OKLAHOMA STATE UNIVERSITY

EFFECT ON SEED YIELD AND MATURITY OF SOYBEAN MATURITY GROUP AND PLANTING DATE

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1981

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of the
requirements for
the Degree of
MASTER OF SCIENCE
July, 1996

EFFECT ON SEED YIELD AND MATURITY OF

SOYBEAN MATURITY GROUP AND

PLANTING DATE

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ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to Dr. L. H. Edwards, major advisor, for his guidance, encouragement, counsel, understanding, and friendship throughout the course of this study. I would also like to thank my other advisory committee members, Dr. A. C. Guenzi and Dr. M. E. Payton, for their help and valuable guidance.

I wish to extend my special appreciation to my parents, brothers, and sister for their help, support, and sacrifices at times of difficulty.

I would also like to express my special thanks to my wife, Emine, for her assistance, patience, and sacrifices during the course of this study.

Finally, I would like to thank the members of the Soybean Breeding Program and all those involved with conducting the Soybean Uniform Test trials from 1958 through 1994 for their assistance and contributions.

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CHAPTER I

INTRODUCTION

More food and feed will be needed in the struggle against starvation and malnutrition as world population increases. We know that the world population and food supplies do not increase at the same rate. The food gap is growing larger and larger. Vegetable crops will probably be the essential resource of food and feed. Thus, we need to increase the qualities and quantities of the agricultural crops used in human and animal nutrition, such as soybeans, Glycine max(L.) Merr. Ilisulu (12) mentioned that soybeans contain 30-50 % protein and 12-24 % fat, plus many vitamins and minerals. Soybeans are an excellent product for human and animal nutrition. Soybean oil provides 30 to 35 % of the world's edible vegetable oil and is used in shortenings, margarines, salad dressings, and cooking oils (25).

Soybeans are the main source of human food in China due to the high protein content and their religious beliefs. In ancient times, soybeans were eaten after roasting them or boiling them in water. Later, various types of human food such as soy sauce, soy paste, soy milk, tofu (a cheese-like product), and bean sprouts were developed. On the other hand, soybean meal has been utilized on a large scale by the poultry industry all around the world. In the United States, approximately 65 % of the domestic soybean meal is used in the production of mixed feed. Soybean oil and protein also have uses in industrial applications in many ways, such as fuel, soap, paints, adhesives, and paper coating and sizing. Therefore, the soybean planting areas and production have greatly expanded especially since World War II to supply food and feed for an increasing world population and to parallel industrial development (25).

The United States produces about 2/3 of the world's soybean crop. In the USA, the Midwest region accounts for about 35 % of the domestic production (26). However, soybean production and acreage in the Southern region have a potential to increase in the future because of doublecropped soybeans. Although the state of Oklahoma has a small share, less than 1 % of the USA soybean production and acreage, the total production could be increased by applying proper production techniques such as cultivar selection, tillage, soil fertility, planting practices, and cropping systems (25).

Genotype, environment and genotype x environment interactions determine the seed yielding capacity. Following the suitable cultivar selection for a certain region, environmental factors should be managed since soybean seed yields are affected by soil and air temperature, soil water, daylength, and their interactions. These factors are closely related to the planting date (21). Increased seed yields may be obtained by adjusting the planting date for a certain region and cultivar in order to minimize temperature and water stress and daylength effects.

The objectives of this study were to determine the effects on soybean seed yield and maturity of planting dates and maturity groups at Bixby, Oklahoma, and to recommend to Oklahoman soybean growers the optimum planting dates for each maturity group.

CHAPTER II

LITERATURE REVIEW

Soybeans are assigned to 13 maturity groups ranging from the earliest maturing Group 000 to the latest maturing Group X, according to their responses to temperature and daylength. Moreover, soybeans are also divided into two growth habit categories, determinate and indeterminate, based on growth habit and flowering period. Determinates with more branches and shorter plant height complete flowering in a short period, while indeterminates with fewer branches and taller plant height can extend flowering until maturity. In the northern United States, the earlier maturing and indeterminate cultivars are adapted, but the later maturing and determinate cultivars prevail in the Southern region (14).

Crop productivity depends on genotype, environment, and genotype x environment interactions. Crop production increases per unit area can be achieved by the applications of genetic improvements and cultural practices for plant crops. However, genetic potential available for all the crops has not been completely used. For example, the record yield is 7,390 kg/ha for soybeans, but the average yield is only 2,000 kg/ha. The average yield of soybeans is only about 27 % of the record yield. The potential yield may be attained by preventing soybeans from suffering disease, insect and weed damages and adverse environmental conditions (6).

Boyer (6) stated that crop reductions resulted from unfavorable climate and soil conditions such as water availability, cold, and soil salinity; two of the main factors limiting seed yields were water and temperature stresses.

