3	55.1
4	19.5	35.5	41.5	47.5	49.5	50.5	52.5	30.5	16.0	52.5
F_2										
1	10.5	33.5	41.2	47.7	51.5	53.8	56.0	22.3	0.5	2.1
2	9.9	38.8	46.8	51.7	55.4	57.2	58.7	19.6	3.9	19.8
3	5.4	25.2	27.7	29.9	31.5	33.1	34.4	57.1	28.2	49.3
4	17.2	38.4	41.2	43.6	45.8	47.7	49.6	40.9	24.6	60.2
Reciprocal										
1	9.0	36.5	44.3	52.5	57.2	59.0	61.1	20.9	1.4	6.8
2	9.4	37.5	46.4	50.7	53.3	55.0	57.0	27.3	4.5	16.6
3	6.6	28.9	32.0	34.7	36.3	38.1	39.6	52.4	25.2	48.1
4	18.3	38.0	41.6	44.0	45.9	47.6	48.7	33.6	18.8	56.1

*, Indicates missing values.

Table 14. Mean number of days from planting to emergence; days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers; number of full-size pods: number of mature pods; and percent mature pods for the cross TxAG-1/TxAG-2 and its reciprocals by replication.

REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP	%MP
F_1										
1	7.3	32.0	35.0	43.3	50.0	52.7	53.7	27.3	1.7	6.1
2	10.0	38.0	44.0	48.0	49.5	50.5	52.0	39.5	16.5	41.8
3	5.3	25.0	26.7	28.0	29.7	31.0	32.0	69.3	34.7	50.0
4	17.0	36.7	38.3	40.0	41.3	41.7	44.0	54.0	39.7	73.5
Reciprocal										
1	9.0	36.3	51.7	53.7	55.7	57.3	58.3	24.0	2.0	8.3
2	*	*	*	*	*	*	*	*	*	*
3	6.0	30.0	37.5	41.0	43.0	44.5	46.0	18.3	10.0	54.6
4	18.2	36.9	40.9	43.1	44.1	45.9	47.1	46.0	27.9	60.6
F_2										
1	7.9	36.1	46.4	53.1	57.1	59.5	61.0	21.3	0.9	4.2
2	7.9	38.5	45.7	50.8	53.9	55.8	57.6	27.0	8.3	30.7
3	5.6	26.2	28.7	30.5	32.6	34.6	36.4	67.9	32.7	48.1
4	19.3	40.7	43.8	46.4	49.0	50.8	52.5	46.9	27.9	59.6
Reciprocal										
1	7.1	38.4	50.2	53.5	56.2	56.6	58.1	27.0	2.6	9.6
2	*	*	*	*	*	*	*	*	*	*
3	5.0	33.0	37.9	41.1	43.4	44.3	46.4	31.6	16.7	52.9
4	*	*	*	*	*	*	*	*	*	*

*, Indicates missing values.

the cases, the F_1, F_2, and reciprocal means do not differ much from their parents in terms of days from planting to twenty and twenty-five flowers. The F_1 plants emerged and flowered earl ier than both parents and most of the F_2.

Some F_2 segregates did emerge and flower earlier than both parents and F_1 (Table 4 and 6). In crosses where Chico or Tx851856 are used as the male parents, the F_1 and F_2 generations are earlier than the rest of the crosses. In fact, the cross TxAG-2/Ch ico emerged and flowered the earliest followed by the cross TxAG-2/TxAG-1 which has the highest %MP. However, the F_2 generation of the cross Chico/Tx851856 and its reciprocal are earl ier than everything else even though the lead is not quite significant.

Correlations Among Traits

Coefficients of correlation between the different variables were estimated on a replication basis. Days from planting ta emergence (DEMR) and to a specified flower number (DONE, DFIVE, DTEN, DFIFT, DTWEN, DTW5) were correlated with the number of full size pods (FULL), number of mature pods (NUMP), and percent mature pods (%MP). The coefficients of correlation for number of full-size pods ranged from -0.199 to -0.469, for DEMR to DTW5, respect ively, in replication one (Table 15). Similar values were obtained for replications two, three, and four. The negative correlation means that fewer days to a given flower number resulted in larger numbers of full-size and mature pods. The association of days to flower and NUMP increased progressively from DONE

Table 15. Coefficients of correlation between days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers with number of full-size pods, number of mature pods, and percent mature pods within each replicaion.

	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5
Replication 1							
FULL	-0.199*	-0.198*	-0.229*	-0.288*	-0.343*	-0.405*	-0.469*
NUMP	-0.102	-0.081	-0.077	-0.062	-0.070	-0.114	-0.152*
%MP	-0.098	-0.105	-0.045	0.063	0.111	0.120	0.124
Replication 2							
FULL	-0.151	-0.338*	-0.354*	-0.403*	-0.466*	-0.494*	-0.512*
NUMP	-0.081	-0.204*	-0.262*	-0.321*	-0.366*	-0.378*	-0.387"
%MP	-0.050	-0.162	-0.241*	-0.292*	-0.293*	-0.276	-0.278*
Replication 3							
FULL	-0.232*	-0.402*	-0.441*	-0.469*	-0.486*	-0.492*	-0.495*
NUMP	-0.247*	-0.506*	-0.551*	-0.575*	-0.578*	-0.572*	-0.576*
%MP	0.028	-0.039	-0.040	-0.032	-0.021	-0 .oog	-0.007
Replication 4							
FULL	-0.295*	-0.292*	-0.344*	-0.368*	-0.393*	-0.398*	-0.409*
NUMP	-0.347*	-0.373*	-0.416*	-0.449*	-0.470*	-0.481*	-0.489*
%MP	-0.203*	-0.216*	-0.210*	-0.220*	-0.220*	-0.215*	-0.213*

* indicates a significance probability level of 0.0001.

to DTW5. In general, NUMP and FULL were better correlated with days to a given number of flower than %MP. The positive correlation of percent mature pods (%MP) and DTEN through DTW5 in replication one was inconsistent with the results in the other repl icat ions. Figures 5, 6, 7, and 8 show the correlations for replications one, two, three, and four, respectively.

Association of the number of days from emergence (DEMR) to a predetermi ned number of f lowers with FULL, NUMP, and %MP are shown in Table 16.

Table 16. Coefficients of correlation between days from emergence to first, fifth, tenth, fifteenth, twentieth, and twenty-f ifth f lowers with number of full-size pods, number of mature pods, and percent mature pods within each replication.

	DONE	DF IVE	DTEN	DFIFT	DTWEN	DTW5
Repl icat ion 1						
FULL	-0.151*	-0.187*	-0.235*	-0.270*	-0.309*	-0.355;:
NUMP	-0.054	-0.052	-0.031	-0.033	-0.068	-0 .ogg
%MP	-0.083	-0.020	0.096	0.146*	0.154*	0.156*
Repl ication 2						
FULL	-0.321*	-0.334*	-0.374*	-0.4382	-0.467*	-0.485*
NUMP	-0.196*	-0.254*	-0.309*	-0.355*	-0.367*	-0.377*
%MP	-0.159	-0.240*	-0.287*	-0.289*	-0.272*	-0.273*
Replication 3						
FULL	-0.366*	-0.420*	-0.451*	-0.468*	-0.474*	-0.476*
NUMP	-0.476*	-0.536*	-0.561*	-0.564*	-0.556*	-0.558*
%MP	-0.053	-0.051	-0.041	-0.028	-0.016	-0.013
Replication 4						
FULL	-0.163*	-0.274*	-0.309"	-0.334*	-0.338*	-0.348*
NUMP	-0.236*	-0.337"	-0.384*	-0.404*	-0.413*	-0.419*
%MP	-0.134*	-0.151*	-0.169*	-0.168*	-0.160*	-0.155"

*, Indicates a significance probabi lity level of 0.0001.

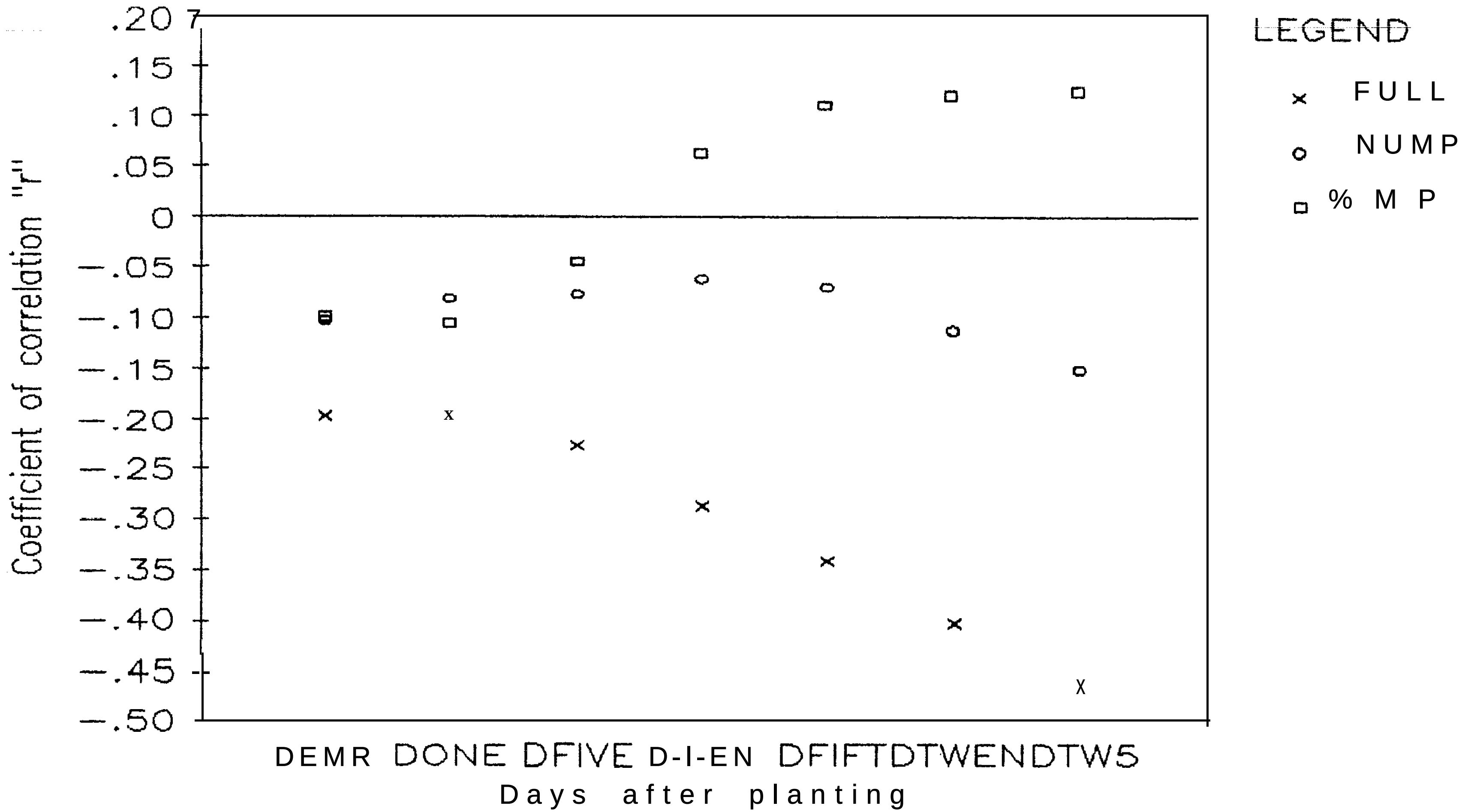

Figure 5. Cor-relation between days from planting to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers, and number of full—size pods, number of mature pods, and percent mature pods for repiicatîon 1.

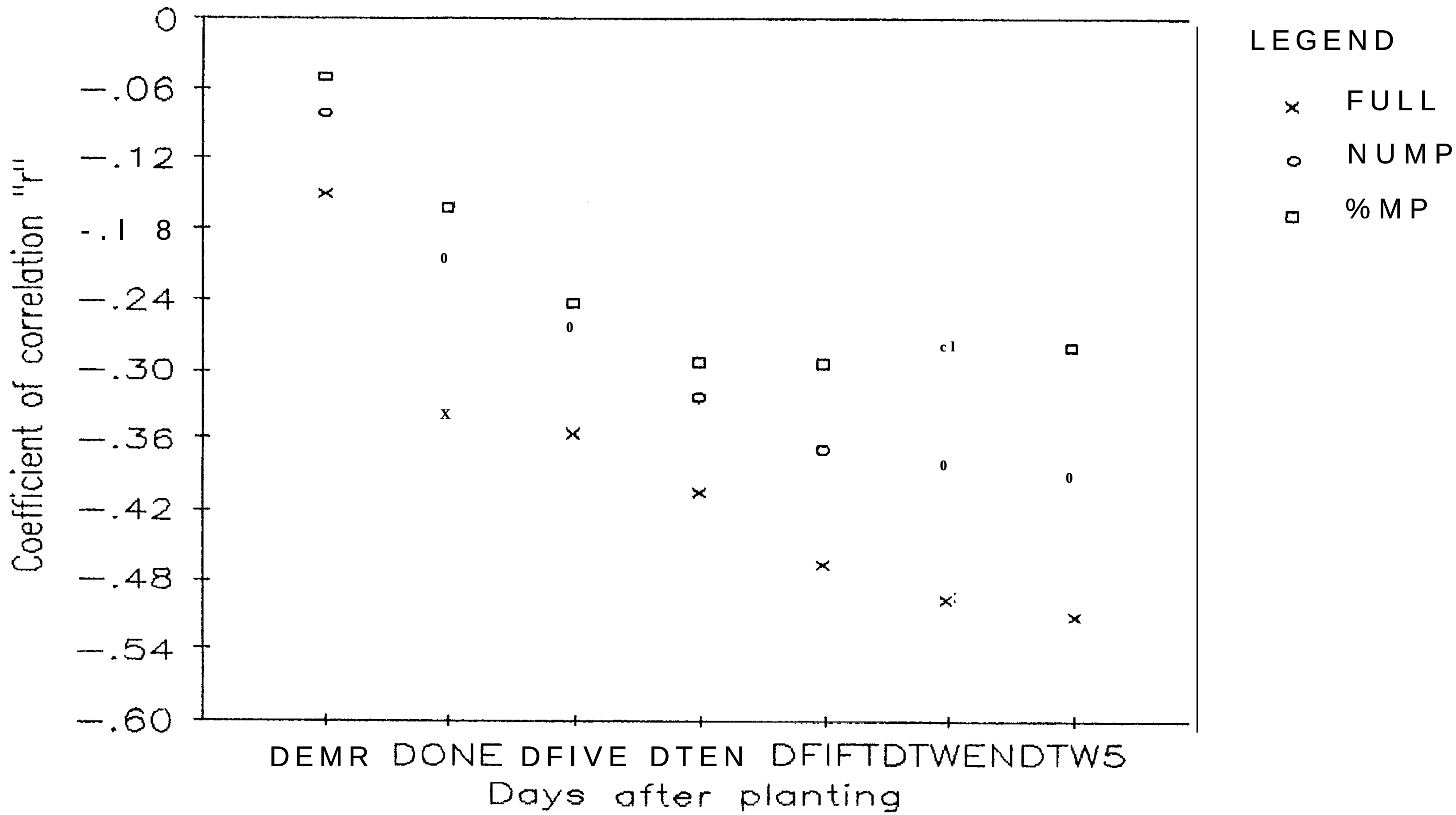

Figure 6. Correlation between days from planting to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers, and number of full-size pods, number of mature pods, and percent mature pods for replication 2

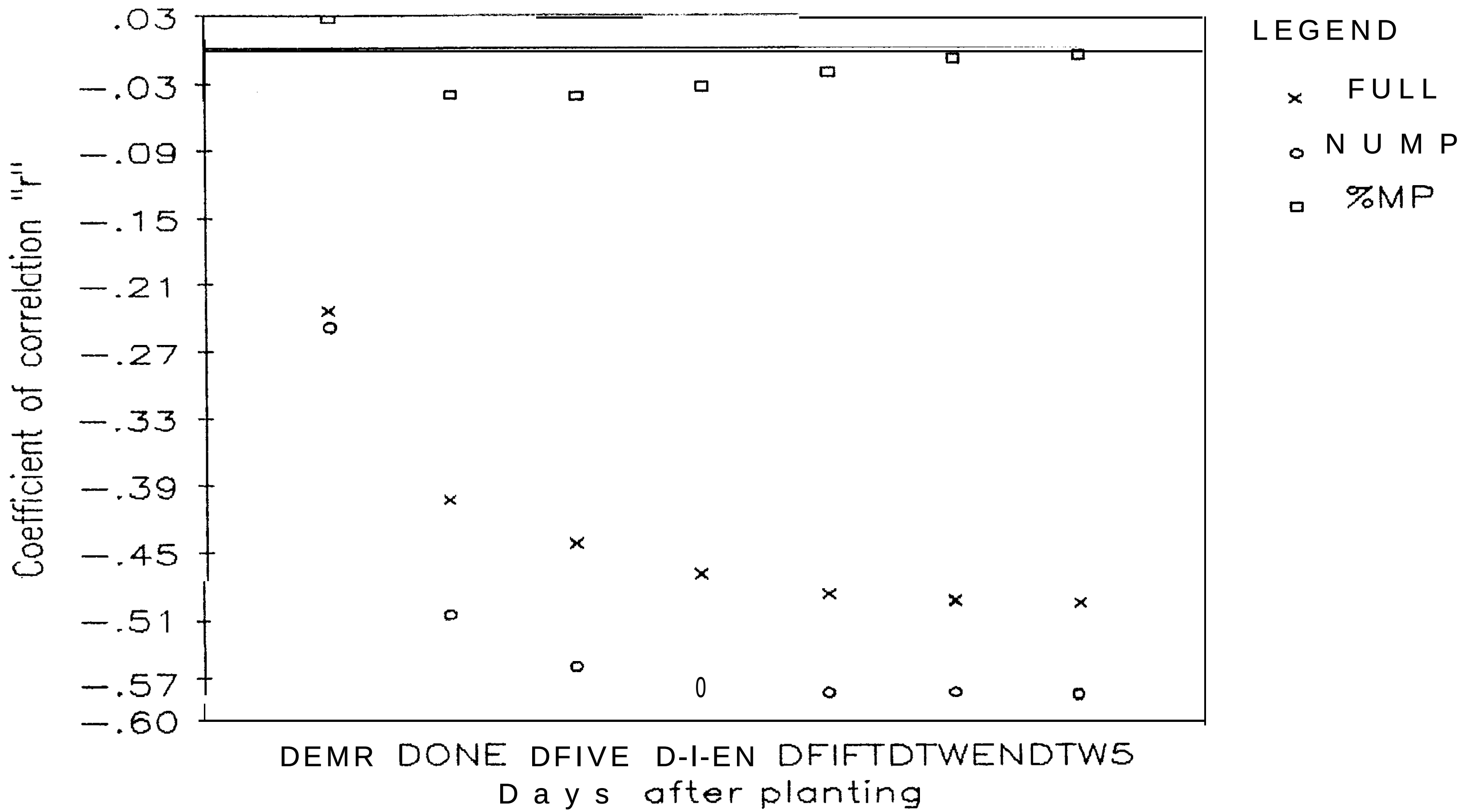

Figure 7. Correlation between days from planting to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers, and number of full-size pods, number of mature pods, and percent mature pods for replication 3

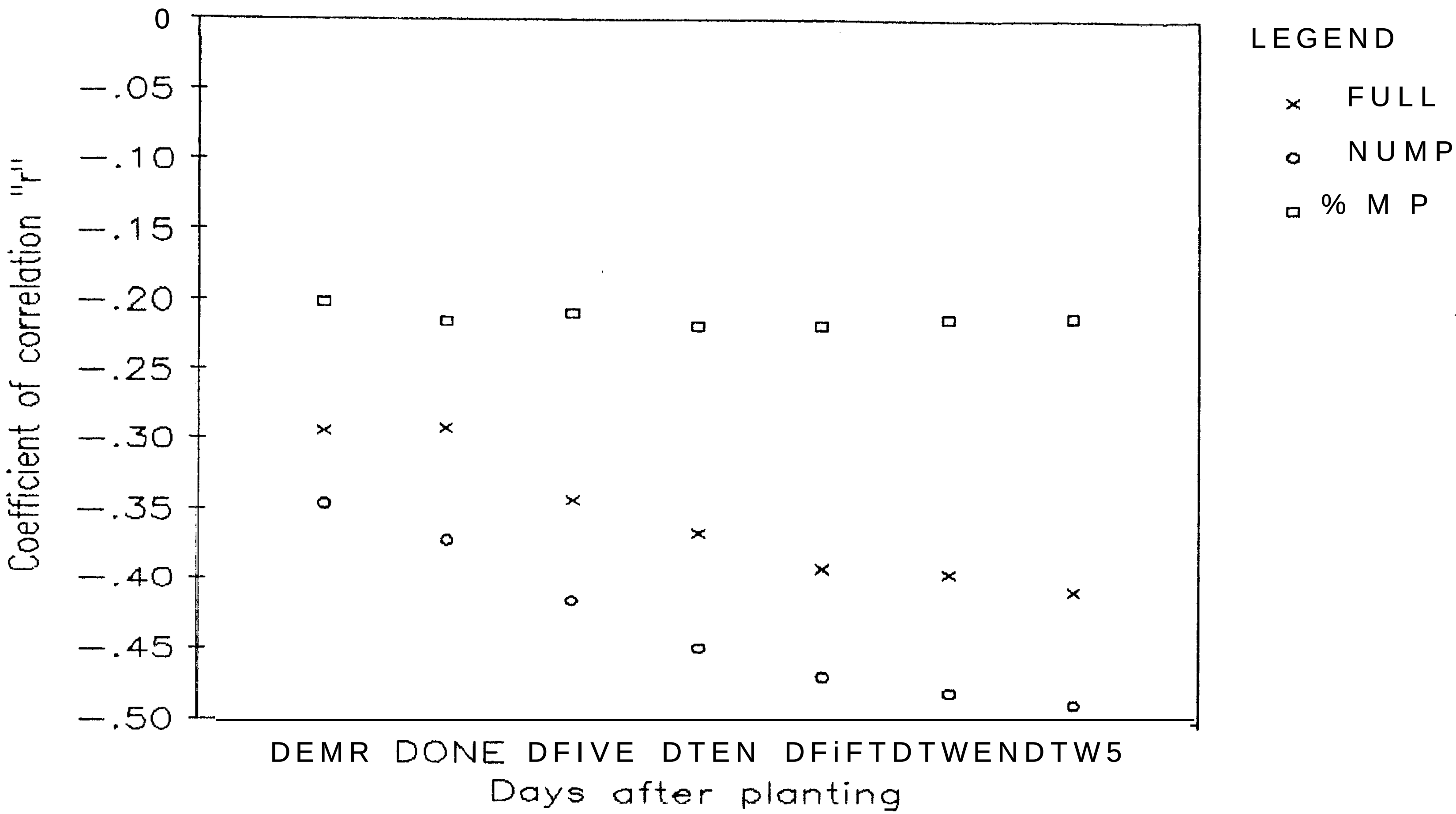

Figure 8. Correlation between days ft-om planting to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers, and number of full—size pods, number of mature pods, and percent ma-tut-e pods for replication 4

Overall , taking off days from planting to emergence from the values of days to a given number of flowers was no better than using days from planting.

The correlation between DONE, DFIVE, DTEN, DFIFT, DTWEN, and DTW5 with DEMR for the four replications are shown in Table 17. In all replications the association becomes smaller as the number of f lowers increased.

Table 17. Coefficients of correlation for days from planting to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers and days from planting to emergence for each replication.

	DONE	DFIVE	DTEN	DFIFT	DTWE N	DTW5
Rep. 1	0.496*	0.382*	0.270*	0.174*	0.106	0.048
Rep.2	0.375"	0.298*	0.244*	0.260*	0.257"	0.261*
Rep.3	0.469*	0.457""	0.430*	0.4139;	0.399*	0.373*
Rep.4	0.747*	0.724*	0.673"	0.631*	0.6051:	0.596*

* indicates a 0.0001 significance probability level.
Rep.=replication.

The "r" values are highest for replication four, which was the slowest replication to emerge, followed by three, the fastest to emerge.

Associations of rate of flowering with FULL, NUMP, and %MP were tested as the days from DONE to DFIVE, DTEN, DFIFT, DTWEN, and DTW5 (Table 18). The coefficients of correlation were smaller than for days from planting and days from emergence and the pod development measures .

Table 18. Coefficients of correlation between days from first flower to days to fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers, and number of full-size pods, number of mature pods, and percent mature pods within the 4 replications.

	DFIVE	DTEN	DFIFT	DTWEN	DTW5
Replication 1					
FULL	-0.085	-0.106	-0.111	-0.118	-0.141
NUMP	-0.010	0.017	0.019	-0.007	-0.028
%MP	0.063	0.177*	0.210*	0.202*	0.193*
Replication 2					
FULL	-0.063	-0.049	-0.086	-0.102	-0.122
NUMP	-0.112	-0.125	-0.145	-0.145	-0.152
%MP	-0.141	-0.145	-0.118	-0.093	-0.091
Replication 3					
FULL	-0.294*	-0.355*	-0.378*	-0.381*	-0.384*
NUMP	-0.362*	-0.419*	-0.420*	-0.402*	-0.4072
%MP	-0.023	-0.010	0.007	0.029	0.033
Replication 4					
FULL	-0.265*	-0.296*	-0.319*	-0.316*	-0.322*
NUMP	-0.281*	-0.338*	-0.356*	-0.359*	-0.359*
%MP	-0.088	-0.122	-0.120	-0.107	-0.100

*, Indicates a 0.0001 significance probability level.

The coefficient of correlation between FULL and NUMP were positive in all four replications; and ranged from 0.388 to 0.753. The "r" values for FULL and %MP were negative and significant (P=0.0001) in two of the four replications (Table 19) resulting in some tendency toward a lower percentage of mature pods as the number of full-size pods increased.

Table 19. Coefficients of correlation for number of full-size pods and number of mature pods and percent mature pods within repl icat ions.

	Rep. 1 FULL	Rep.2 FULL	Rep.3 FULL	Rep.4 FULL
NUMP	0.388*	0.602*	0.648*	0.753"
%MP	-0.067	0.136	-0.484*	-0.177""

*, Indicates a significance probability level of 0.0001.
Rep.=replication.

The coefficients of correlation for NUMP and %MP were positive in all replications (Table 20). The correlation was strong for replication two, intermediate for replications one and four, and relatively low for replication three.

Table 20. Coefficient of correlation for number of mature pods and percent mature pods within replications.

	Rep.1	Rep.2	Rep.3	Rep.4
%MP	0.592*	0.759*	0.244*	0.420*

*, Indicates a significance probability level of 0.0001.
Rep.=replication.

Heritability

Heritability is an estimate of the proportion of the total variability that is due to genetic causes, or the ratio of the genetic variance to the total variance (1).

Heritability estimates in the broad sense were calculated for the variables DONE, DTEN, DTW5, FULL, and NUMP using the formula of Allard (1) which is as follows:

$H=V_G/V_P$ where

V_G=genetic variance

V_P=total phenotypic variance

The variance of the F_2 generation represents the total variance, and the variances of the F_1 and the two parents correspond to the environmental variance. Thus, to estimate broad sense heritability (H) in these conditions we used the equation

$H=(V_{F2}-(V_{F1+P1+P2})/V_{F2})\times100$ where

V_{F2}= mean of the variances of F_2 of a cross and its reciprocal.

$V_{F1+P1+P2}$= mean of the variances of F_1 and the two parents of a cross and its reciprocal.

Heritability estimates were computed for each replication of a cross. thereafter, the mean heritability was estimated by averaging the four replicate estimates of a cross: (H1+H2+H3+H4)/4. Estimates of heritability for DONE, DTEN, DTW5, FULL, and NUMP are shown in Table 21.

Table 21. Mean heritability estimates for days from planting to first, tenth, and twenty-fifth flowers, number of full-site pods, and number of mature pods for each cross and its reciprocal over replications.

Cross*	DONE	DTEN	DTW5	FULL	NUMP
TxAG-2/Chico	45.7	22.2	49.2	27.1	54.3
TxAG-2/Sn55-437	49.4	64.6	48.8	39.5	40.4
TxAG-2/Tx851856	10.7	36.7	36.4	41.0	43.4
TxAG-2/TxAG-1	39.3	53.1	60.6	39.5	4.9
TxAG-1/Chico	22.5	25.3	16.8	9.9	3.8
TxAG-1/Sn55-437	37.0	43.3	60.0	13.0	27.9
TxAG-1/Tx851856	13.9	27.4	51.6	52.5	20.9
Chico/Sn55-437	40.0	38.8	48.6	22.8	58.8
Chico/Tx851856	54.7	59.3	46.2	61.1	57.2
Sn55-437/Tx851856	42.8	43.8	33.6	58.3	44.7

*, Crosses and their reciprocals were used to estimate heritability.

Estimates of the heritability of the various traits for the 10 cross combinations were intermediate to low. The heritabilities tended to be higher for some crosses than others, although for no cross were the heritabilities of the different traits consistently high. In general, the heritability estimates for Chico/Tx851856 tended to be high and those for TxAG-1/Chico low. The heritabilities averaged highest over crosses for DTW5. The low estimate for NUMP in the cross TxAG-2/TxAG-1 may relate to a very small population size. The number of F_2 plants for this cross was much lower than for the other crosses.

The variances of the F_1 and parent plants were sometimes very high compared to the variances of F_2. The number of F_1 and parent plants were lower than those of the F_2. In some situations only two plants were used to compute the variance of the F_1 in a replication.

The estimates of heritability suggest that some progress could be expected in selection for the various traits among most crosses. The estimates would also suggest that progress might be better in some crosses than in others.

Segregation Patterns

The number of full-size pods (FULL) and number of mature pods (NUMP) were assigned *a priori* as the most useful indicator of earliness: hence, the segregation patterns were examined based on these criteria. Data for crosses and reciprocal crosses were combined within each replication for analyses of the segregation.

No groupings for meaningful segregation ratios were discernible; thus, the means, variances, standard deviations, and ranges are shown by replication for the variables FULL and NUMP in Tables 22 through 41.

In general, the F_1 and F_2 generation means were within or more than their respective parental means. Only for the cross Sn55-437/TxAG-2 were the means of all replications of both the F_1 and the F_2 generations greater than those of their parents. All F_1 means of Chico/Tx851856 and all F_2 means of Tx851856/TxAG-1 were between the parental means. The number of full-size pods produced by the F_1 plants were mostly within the range of the parents, but the F_2 ranges often extended beyond those of the parents.

Within replications the ranges for the F_2 generations surpassed the parents in the number of full-size or mature pods in one or more replications in all crosses. This is an indication of a transgressive segregation. Consequently, it should be possible to have segregates that have more full-size pods and more mature pods than their parents when allowed to mature within the same period of time. Progress in selecting for earliness in progeny of these crosses, using FULL and NUMP as selection criteria, should be possible because of the trangressive segregation and relatively high heritability.

The distribution of F_1, F_2, and parental plants in replication three was chosen for illustration because the plants in that replication were not affected by excessive moisture.

Table 22. Mean, variance, standard deviation, and range for the variable number of full-size pods in the cross Chico/Sn55-437 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Chico	20.14	144.98	12.04	2-40
Sn55-437	15.14	47.69	6.90	4-28
F_1	28.40	58.24	7.63	20-41
F_2	22.61	196.64	14.02	1-69
Replication 2				
Chico	46.60	589.84	24.28	9-72
Sn55-437	24.71	171.34	13.09	7-50
F_1	26.00	134.00	11.57	6-34
F_2	29.24	214.78	14.65	5-78
Replication 3				
Chico	69.64	434.37	20.84	25-98
Sn55-437	53.46	726.64	26.95	4-98
F_1	87.16	1404.81	37.48	41-133
F_2	64.98	951.22	30.84	6-147
Replication 4				
Chico	45.97	739.54	27.19	2-98
Sn55-437	34.13	630.57	25.11	4-98
F_1	74.40	1001.84	31.65	40-117
F_2	51.36	325.64	18.04	11-107

Table 23. Mean, variance, standard deviation, and range for the variable number of full-size pods in the cross Chico/Tx851856 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Chico	20.14	144.98	12.06	2-40
Tx851856	13.93	46.06	6.78	6-27
F_1	18.16	152.47	12.34	4-42
F_2	17.45	92.99	9.64	1-45
Replication 2				
Chico	46.60	589.84	24.28	9-72
Tx851856	20.33	160.22	12.65	1-38
F_1	42.40	190.64	13.80	24-64
F_2	40.05	296.98	17.23	3-96
Replication 3				
Chico	69.64	434.37	20.84	25-98
Tx851856	37.06	113.12	10.63	22-59
F_1	46.00	285.20	16.88	20-63
F_2	57.64	589.69	24.28	8-126
Replication 4				
Chico	45.97	739.54	27.19	2-98
Tx851856	24.72	200.89	14.17	1-59
F_1	39.80	32.56	5.70	33-48
F_2	47.50	359.60	18.96	11-99

Table 24. Mean, variance, standard deviation, and range for the variable number of full-size pods in the cross Chico/TxAG-1 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Chico	20.14	144.98	12.04	2-40
TxAG-1	25.00	152.13	12.33	9-47
F_1	28.00	290.33	17.03	10-61
F_2	19.33	180.36	13.42	1-71
Replication 2				
Chico	46.60	589.84	24.28	9-72
TxAG-1	36.85	46.12	6.79	24-46
F_1	44.66	104.22	10.20	36-59
F_2	37.56	293.24	17.12	6-72
Replication 3				
Chico	69.64	434.37	20.84	25-98
TxAG-1	96.61	622.85	24.95	64-139
F_1	73.33	903.55	30.05	39-119
F_2	84.30	781.39	27.95	11-168
Replication 4				
Chico	45.97	739.54	27.19	2-98
TxAG-1	52.79	1250.50	35.36	9-139
F_1	71.50	1071.25	32.73	18-101
F_2	56.86	480.85	21.92	15-121

Table 25. Mean, variance, standard deviation, and range for the variable number of full-size pods in the cross Chico/TxAG-2 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Chico	20.14	144.98	12.04	2-40
TxAG-2	17.28	96.77	9.83	1-35
F_1	18.20	155.36	12.46	4-36
F_2	21.26	242.45	15.57	1-62
Replication 2				
Chico	46.60	589.84	24.28	Y-72
TxAG-2	19.33	154.22	12.41	1-34
F_1	45.25	111.68	10.56	34-62
F_2	36.43	353.86	18.81	3-84
Replication 3				
Chico	69.64	434.37	20.84	25-98
TxAG-2	60.41	430.91	20.75	16-82
F_1	75.83	302.47	17.39	44-97
F_2	62.20	608.82	24.67	4-112
Replication 4				
Chico	45.97	739.54	27.19	2-98
TxAG-2	34.23	558.58	23.63	t-82
F_1	32.66	572.22	23.92	11-66
F_2	55.30	616.93	24.83	5-110

Table 26. Mean, variance, standard deviation, and range for the variable number of full-sire pods in the cross Sn55-437/Tx851856 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Sn55-437	15.14	47.69	6.90	4-58
Tx851856	13.93	46.06	6.78	5-27
F_1	15.40	10.24	3.20	11-20
F_2	15.22	80.20	8.95	1-39
Replication 2				
Sn55-437	24.71	171.34	13.09	7-50
Tx851856	20.33	160.22	12.65	1-38
F_1	45.25	111.68	10.56	34-62
F_2	25.56	136.37	11.67	4-56
Replication 3				
Sn55-437	53.46	726.64	26.95	4-98
Tx851856	37.06	113.12	10.63	22-59
F_1	47.83	447.13	21.14	25-76
F_2	47.30	520.49	22.81	2-99
Replication 4				
Sn55-437	34.13	630.57	25.11	4-98
Tx851856	24.72	200.89	14.17	1-59
F_1	41.40	73.84	8.59	31-56
F_2	32.70	266.66	16.32	6-71

Table 27. Mean, variance, standard deviation, and range for the variable number of full-size pods in the cross Sn55-437/TxAG-1 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Sn55-437	15.14	47.69	6.90	4-58
TxAG-1	25.00	152.13	12.33	9-47
F_1	24.50	106.91	10.34	6-36
F_2	14.15	45.20	6.72	2-34
Replication 2				
Sn55-437	24.71	171.34	13.09	7-50
TxAG-1	36.85	46.12	6.79	24-46
F_1	36.40	157.84	12.56	26-61
F_2	28.03	130.03	11.40	4-59
Replication 3				
Sn55-437	53.46	726.64	26.95	4-98
TxAG-1	96.61	622.85	24.95	64-139
F_1	53.00	767.00	27.69	5-87
F_2	60.21	591.02	24.31	10-138
Replication 4				
Sn55-437	34.13	630.57	25.11	4-98
TxAG-1	52.79	1250.50	35.36	9-139
F_1	67.80	584.56	24.17	38-109
F_2	45.46	227.86	15.09	8-81

Table 28. Mean, variance, standard deviation, and range for the variable number of full-size pods in the cross Sn55-437/TxAG-2 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Sn55-437	15.14	47.69	6.90	4-58
TxAG-2	17.28	96.77	9.83	1-35
F_1	21.16	121.47	11.02	9-43
F_2	18.56	80.07	8.94	1-38
Replication 2				
Sn55-437	24.71	171.34	13.09	7-50
TxAG-2	19.33	154.22	12.41	1-34
F_1	24.83	28.80	5.36	17-35
F_2	29.89	205.02	14.31	5-72
Replication 3				
Sn55-437	53.46	726.64	26.95	4-98
TxAG-2	60.41	430.91	20.75	16-82
F_1	68.00	322.66	17.96	35-94
F_2	67.31	722.41	26.88	5-124
Replication 4				
Sn55-437	34.13	630.57	25.11	4-98
TxAG-2	34.23	558-58	23.63	1-82
F_1	55.50	1036.25	32.19	16-105
F_2	50.08	350.07	18.71	1-98

Table 29. Mean, variance, standard deviation, and range for the variable number of full-size pods in the cross Tx851856/TxAG-1 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Tx851856	13.93	46.06	6.78	5-27
TxAG-1	25.00	152.13	12.33	9-47
F_1	29.50	79.58	8.92	18-42
F_2	21.91	233.09	15.26	1-62
Replication 2				
Tx851856	20.33	160.22	12.65	1-38
TxAG-1	36.85	46.12	6.79	24-46
F_1	38.00	97.00	9.84	23-54
F_2	25.17	139.16	11.79	5-64
Replication 3				
Tx851856	37.06	113.12	10.63	22-59
TxAG-1	96.61	622.85	24.95	64-139
F_1	45.50	505.58	22.48	14-77
F_2	57.17	496.11	22.27	11-119
Replication 4				
Tx851856	24.72	200.89	14.17	1-59
TxAG-1	52.79	1250.50	35.36	9-139
F_1	32.33	131.55	11.46	19-47
F_2	37.75	353.08	18.79	1-99

Table 30. Mean, variance, standard deviation, and range for the variable number of full-size pods in the cross Tx851856/TxAG-2 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Tx851856	13.93	46.06	6.78	5-27
TxAG-2	17.28	96.77	9.83	1-35
F_1	32.80	156.56	12.51	17-48
F_2	21.96	144.85	12.03	2-50
Replication 2				
Tx851856	20.33	160.22	12.65	1-38
TxAG-2	19.33	154.22	12.41	1-34
F_1	28.00	33.50	5.78	22-36
F_2	22.93	148.74	12.19	3-59
Replication 3				
Tx851856	37.06	113.12	10.63	22-59
TxAG-2	60.41	430.91	20.75	16-82
F_1	55.00	144.66	12.02	39-68
F_2	54.94	431.16	20.76	13-105
Replication 4				
Tx851856	24.72	200.89	14.17	1-59
TxAG-2	34.23	558.58	23.63	1-89
F_1	48.00	398.00	19.94	22-83
F_2	37.75	325.64	18.04	1-68

Table 31. Mean, variance, standard deviation, and range for the variable number of full-size pods in the cross TxAG-1/TxAG-2 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
TxAG-1	25.00	152.13	12.33	Y-47
TxAG-2	17.28	96.77	9.83	1-35
F_1	25.66	58.55	7.65	13-37
F_2	23.36	175.07	13.23	3-53
Repl icat ion 2				
TxAG-1	36.85	46.12	6.79	24-46
TxAG-2	19.33	154.22	12.41	1-34
F_1	39.50	6.25	2.50	37-42
F_2	27.00	145.09	12.04	4-54
Repl icat ion 3				
TxAG-1	96.61	622.85	24.95	64-139
TxAG-2	60.41	430.91	20.75	16-82
F_1	52.6	697.84	26.41	11-93
F_2	60.68	750.73	27.39	4-108
Repl icat ion 4				
TxAG-1	52.79	1250.50	35.36	Y-139
TxAG-2	34.23	558.58	23.63	1-82
F_1	48.00	209.16	14.46	19-78
F_2	46.89	259.35	16.10	18-75

Table 32. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross Chico/Sn55-437 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Chico	1.00	1.85	1.36	0-4
Sn55-437	0.57	1.10	1.04	0-4
F_1	1[illegible]40	1.84	1.35	0-3
F_2	0.87	1.55	1.24	0-7
Replication 2				
Chico	7.60	22.64	4.75	2-13
Sn55-437	4.00	30.85	5.55	0-17
F_1	3.75	3.68	1.92	1-6
F_2	6.34	43.86	6.62	0-34
Replication 3				
Chico	35.23	51[illegible]71	7.20	12-42
Sn55-437	25.40	115.44	10.74	1-38
F_1	27.50	72.25	8.50	18-41
F_2	30.09	88.42	9.40	4-42
Replication 4				
Chico	18.40	266.24	16.31	0-45
Sn55-437	12.31	173.76	13.18	0-38
F_1	28.20	88.96	9.43	12-39
F_2	24.04	80.40	8.96	8-42

Table 33. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross Chico/Tx851856 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Repl icat ion 1				
Chico	1 .00	1.85	1.36	o-4
Tx85 1856	0.93	1.12	1.06	O-3
F_1	1.33	0.88	0.94	O-3
F_2	0.43	0.44	0.66	o-2
Repl icat ion 2				
Chico	7.60	22.64	4.75	2-13
Tx85 1856	4.16	11.80	3.43	0-9
F_1	5.40	3.04	1.74	4-8
F_2	6.05	39.87	6.31	0-30
Repl icat ion 3				
Chico	35.28	51.91	7.20	12-42
Tx851856	22.86	57.18	7.56	13-37
F_1	29.40	134.64	11.60	12-41
F_2	27.35	85.37	9.23	2-42
Replication 4				
Chico	18.40	266.24	16.31	o-45
Tx851856	il.27	132.04	11.49	0-37
F_1	24.40	72.64	8.52	10-34
F_2	26.56	181.30	13.46	5-60

Table 34. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross Chico/TxAG-1 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Chico	1.00	1.85	1.36	0-4
TxAG-1	2.13	4.38	2.09	0-6
F_1	1.66	3.55	1.88	0-5
F_2	0.96	1.61	1.26	0-5
Replication 2				
Chico	7.60	22.64	4.75	2-13
TxAG-1	10.28	30.20	5.49	2-19
F_1	9.33	56.88	7.54	4-20
F_2	8.11	46.55	6.82	0-34
Replication 3				
Chico	45.28	51.91	7.20	12-42
TxAG-1	34.00	30.92	5.56	18-40
F_1	29.66	62.22	7.88	19-39
F_2	33.62	48.66	6.97	6-44
Replication 4				
Chico	18.40	266.24	16.31	0-45
TxAG-1	16.74	195.63	13.98	0-40
F_1	36.50	262.25	16.19	11-51
F_2	30.84	145.91	12.07	7-66

Table 35. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross Chico/TxAG-2 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Chico	1.00	1.85	1.36	0-4
TxAG-2	2.50	4.96	2.22	0-6
F_1	2.20	2.96	1.72	0-5
F_2	1.94	6.05	2.46	0-12
Replication 2				
Chico	7.60	22.64	4.75	2-13
TxAG-2	5.33	22.55	4.74	0-13
F_1	8.50	3.25	1.80	6-11
F_2	6.59	37.43	6.11	0-30
Replication 3				
Chico	35.28	51.91	7.20	12-42
TxAG-2	26.08	170.57	13.06	1-38
F_1	33.50	30.91	5.56	24-41
F_2	26.50	95.02	9.74	0-41
Replication 4				
Chico	18.40	266.24	16.31	0-45
TxAG-2	13.92	191.45	13.83	0-39
F_1	16.33	162.88	12.76	2-33
F_2	24.76	115.50	10.74	1-42

Table 36. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross Sn55-437/Tx851856 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Sn55-437	0.57	1.10	1.04	o-4
Tx851856	0.93	1.12	1.06	0-3
F_1	0.60	0.64	0.80	o-2
F_2	0.94	1.60	1.26	o-4
Replication 2				
Sn55-437	4.00	30.85	5.55	o-17
Tx851856	4.16	11.80	3.43	0-9
F_1	5.20	8.96	2.99	2-10
F_2	7.86	40.41	6.35	o-28
Replication 3				
Sn55-437	25.40	115.44	10.74	1-38
TX851856	22.86	57.18	7.56	13-37
F_1	21.16	90.47	9.51	10-33
F_2	22.32	80.61	8.97	1-40
Replication 4				
Sn55-437	12.31	173.76	13.18	o-38
Tx851856	11.27	132.04	11.49	0-37
F_1	25.20	34.96	5.91	14-30
F_2	19.50	102.20	10.10	I-43

Table 37. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross Sn55-437/TxAG-1 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Sn55-437	0.57	1.10	1.04	o-4
TxAG-1	2.13	4.38	2 .og	0-6
F_1	2.50	7.25	2.69	o-8
F_2	0.86	1.61	1.27	0-5
Replication 2				
Sn55-437	4.00	30.85	5.55	o-17
TxAG-1	10.28	30.20	5.49	2-19
F_1	6.40	9.04	3.00	4-12
F_2	5.51	17.84	4.22	o-2 1
Replication 3				
Sn55-437	25.40	115.44	10.74	1-38
TxAG-1	34.00	30.92	5.56	18-40
F_1	21.83	113.80	10.66	1-36
F_2	26.08	66.97	8.18	3-41
Replication 4				
Sn55-437	12.31	173.76	13.18	o-38
TxAG-1	16.74	195.63	13.98	0-40
F_1	30.20	66.56	8.15	22-45
F_2	21.87	74.06	8.60	5-44

Table 38. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross Sn55-437/TxAG-2 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Sn55-437	0.57	1.10	1.04	0-4
TxAG-2	2.50	4.96	2.22	0-6
F_1	2.33	4.55	2.13	1-7
F_2	2.78	6.76	2.60	0-10
Replication 2				
Sn55-437	4.00	30.85	5.55	0-17
TxAG-2	5.33	22.55	4.74	0-13
F_1	9.83	5.80	2.40	6-13
F_2	11.14	58.12	7.62	2-31
Replication 3				
Sn55-437	25.40	115.44	10.74	1-38
TxAG-2	26.08	170.57	13.06	1-38
F_1	29.16	46.13	6.79	19-39
F_2	27.12	100.92	10.04	4-42
Replication 4				
Sn55-437	12.31	173.76	13.18	0-38
TxAG-2	13.92	191.45	13.83	0-39
F_1	34.75	301.18	17.35	9-57
F_2	28.76	143.94	11.99	1-56

Table 39. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross Tx851856/TxAG-1 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Tx851856	0.93	1.12	1.06	0-3
TxAG-1	2.13	4.38	2.09	0-6
F_1	1.66	1.55	1.24	0-3
F_2	1.33	2.81	1.67	0-7
Replication 2				
Tx851856	4.16	11.80	3.43	0-9
TxAG-1	10.28	30.20	5.49	2-19
F_1	8.66	16.22	4.02	3-19
F_2	4.72	17.09	4.13	0-19
Replication 3				
Tx851856	22.86	57.18	7.56	13-37
TxAG-1	34.00	30.92	5.56	18-40
F_1	20.66	75.55	8.69	8-30
F_2	26.50	85.82	9.26	4-42
Replication 4				
Tx851856	11.27	132.04	11.49	0-37
TxAG-1	16.74	195.63	13.98	0-40
F_1	21.00	52.66	7.25	ii-28
F_2	21.48	139.11	11979	1-52

Table 40. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross Tx851856/TxAG-2 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
Tx851856	0.93	1.12	1.06	0-3
TxAG-2	2.50	4.96	2.22	0-6
F_1	0.80	1.36	1.16	0-3
F_2	0.96	3.03	1.74	0-8
Replication 2				
Tx851856	4.16	11.80	3.43	0-9
TxAG-2	5.33	22.55	4.74	0-13
F_1	4.75	3.18	1.78	2-7
F_2	4.15	14.81	3.84	0-16
Replication 3				
Tx851856	22.86	57.18	7.56	13-37
TxAG-2	26.08	170.57	13.06	1-38
F_1	30.33	40.22	6.34	24-39
F_2	26.79	74.94	8.65	8-44
Replication 4				
Tx851856	11.27	132.04	11.49	0-37
TxAG-2	13.92	191.45	13.83	0-39
F_1	28.80	233.36	15.27	16-56
F_2	21.86	173.09	13.15	0-60

Table 41. Mean, variance, standard deviation, and range for the variable number of mature pods in the cross TxAG-1/TxAG-2 and its reciprocal within replications.

	Mean	Variance	St.dev.	Range
Replication 1				
TxAG-1	2.13	4.38	2.09	0-6
TxAG-2	2.50	4.96	2.22	0-6
F_1	1.83	1.13	1.06	0-3
F_2	1.36	2.02	1.42	0-5
Replication 2				
TxAG-1	10.28	30.20	5.49	2-19
TxAG-2	5.33	22.55	4.74	0-13
F_1	16.50	56.25	7.50	9-24
F_2	8.29	35.62	5.96	0-21
Replication 3				
TxAG-1	34.00	30.92	5.56	18-40
TxAG-2	26.08	170.57	13.06	1-38
F_1	26.80	161.76	12.71	5-41
F_2	29.48	112.13	10.58	1-43
Replication 4				
TxAG-1	16.74	195.63	13.98	0-40
TxAG-2	13.92	191.45	13.83	0-39
F_1	30.83	98.63	9.93	12-57
F_2	27.94	139.94	11.82	6-54

Combining Ability Estimates

The number of mature pods and weight of mature seeds best represented the yield in this experiment. In order to estimate the combining ability these two variables were considered. The analysis of variance for the variables number of mature pods (NUMP) and weight of mature seeds (WTMS) is given in Table 42.

Table 42. Analysis of variance for general and specific combining abilities estimates for the variables number of mature pods (NUMP) and weight of mature seeds (WTMS).

Source of variation	D.F.	Sum of squares	Mean squares	F values
NUMP				
GCAF	4	200.15	50.04	2.31
GCAM	4	161.31	40.33	1.86
SCA	6	308.93	51.49	2.37
Reciprocals	10	858.42	85.84	3.96*
WTMS				
GCAF	4	32.78	8.19	0.44
GCAM	4	39.07	9.77	0.53
SCA	6	187.99	31.33	1.70
Reciprocals	10	350.31	35.03	1.90

* significant at the 0.01 probability level.

The general combining ability (GCA) for the parental lines was estimated for each parent used when as a male (GCAM) or as a female (GCAF). The GCAM as well as the GCAF were not significantly different (P=0.01) for either NUMP or WTMS. Similarly, the specific combining abilities (SCA) were not different statistically (Table 42). Reciprocal differences were apparent for NUMP but not for WTMS

TxAG-1 had the best GCA when used either as a male or as a female parent for the variable NUMP (Table 43); it was followed by Chico which had a GCAF of 0.15 and a GCAM of 1.1. The GCAM for TxAG-2 was quite low.

Table 43. General combining ability estimates of the five parental lines used as female or as male parents for the variables number of mature pods (NUMP) and weight of mature seeds (WTMS).

	Chico	Sn55-437	Tx851856	TxAG-1	TxAG-2
NUMP					
GCAF	0.15	-0.04	-2.18	1.01	1.06
GCAM	1.10	1.02	-1.10	2.20	-3 [illegible] 22
WTMS					
GCAF	0.33	-0.23	0.40	-0.06	-0.44
GCAM	0.94	0.28	1.62	0.70	-3.58

For WTMS, Tx851856 was the best parent when used either as a male or as a female. It was followed by Chico and Sn55-437. TxAG-1 and TxAG-2 did not perform well for this variable.

Specific combining ability as measured by the parent and F_1 generations was not different ($P=0.01$) for either of the variables under consideration. Numerically, the best combination of parents for NUMP was the cross Chico/TxAG-1. For WTMS, the crosses Tx851856/TxAG-1 and Chico/TxAG-1 gave the best positive SCA values. The SCA for Sn55-437/Tx851856 was low for both variables considered. Reciprocal differences were found for both variables with the greatest difference in the cross TxAG-1/Sn55-437 for NUMP.

DISCUSSION

Emergence rate was variable between replications because of the weather during the planting period. As a consequence, the rate of emergence varied greatly among the different replications (Figures 1 through 4). The analysis of the homogeneity of variances using Bartlett's formula showed differences between replications which prevented their combination for the analyses.

Mean number of days from planting to a given number of flowers for the five parental lines showed that the first flowers were produced by Chico followed by Sn 55-437. However, after 10 flowers there was'no significant difference (P-0.05) among the parents according to the Waller-Duncan test (Table 3). in using flowering pattern to estimate earliness there was no apparent need to count to 25 flowers for the short maturing peanut cultivars used in this study. This might differ somewhat from the conclusions of Bear and Bailey (6) who stated that a high proportion of the 25 first flowers to open on plants of diverse genotypes developed into mature pods.

Differences in flower development and flowering pattern existed among the parental lines (Table 4). Although Chico was first in setting flowers, it did not have the highest percentage of mature pods. This suggests that the fruit development of Chico was not as fast as that of some other varieties. Thus, we could not classify Chico as earlier than the other varieties. In fact, flowering pattern, especially first flower, was ineffective as a criterion for earliness among the short growth duration parents used in this experiment. Researchers should be cautious about using first flower by itself as a criterion for estimating earliness.

Crosses between these early maturing cultivars yielded some progen ies that set f lowers earl ier, produced higher numbers of mature pods (NUMP), and had higher percentages of mature pods (%MP) than their parents (e.g.Chico/Tx851856). This suggests that earlier maturing cultivars might be developed by crossing early matur ing lines.In future breeding programs for earliness the use of Chico, Tx851856, and TxAG-2 should be considered.

The correlation study showed that a given number of f lowers was better correlated with number of full-size pods (FULL) and number of mature pods (NUMP) than percentage of mature pods. The association of number of days from planting to a predetermined number of flowers with NUMP and FULL showed a better correlation than number of days from emergence, o r rate of flowering. According to our data, estimates of earliness should not be made on flowering pattern alone, FULL and/or NUMP should be considered. On the basis of this study we suggest that flowering pattern not be used as the criterion for earliness if all the parental lines are early maturing. A line can initiate flowering earlier than another but have a slower rate of flowering and pod development and produce comparatively low numbers of full-size and mature pods at an early harvest. Based on the results and experience gained from this study, the number of full-sire pods might be a useful criterion for earliness in combination with early digging. The number of full-size pods can be determined more easily than number of mature pods. However, awareness should be given to pod sire to avoid the shifting of populations to the production of large numbers of pods of unacceptable size.

The heritability estimates for days from planting to first (DONE), tenth (DTEN), and twenty-fifth flower (DTW5); number of full-size pods (FULL), and number of mature pods (NUMP) were similar. The heritability percentages for DTW5 and DTEN were slightly higher than for the other variables. The crosses involving Tx851856 had higher heritability values than those involving the other parents, especially the cross Chico/Tx851856. The tendency of higher heritability for this cross indicates greater genetic variability and suggests that the two parents differ in genes for the variables under consideration. In contrast, low heritability estimates resulted from the cross Chico/TxAG-1 indicating a possible similarity of genes. The values for the other crosses were intermediate between the two crosses mentioned. No consistency in the relative heritability percentages for the varied number of flowers tested was apparent among crosses. The mean value over all crosses was lower for DONE than for DTEN or DTW5 which had the highest mean value over crosses. The moderate to low heritability of flowering, plus moderate to low correlation of days to flower and number of mature pods, lessens the probable success of selection for earliness on the basis of flowering pattern.

Segregation patterns used in this study did not reveal any meaningful segregation ratios. Hence, it was not possible to ascertain the number of genes involved in flowering pattern or in pod development among these parents. In future studies this question should be fully addressed.

The good combining ability of TxAG-1 for NUMP probably relates to the fact that it has small seeds that mature fast. Tx851856, which had the least favorable GCA for NUMP, had the highest GCA for WTMS. Among the five parental lines TX851856 has the biggest seeds, which is assumed to explain the good GCA for WTMS. Chico was above average in GCA for both NUMP and WTMS.

The SCA of Chico/TxAG-1 was among the best SCA for both NUMP and WTMS. However, significant differences (P=0.05) among SCA values were not detected by the analysis of variance for either of the variables.

SUMMARY AND CONCLUSIONS

Five early maturing cultivars, Chico, Sn 55-437, TxAG-1, TxAG-2, and Tx851856 were crossed in a complete diallel. Parents, F_1's, and F_2's of the different combinations were evaluated in the field for flowering pattern and pod development.

There were differences in rate of emergence and flowering pattern between the parental lines and between the progenies of the crosses. Some progenies were found to set flower earlier and to have higher numbers of full-size and mature pods than both of their parents, indicating transgressive segregation.

Tests for correlations between FULL, NUMP, and %MP and a given number of flowers indicated that flowering pattern alone, especially first flower, could not be used effectively to determine earliness among these early maturing cultivars. This technique might be applicable in estimating relative earliness between genotypes of different maturity groups, such as runner-type and spanish-type peanuts, or in a cross between them. FULL and NUMP are more reliable criteria in selecting for earliness. Caution in selection on the basis of full-size and mature pods should be given to avoid plants with unacceptable small pods.

In some situations heritability estimates for a predetermined number of flowers were lower than heritability values of FULL and NUMP. Days from planting to twenty-fifth flower (DTW5) had a higher overall mean value of heritability estimates.

Combining ability estimates involving parents and F_1

generations showed that there were no significant differences among the parents in GCA when used as females or as males, or in SCA for the variables NUMP and WTMS. However, for NUMP there were reciprocal differences.

No meaningful segregation ratios could be detected in studies on the segregation patterns. Hence, the number of genes involved was not determined. Future research should address that question.

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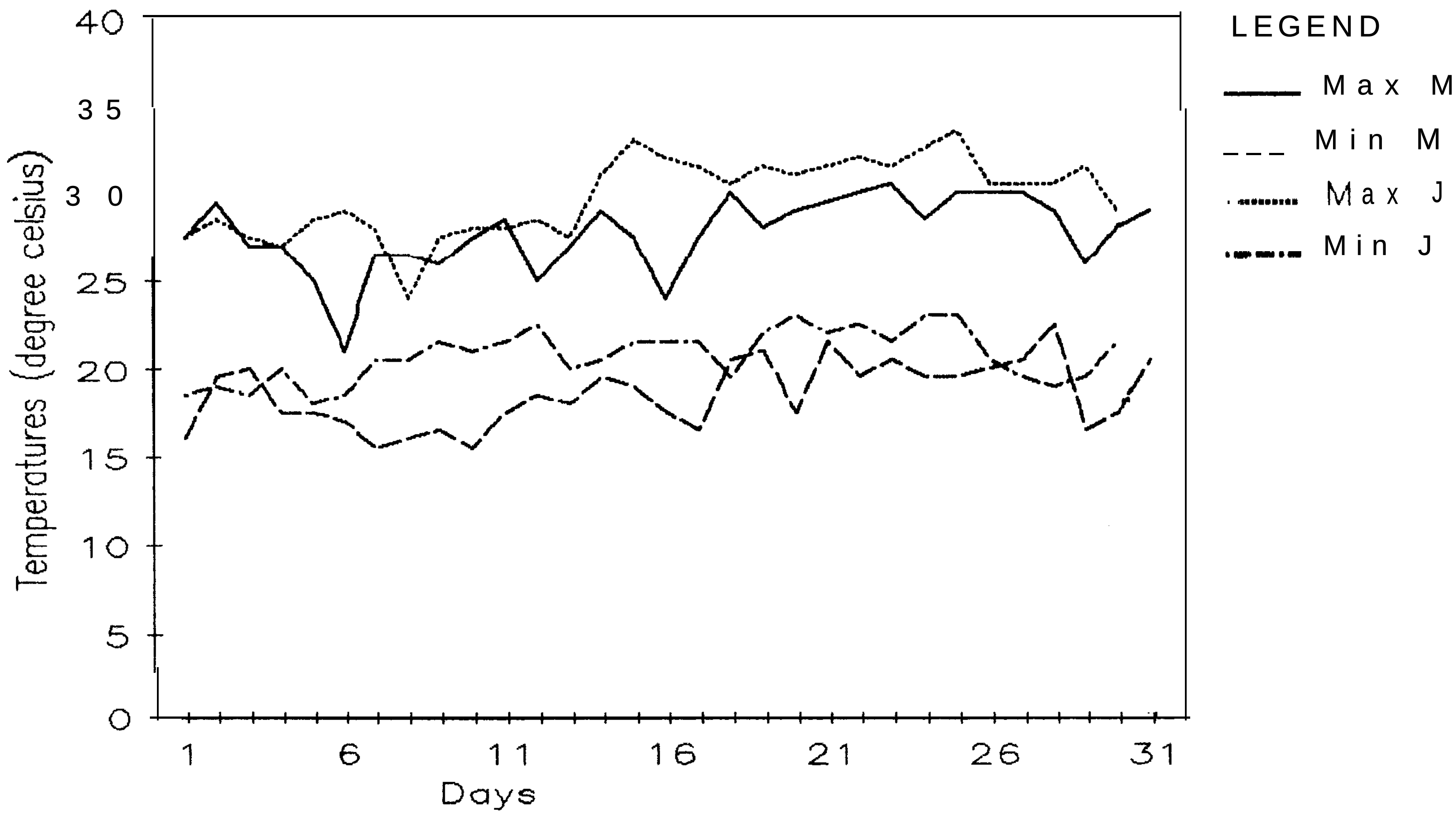
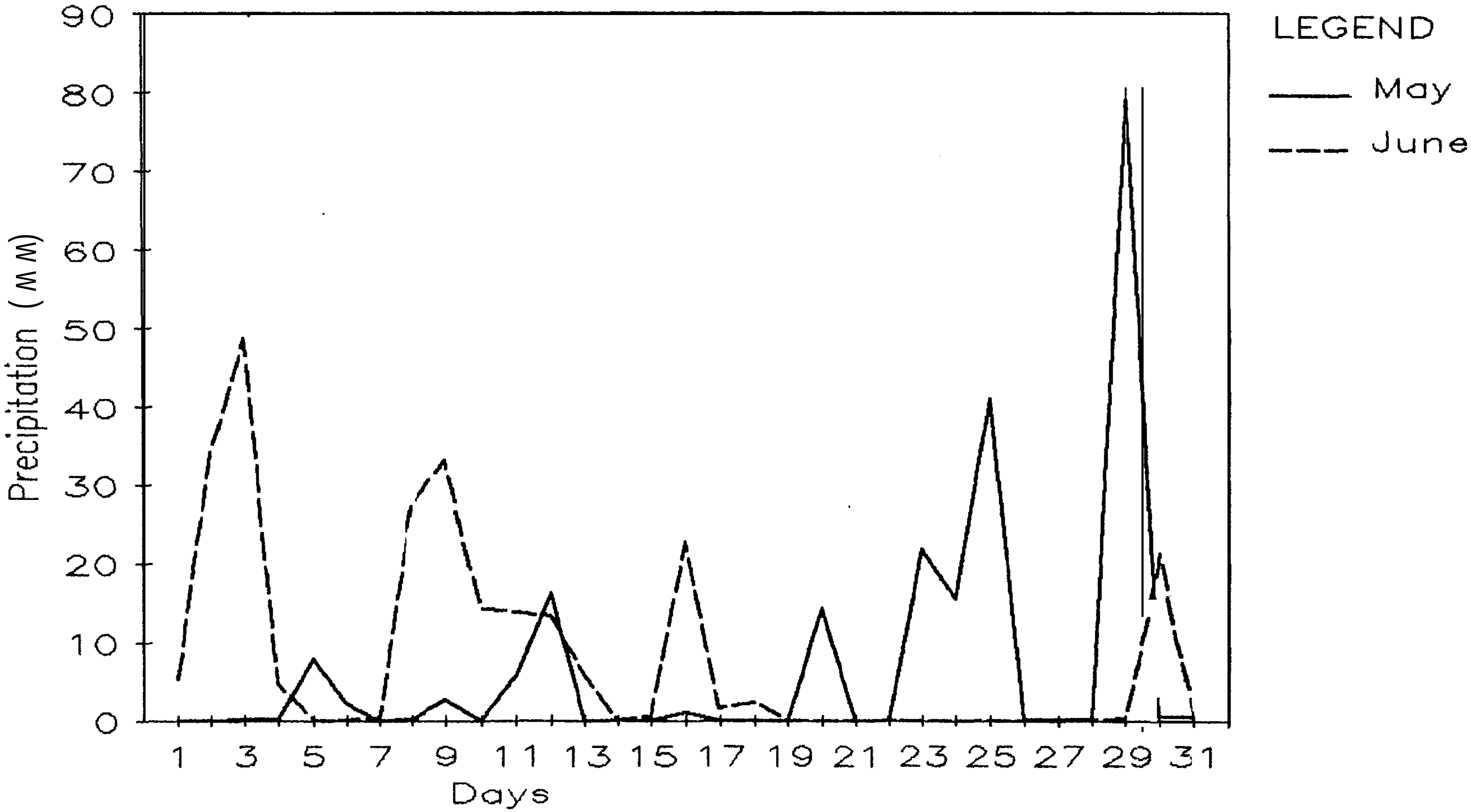
APPEND IX

Appendix figure 1. Maximum and minimum temperatures during planting period



Appendix figure 2. Precipitations during planting period



Appendix table 1. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, twenty-fith flowers and number of full-size pods and number of mature pods for the cross Chico/Sn55-437 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
Chico	1	8.75	31.75	34.00	44.75	50.75	53.75	58.00	32.25	1.50
	2	7.00	34.00	48.00	57.00	64.00	66.00	68.00	9.00	2.00
	3	6.00	24.00	26.50	28.00	30.00	32.50	34.00	81.50	38.00
	4	18.50	37.75	41.00	43.75	47.75	50.00	52.50	48.50	28.00
Mean		10.06	31.87	37.37	43.37	48.12	50.56	53.12	42.81	17.37
Sn55-437	1	7.50	37.25	51.00	52.25	58.50	59.75	61.00	19.00	1.25
	2	8.00	44.50	51.50	56.50	58.00	60.00	62.00	17.00	2.50
	3	7.00	27.00	29.91	32.25	33.66	36.00	37.75	58.00	29.00
	4	21.00	41.00	43.75	45.25	47.25	48.00	49.50	30.25	11.75
Mean		10.87	37.43	44.04	46.56	49.35	50.93	52.43	31.06	11.12

Appendix table 1. (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	16.33	43.67	47.00	51.33	54.67	56.33	57.67	23.33	2.00
	2	9.00	36.00	42.00	46.00	49.00	51.50	54.50	20.00	2.00
	3	5.67	26.67	30.00	31.67	32.33	33.67	34.67	94.00	31.33
	4	15.33	34.00	35.67	36.33	37.00	38.33	39.33	97.00	35.00
Recip.	1	8.00	30.33	39.67	48.00	51.67	55.67	61.00	24.00	0.33
	2	12.00	41.50	48.50	50.50	52.50	54.50	56.00	32.00	5.50
	3	6.00	26.00	28.00	30.33	32.00	33.33	34.67	80.33	23.67
	4	18.00	40.00	47.50	49.50	53.00	56.50	56.50	40.50	18.00
Mean		11.29	34.77	39.79	42.95	45.27	47.47	49.29	51.39	14.72
F_2	1	10.00	35.75	46.64	54.43	57.82	60.50	62.32	18.07	0.82
	2	8.56	40.44	49.74	53.52	56.56	58.48	60.00	26.96	5.22
	3	6.08	24.96	28.12	30.12	31.84	33.32	34.72	57.28	27.36
	4	17.40	36.50	39.15	42.20	44.30	46.65	48.20	45.15	21.85
Recip.	1	8.39	32.14	40.00	46.89	52.29	55.50	57.29	25.54	0.86
	2	10.36	39.28	46.80	53.08	56.00	58.48	60.64	29.36	7.04
	3	5.68	25.00	27.21	28.75	30.00	31.29	31.30	71.86	32.54
	4	17.25	36.38	39.63	41.83	43.79	45.58	48.08	56.54	25.88
Mean		10.46	33.80	39.66	43.85	46.57	48.72	50.31	41.34	15.19

Recip.=reciprocal.

Appendix table 2. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, and twenty-fifth flowers and number of full-size pods and number of mature pods for the cross Chico/Tx851856 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
Chico	1	11.75	45.00	51.75	55.50	60.75	63.75	66.50	10.50	0.25
	2	8.50	39.00	48.50	52.00	55.00	57.00	59.00	67.50	12.50
	3	9.00	27.50	30.75	33.00	34.75	36.25	37.75	69.00	17.25
	4	16.00	36.00	38.50	44.50	46.50	50.00	52.00	71.00	41.00
Mean		11.31	36.87	42.37	46.25	49.25	51.75	66.75	54.50	17.75
Tx851856	1	8.75	36.75	51.00	60.25	62.75	65.25	66.75	11.50	1.00
	2	9.00	31.00	48.00	53.00	57.00	59.00	61.00	34.00	7.00
	3	6.25	29.75	31.50	34.25	36.75	38.25	40.00	34.25	21.25
	4	*	*	*	*	*	*	*	*	*
Mean		8.00	32.25	43.50	49.16	52.16	54.16	55.91	26.58	9.75

*, Indicates missing values.

Appendix table 2. (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	9.33	33.33	35.67	43.33	49.00	54.00	57.67	22.33	1.33
	2	7.67	32.00	36.33	40.67	47.67	50.67	51.67	51.67	5.00
	3	9.00	30.00	34.50	37.00	39.00	40.50	42.50	26.50	16.00
	4	15.00	33.67	34.67	36.33	37.33	38.33	39.67	42.00	30.00
Recip.	1	8.67	31.67	40.00	53.67	60.33	63.33	65.33	14.00	1.33
	2	9.00	34.50	38.50	46.00	48.50	52.00	54.50	28.50	6.00
	3	5.33	25.67	29.33	32.33	35.00	36.67	38.33	59.00	38.33
	4	18.50	37.00	41.00	43.50	47.00	49.50	52.50	36.50	16.00
Mean		10.31	32.23	36.25	41.60	45.47	48.12	50.27	35.06	14.24
F_2	1	10.07	32.93	39.55	46.45	50.76	54.62	57.76	19.29	0.43
	2	8.48	34.21	41.31	48.21	51.45	54.07	55.62	37.86	5.45
	3	6.44	27.85	31.00	33.04	34.74	36.00	37.15	61.89	25.04
	4	16.41	34.66	36.76	38.79	40.34	41.72	43.28	46.17	28.38
Recip.	1	9.17	32.17	39.38	46.52	52.24	56.28	59.45	12.07	0.34
	2	7.97	35.72	44.90	51.48	53.17	54.90	56.31	42.24	6.66
	3	5.38	23.90	26.72	28.59	30.48	32.17	33.69	53.69	29.52
	4	17.46	36.25	38.25	40.08	42.00	43.74	45.04	49.13	24.38
Mean		10.17	32.21	37.23	41.64	44.39	46.68	48.53	40.29	15.02

Recip.=reciprocal.

Appendix table 3. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers and number of full-size pods and number of mature pods for the cross Chico/TxAG-1 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
Chico	1	14.50	34.75	47.75	51.75	60.75	64.00	66.00	15.75	1.25
	2	11.00	41.50	43.50	45.00	48.50	54.50	57.00	44.50	5.50
	3	6.75	24.50	28.75	35.50	33.00	34.00	35.25	80.00	37.75
	4	18.50	48.00	56.00	57.50	58.50	60.00	61.50	47.75	19.00
Mean		12.68	37.18	44.00	47.43	50.18	53.12	54.93	47.00	15.87
TxAG-1	1	9.75	45.00	50.75	56.50	58.25	60.00	61.25	22.75	3.00
	2	9.00	40.00	48.50	58.00	60.00	61.00	63.00	35.00	9.50
	3	6.00	27.00	28.00	30.25	32.75	35.25	37.50	84.75	33.75
	4	20.50	48.00	56.00	57.50	58.50	60.00	61.50	29.00	18.50
Mean		11.31	40.00	45.81	50.56	52.37	54.06	55.81	42.87	16.06

Appendix table 3. (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	10.00	33.33	36.67	43.33	47.33	52.33	55.33	22.00	1.67
	2	9.00	33.00	37.00	42.00	48.00	53.00	56.00	39.00	4.00
	3	5.00	25.33	28.67	30.33	32.00	33.33	34.33	84.00	33.67
	4	17.00	37.33	38.67	40.33	41.67	42.67	45.00	63.67	37.33
Recip.	1	11.00	37.00	44.00	51.00	55.33	58.00	60.00	34.00	1.67
	2	8.00	33.00	43.00	47.50	50.00	52.00	53.00	47.50	12.00
	3	6.33	30.00	35.67	38.00	39.67	40.67	42.67	62.67	25.67
	4	15.00	36.00	38.00	39.00	42.00	44.00	46.00	95.00	34.00
Mean		10.16	33.08	37.71	41.37	44.50	47.00	48.95	55.98	18.75
F_2	1	12.00	40.28	47.24	52.97	56.55	59.21	61.24	16.97	0.97
	2	10.83	39.56	46.28	51.61	55.22	57.28	60.00	32.22	6.39
	3	5.43	24.71	27.32	29.75	31.86	33.57	35.36	87.29	32.89
	4	17.24	37.14	40.71	43.14	46.05	48.33	50.24	54.76	34.81
Recip.	1	11.76	38.90	47.59	54.38	57.00	59.17	60.76	21.03	0.93
	2	9.26	40.30	47.78	53.04	55.81	57.59	59.41	39.74	8.96
	3	5.68	24.68	27.68	29.61	31.39	33.04	34.46	81.32	34.36
	4	17.80	37.64	40.80	43.04	44.88	46.68	48.60	58.64	27.52
Mean		11.25	35.40	40.67	44.69	47.34	49.35	51.25	48.99	18.35

Recip .=reciprocal

Appendix table 4. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers and number of full-size pods and number of mature pods for the cross Chico/TxAG-2 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
Chico	1	8.00	30.50	36.25	42.50	54.00	57.75	60.75	16.25	1.00
	2	*	*	*	*	*	*	*	*	*
	3	5.25	25.00	27.50	31.00	31.75	34.63	35.75	54.00	30.25
	4	18.00	37.00	38.00	45.00	48.00	51.00	53.00	18.00	9.00
Mean		10.41	30.83	33.91	39.50	44.58	47.79	49.83	29.41	13.41
TxAG-2	1	9.00	41.00	57.25	61.25	63.50	64.50	66.00	7.75	0.75
	2	10.00	51.50	55.50	58.00	68.00	70.50	72.00	17.50	4.00
	3	5.00	26.50	28.50	31.50	32.50	34.25	35.50	44.00	18.25
	4	16.50	45.00	48.50	50.00	53.00	54.50	56.50	27.00	15.50
Yean		10.12	41.00	47.43	50.18	54.25	55.93	57.50	24.06	9.62

*, Indicates missing values.

Appendix table 4 . (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	9.00	31.33	33.33	37.33	46.33	49.00	55.67	13.67	1.00
	2	9.00	31.00	33.00	37.00	47.00	50.00	52.00	34.00	8.00
	3	5.33	24.00	25.67	28.00	31.33	34.00	36.00	86.67	34.67
	4	28.00	48.50	53.50	54.50	56.50	58.50	59.50	38.50	17.50
Recip.	1	10.00	32.67	45.67	50.00	60.33	64.00	67.00	16.67	2.67
	2	9.67	33.67	39.67	47.33	51.33	54.00	56.00	49.00	8.67
	3	5.33	24.67	26.33	28.33	30.33	31.67	33.00	65.00	32.33
	4	16.00	33.00	40.00	45.00	47.00	50.00	52.00	21.00	14.00
Mean		11.53	32.35	37.14	40.93	46.26	48.89	51.39	40.56	14.85
F_2	1	12.24	34.27	40.96	46.12	50.19	55.31	58.62	14.77	1.08
	2	11.10	38.40	44.60	49.50	52.50	54.30	56.30	36.20	5.00
	3	5.61	26.18	29.79	33.04	35.93	38.25	40.50	54.38	23.28
	4	16.59	36.31	39.41	42.62	44.90	47.10	48.76	63.89	25.29
Recip.	1	8.55	34.38	43.79	53.03	57.38	59.83	61.62	25.62	2.59
	2	8.00	36.43	46.32	53.00	55.25	57.29	59.39	35.21	6.93
	3	5.58	25.35	27.62	29.31	30.88	32.27	33.58	71.28	30.24
	4	17.44	36.76	39.80	42.60	45.04	47.16	48.21	44.36	24.09
Mean		10.63	33.51	39.03	43.65	46.50	48.93	50.87	43.21	14.81

Recip.= reciprocal.

Appendix table 5. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers and numberof full-size pods and number of mature pods for the cross Sn55-437/Tx851856 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
Sn55-437	1	8.75	49.50	58.25	60.00	62.75	63.25	64.25	16.50	0.50
	2	8.00	49.00	58.00	61.00	63.00	65.00	66.00	23.00	0.00
	3	6.00	26.00	28.25	30.00	32.75	35.00	36.75	46.25	17.50
	4	17.00	37.00	38.00	41.00	45.00	49.00	51.00	21.00	14.00
Mean		9.93	40.37	45.62	48.00	50.87	53.06	54.50	26.68	7.87
Tx851856	1	14.00	38.00	47.50	52.25	55.50	57.75	59.50	12.00	0.75
	2	7.00	35.00	48.00	51.00	52.00	53.00	55.00	38.00	9.00
	3	7.50	29.75	35.75	37.25	38.50	39.50	41.25	38.75	23.25
	4	21.00	40.00	47.00	55.00	57.00	59.00	60.00	12.00	10.00
Mean		12.37	35.68	44.56	48.87	50.75	52.31	53.93	25.18	10.75

Appendix table 5. (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	11.00	40.67	50.33	53.33	55.67	57.33	59.33	16.33	0.67
	2	9.33	40.33	50.67	57.33	60.00	63.00	65.67	22.33	6.00
	3	5.33	27.67	31.67	35.33	38.33	39.67	40.67	53.00	22.00
	4	19.50	42.00	47.00	49.00	50.50	51.50	52.50	33.50	20.50
Recip.	1	9.00	36.50	54.50	58.50	62.00	64.00	66.00	14.00	0.50
	2	9.67	37.00	45.00	50.50	53.50	56.50	58.00	24.00	4.00
	3	6.33	28.00	33.00	35.00	37.00	39.00	40.67	42.67	20.33
	4	16.00	36.00	38.00	39.33	41.00	42.67	44.67	46.67	28.33
Mean		10.77	36.02	43.77	47.29	49.75	51.70	53.43	31.56	12.79
F_2	1	11.69	42.97	51.24	57.62	60.10	61.90	63.38	12.59	0.97
	2	9.89	46.17	54.61	59.89	61.83	63.61	64.94	22.61	4.78
	3	5.64	30.05	36.00	39.77	42.36	43.95	45.32	49.09	18.91
	4	17.93	38.07	42.33	45.73	47.40	48.93	50.60	36.53	20.47
Recip.	1	9.34	35.21	45.38	54.00	57.24	60.24	62.45	15.76	0.79
	2	8.50	37.18	45.46	50.21	53.04	55.46	56.89	27.46	9.86
	3	7.89	27.56	30.22	32.78	34.19	35.78	36.63	45.89	25.00
	4	17.00	36.04	38.80	41.28	44.00	45.28	47.16	30.40	18.92
Mean		10.98	36.65	43.00	47.66	50.02	51.89	53.42	30.04	12.46

Recip.=reciprocal.

Appendix table 6. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers and number of full-size pods and number of mature pods for the cross Sn55-437/TxAG-1 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
Sn55-437	1	12.50	39.00	47.50	54.00	57.50	61.25	62.50	12.00	0.00
	2	9.00	37.50	52.50	56.50	57.50	60.00	62.00	16.00	1.50
	3	5.00	24.75	29.00	31.50	34.75	37.00	38.00	56.25	26.00
	4	18.25	43.75	50.50	53.50	54.50	56.00	57.50	45.75	17.50
Mean		11.18	36.25	44.87	48.87	51.06	53.56	55.00	32.50	11.25
TxAG-1	1	12.83	47.08	53.16	55.50	57.25	58.41	60.50	36.08	0.50
	2	8.50	45.00	49.00	53.00	55.00	56.00	57.50	40.00	14.00
	3	5.75	25.25	28.75	30.75	32.00	33.00	34.00	101.25	36.75
	4	17.25	37.75	40.50	42.50	45.50	47.25	48.75	59.50	23.50
Mean		11.08	38.78	42.85	45.43	47.43	48.66	50.18	59.20	18.68

Appendix table 6. (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	11.33	44.67	49.00	53.00	56.33	59.33	61.00	17.33	1.00
	2	9.00	41.00	51.00	54.50	56.50	57.50	58.50	30.50	4.50
	3	6.00	27.00	32.33	34.67	36.67	38.33	39.67	62.67	24.33
	4	17.50	37.50	40.50	42.50	45.50	46.50	49.00	63.00	34.50
Recip.	1	11.00	36.00	43.00	48.67	51.33	52.33	54.00	31.67	4.00
	2	8.67	35.33	38.00	43.00	48.67	51.00	53.33	40.33	7.67
	3	6.33	27.00	31.00	33.33	34.33	36.67	38.00	43.33	19.33
	4	18.00	36.00	38.33	39.33	40.67	41.67	43.33	71.00	27.33
Mean		10.97	35.56	40.39	43.62	46.25	47.91	49.60	44.97	15.33
F_2	1	10.19	37.42	44.92	52.62	57.04	59.92	61.96	12.12	1.00
	2	8.46	38.32	49.14	53.43	56.11	57.86	59.82	26.64	3.29
	3	6.32	28.57	32.04	34.36	35.93	37.61	39.50	61.46	27.04
	4	17.12	37.04	40.46	42.96	44.69	46.58	48.46	46.64	22.80
Recip.	1	11.29	41.64	50.86	57.25	60.43	62.29	63.50	15.04	0.68
	2	8.21	37.21	45.59	50.83	53.86	56.14	57.83	26.48	7.10
	3	5.79	26.43	30.04	33.14	35.25	36.71	38.82	58.96	25.14
	4	17.64	37.18	39.95	42.68	45.27	47.59	49.50	44.14	20.82
Mean		10.62	35.47	41.62	45.90	48.57	50.59	52.42	36.43	13.48

Recip .=reciprocal.

Appendix table 7. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers and number of full-sire pods and number of mature pods for the cross Sn55-437/TxAG-2 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
Sn55-437	1	13.50	23.25	33.75	36.75	39.25	40.75	42.00	5.50	0.25
	2	9.50	47.00	53.50	55.00	56.00	57.00	58.00	42.00	10.00
	3	5.00	25.50	27.75	30.75	34.50	37.25	40.00	53.25	30.00
	4	15.00	34.00	36.00	38.00	39.00	40.00	41.00	53.00	24.00
Mean		10.75	32.43	37.75	40.12	42.18	43.75	45.25	38.43	16.06
TxAG-2	1	10.00	45.25	51.50	53.25	58.00	59.50	61.75	19.25	4.75
	2	9.00	36.00	43.00	51.00	52.00	54.00	55.00	20.00	3.00
	3	5.25	26.50	27.25	28.50	29.75	31.00	32.00	49.75	19.00
	4	29.00	50.50	53.50	56.50	58.50	61.00	61.50	33.00	19.50
Mean		13.31	39.56	43.81	47.31	49.56	51.37	52.56	43.64	11.56

Appendix table 7. (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	9.33	48.00	57.67	60.00	62.00	64.00	65.00	14.00	1.33
	2	10.00	43.67	49.00	55.33	60.00	62.00	62.67	27.00	10.00
	3	5.00	28.33	30.33	33.67	36.00	37.33	39.00	69.00	30.00
	4	18.50	45.00	47.50	50.00	52.50	55.50	58.00	30.00	20.50
Recip.	1	7.33	32.33	38.00	48.67	54.67	56.00	57.67	28.33	3.33
	2	9.33	34.00	36.67	42.00	49.67	53.00	54.33	22.67	9.67
	3	5.33	25.33	26.33	28.33	29.67	30.67	31.67	67.00	28.00
	4	19.00	38.50	40.00	41.50	42.50	43.50	45.00	81.00	49.00
Mean		10.47	36.89	40.68	44.93	48.37	50.25	51.66	42.37	18.97
F_2	1	10.36	37.54	47.50	52.64	55.68	58.82	60.61	17.54	2.14
	2	9.58	43.33	50.25	54.25	56.58	58.42	60.25	30.00	12.38
	3	5.82	27.39	31.18	33.86	35.75	37.36	38.71	66.33	22.19
	4	16.82	38.25	41.57	44.86	47.61	49.82	51.18	52.50	29.32
Recip.	1	10.93	43.17	52.24	56.45	58.62	61.34	62.79	19.55	3.41
	2	10.25	42.06	49.13	53.75	56.19	58.25	59.75	26.06	9.44
	3	5.93	25.33	27.78	29.74	31.22	32.81	34.22	68.30	32.07
	4	18.36	39.77	42.73	45.27	47.14	48.64	50.00	47.00	28.05
Mean		11.00	37.10	42.79	46.35	48.59	50.68	52.18	40.91	17.37

Recip.=reciprocal.

Appendix table 8. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers and number of full-size pods and number of mature pods for the cross Tx851856/TxAG-1 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
Tx851856	1	10.00	38.50	51.75	56.25	58.00	60.50	61.25	14.25	0.75
	2	11.50	51.00	60.50	62.00	63.50	64.00	65.00	14.00	1.50
	3	5.75	30.50	37.00	39.75	42.00	43.50	43.75	31.50	20.50
	4	16.00	38.00	41.00	45.00	47.00	48.00	52.00	41.00	30.00
Mean		10.81	39.50	47.56	50.75	52.62	54.00	55.50	25.18	13.18
TxAG-1	1	9.50	46.50	53.25	59.25	61.50	62.50	63.50	24.25	1.50
	2	9.00	42.00	49.50	55.00	57.00	58.50	60.50	38.50	9.50
	3	5.25	25.75	28.00	29.75	31.25	33.25	34.50	109.75	30.25
	4	20.00	45.00	51.00	54.00	56.00	57.00	57.00	31.00	17.00
Mean		10.93	39.81	45.43	49.50	51.43	52.81	53.87	64.34	14.56

Appendix table 8. (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	9.33	34.00	41.67	50.67	52.33	55.33	57.33	22.67	0.67
	2	9.67	38.00	43.00	46.33	51.33	53.33	55.00	45.67	11.67
	3	6.00	28.00	33.00	36.33	37.00	39.00	41.00	27.67	12.67
	4	19.00	42.50	47.50	50.50	52.00	53.50	54.50	25.00	17.50
Recip.	1	7.67	33.00	47.00	52.33	56.67	58.33	59.67	36.33	2.67
	2	10.00	38.33	45.67	51.00	53.00	56.33	58.00	30.33	5.67
	3	5.33	25.00	26.67	28.00	29.67	30.67	33.67	63.33	28.67
	4	20.00	40.00	44.00	49.00	51.00	52.00	54.00	47.00	28.00
Mean		10.87	34.85	41.06	45.52	47.87	49.81	51.64	37.25	13.44
F_2	1	11.76	37.66	46.69	52.48	55.34	57.10	58.48	15.45	1.10
	2	8.10	37.21	45.79	50.45	53.66	55.34	56.79	25.14	4.76
	3	5.41	26.10	28.72	30.48	31.97	33.24	34.34	63.52	26.79
	4	16.52	35.48	38.84	41.52	44.84	47.26	48.94	33.61	18.71
Recip.	1	8.24	31.10	39.24	47.07	53.31	58.00	60.17	27.62	1.52
	2	10.50	40.11	47.06	51.06	53.56	55.67	57.28	25.22	4.67
	3	5.29	27.11	30.96	33.61	36.04	36.81	38.48	50.61	26.21
	4	17.29	38.22	41.52	44.04	46.48	47.89	49.22	42.52	24.67
Mean		10.38	34.12	39.85	43.83	46.90	48.91	50.46	35.46	13.55

Recip.=reciprocal.

Appendix table 9. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers and number of full-size pods and number of mature pods for the cross Tx851856/TxAG-2 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
Tx851856	1	10.75	42.75	59.00	60.50	62.25	63.75	65.25	19.25	1.25
	2	10.50	44.50	51.50	55.50	61.50	63.00	65.50	11.00	3.00
	3	5.50	30.00	35.00	39.50	40.75	42.75	43.25	43.25	24.50
	4	21.50	46.50	48.00	49.50	50.50	52.00	53.50	24.50	14.50
Mean		12.06	40.93	48.37	51.25	53.75	55.37	56.87	24.50	10.81
TxAG-2	1	11.00	43.25	53.25	56.00	57.25	59.00	60.75	14.25	2.25
	2	8.50	54.00	57.00	58.50	59.50	66.00	67.50	15.00	4.00
	3	5.50	26.50	28.25	29.25	30.75	32.00	33.75	73.25	31.75
	4	15.50	37.50	40.50	42.00	44.50	46.00	47.50	41.00	32.00
Mean		10.12	40.31	44.75	46.43	48.00	50.75	52.37	35.87	17.50

Appendix table 9. (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	9.00	32.00	38.33	44.00	54.67	57.67	59.33	30.67	0.33
	2	11.50	41.50	48.50	51.50	53.00	57.00	58.50	27.00	4.50
	3	*	*	*	*	*	*	*	*	*
	4	17.00	37.33	40.00	41.67	42.67	45.33	46.33	59.67	37.33
Recip.	1	8.67	40.67	48.67	51.67	58.67	59.67	61.33	24.00	1.00
	2	8.00	41.50	49.50	53.00	55.00	57.00	59.00	29.00	5.00
	3	6.33	30.33	32.00	33.00	36.33	37.67	38.67	55.00	30.33
	4	19.50	35.50	41.50	47.50	49.50	50.50	52.50	30.50	16.00
Mean		11.35	36.97	42.64	46.04	49.97	52.12	53.66	36.54	13.49
F_2	1	10.50	33.54	41.25	47.68	51.54	53.82	56.00	22.32	0.46
	2	9.88	38.84	46.76	51.68	55.40	57.20	58.72	19.64	3.88
	3	5.38	25.19	27.72	29.94	31.53	33.09	34.44	57.09	28.16
	4	17.16	38.36	41.20	43.56	45.84	47.72	49.60	40.92	24.64
Recip.	1	9.00	36.52	44.31	52.55	57.17	59.00	61.14	20.86	1.41
	2	9.42	37.47	46.37	50.74	53.32	55.05	57.00	27.26	4.53
	3	6.63	28.89	32.04	34.67	36.30	38.15	39.56	52.41	25.19
	4	18.32	38.00	41.58	44.00	45.95	47.63	48.74	33.58	18.84
Mean		10.78	34.60	40.15	44.35	47.13	48.95	50.65	34.26	13.38

*, Indicates missing values.
Recip.=reciprocal.

Appendix table 10. Mean number of days from planting to emergence, to first, fifth, tenth, fifteenth, twentieth, twenty-fifth flowers and number of full-size pods and number of mature pods for the cross TxAG-1/TxAG-2 and its reciprocal.

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
TxAG-1	1	7.25	45.00	53.00	56.50	58.25	60.00	61.00	40.00	4.50
	2	10.00	50.00	55.00	56.00	58.00	59.00	60.00	31.00	6.00
	3	5.00	27.00	29.00	31.00	32.00	34.00	36.00	73.00	39.00
	4	15.00	38.00	42.00	46.00	49.00	51.00	54.00	54.00	26.00
Mean		9.31	40.00	44.75	47.37	49.31	51.00	52.75	49.50	18.87
TxAG-2	1	7.25	34.00	41.50	54.25	60.00	61.75	64.50	26.00	1.00
	2	10.00	36.00	41.00	45.00	48.00	50.00	51.00	31.00	13.00
	3	5.00	26.00	27.00	27.00	29.00	29.00	30.00	73.00	38.00
	4	19.00	43.00	46.00	49.00	50.00	51.00	52.00	50.00	29.00
Mean		10.31	34.75	38.87	43.81	46.75	47.93	49.37	45.00	20.25

Appendix table 10. (Continued).

	REP	DEMR	DONE	DFIVE	DTEN	DFIFT	DTWEN	DTW5	FULL	NUMP
F_1	1	7.33	32.00	35.00	43.33	50.00	52.67	53.67	27.33	1.67
	2	10.00	38.00	44.00	48.00	49.50	50.50	52.00	39.50	16.50
	3	5.33	25.00	26.67	28.00	29.67	31.00	32.00	69.33	34.67
	4	17.00	36.67	38.33	40.00	41.33	41.67	44.00	54.00	39.67
Recip.	1	9.00	36.33	51.67	53.67	55.67	57.33	58.33	24.00	2.00
	2	*	*	*	*	*	*	*	*	*
	3	6.00	30.00	37.50	41.00	43.00	44.50	46.00	18.33	10.00
	4	18.22	36.89	40.89	43.11	44.11	45.89	47.11	46.00	27.89
Mean		10.41	33.55	39.15	42.44	44.75	46.22	47.58	39.78	18.91
F_2	1	7.93	36.14	46.41	[illegible]	53.10	56.00	59.52	21.31	0.90
	2	7.94	38.55	45.71	50.77	53.94	55.84	57.58	27.00	8.29
	3	5.57	26.21	28.75	30.54	32.61	34.46	36.04	67.96	32.68
	4	19.32	40.68	43.79	46.42	49.00	50.84	52.47	46.89	27.95
Recip.	1	7.10	38.40	50.20	53.50	56.20	56.60	58.10	27.00	2.60
	2	*	A	*	*	*	*	*	*	*
	3	5.00	33.00	37.86	41.14	43.43	44.29	46.43	31.57	16.71
	4	*	*	*	*	*	*	*	*	*
Mean		8.81	35.49	42.12	45.91	48.71	50.25	51.93	36.95	14.85

*, Indicates missing values.
Recip.=reciprocal.

VITA

Ousmane Ndoye was born December 4.1957. in Pire, Senegal, to Sophie and Abdou Khadir Ndoye. He graduated from the Lycee El Hadji Malick Sy of Thies in 1977 and entered the University of Dakar where he obtained a Maitrise of Natural Sciences in 1983. In 1984 he obtained a DEA (Diplome d°Etudes Approfondies) in Biology and worked as *an* assistant in the department of Vegetal Biology at the sarne University.

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