Major et al. (17) conducted various experiments to determine the influences of daylength and temperature on soybean development by planting soybean cultivars from Group I through Group V at different times, ranging from mid-April to mid-August, in Missouri (USA), Iowa (USA), and Ontario (Canada) in 1971-73. They stated that cooler spring temperatures had a larger effect on delaying flowering than the increasing daylengths, while daylengths had a more determining effect on flowering in the plantings after June 1. Short daylengths stimulated the flowering to physiological maturity period (F-PM) to shorten. In addition, they found that there were no significant differences between maturity groups with respect to sensitivity of F-PM to temperatures and daylengths, but the later maturing groups showed more sensitive reaction to daylengths than the early maturing groups for the planting to flowering period.

Schaik and Probst (24) reported that the increasing temperature and photoperiod generally affected in a positive way the soybean plant growth. The planting to first flower period was shortened by increasing temperature and decreasing photoperiod. Both longer daylengths and higher temperatures increased flower and pod number per node and node number per plant. As temperature and daylength increased, more flowers and pods were shed, but the soybean plants produced many more flowers and pods than were shed. As a result, 32 C of day temperature and 21 C of night temperature and 16-hour daylength provided the better conditions for soybean seed yields.

Gibson and Mullen (9) studied soybean seed yields responding to the day/night temperatures of 30/20, 30/30, 35/20, and 35/30 C under controlled conditions at different reproductive stages, including flowering to podset (R1-R5), seed fill to maturation (R5-R8), and complete reproductive stage (R1-R8). They stated that day temperatures of 35 C compared with 30 C caused the seed yields to decrease at the three different reproductive stages due to reduced photosynthetic rates. Seed yields decreased 27 %, 18 %, and 17 % for R1-R8, R1-R5, and R5-R8 periods, respectively. However, 20 C and 30 C night temperatures showed no significant differences in seed yield. They concluded that the day/night temperatures of 30/20 and 30/30 produced higher seed yields.

Jiang and Egli (13) reported that soybean seed yields were very much affected by the number of seeds per square meter, and seeds per unit area were associated with photosynthesis throughout flowering and podset. The maximum light interception and optimization of the environmental conditions such as temperature, water, and CO2 during the flowering and podset (R1-R5) had a greater effect on seed yield than the other vegetative and reproductive stage conditions.

Early planting dates of soybeans are delayed by late spring frosts, soil temperatures, and daylength while late planting dates are determined by early autumn frosts and late summer droughts (21). Soybeans can be grown as either full season monocropping, or doublecropping after small grains, in the Southern United States (4).

Boerma and Ashley (4), in Georgia, investigated irrigation, row spacing, and genotype effects on seed yields when soybeans were planted late and ultra-late over three years. The determinate soybean cultivar Bragg and the indeterminate cultivar Ga76-32 from maturity Group VII were used for planting. They found that the planting and irrigation conditions in late June or early July resulted in higher seed yields than late July or early August planting and irrigation conditions. As the July plantings were delayed, seed yield decreased 1.2 % per day. They stressed that soybeans should be planted in early July at the latest when doublecropping or planting late.

Hartwig (10) reported that the most satisfactory soybean yields were usually obtained from early May plantings for Group IV, V, VI, and VII cultivars. Later maturing soybean cultivars (Groups VI and VII) produced higher seed yields than early soybean cultivars (Groups IV and V) over the planting dates ranging from 4 April to 20 June in Mississippi conditions. He also stated that soybean yields were related to the length of the reproductive period and maximum soybean seed yields could be obtained with reproductive periods of 90 to 100 days. As the time from flowering to maturity was extended, seed yields increased. Finally, he stated that significant yield reductions after a 20 June planting date occurred due to the short reproductive period. However, Leffel (16) indicated that the highest seed yield was produced when Group IV soybean cultivars were planted on 20 May in Maryland. He compared planting dates from May 1 to July 28 and Group IV, V, and VI cultivars.

Boquet et al. (5) investigated the effects on seed yields of the determinate soybean cultivars planted in various row spacings from 15 April to 1 July in Northeast Louisiana during 1976-1979. They observed that although there existed significant planting date x cultivar interactions, all cultivars including of 'Forrest' (Group V), 'Lee 74', 'Davis', and

'Centennial' (Group VI), and 'Bragg' (Group VII) showed the best performance for 15 May planting and narrow rows. However, the later maturing cultivars (except Lee 74) also produced higher seed yields at the 1 May and 1 June plantings than the earlier maturing cultivar Forrest.

Parker et al. (19) reported that 'Essex', Davis, Bragg, and 'Hutton' soybean cultivars, from maturity Group V to VIII, respectively, produced the highest seed yields at May plantings during the period ranging from 7 April to 8 July. Davis, Bragg, and Hutton also yielded the highest at late April and early June plantings. However, seed quality and plant height were reduced from late April plantings for all cultivars. The earlier cultivar, Essex, was still not tall enough at all planting dates for efficient combining. Thus, they implied that Davis, Bragg, and Hutton should be sowed between early May and early June and Essex should not be used in Georgia. They also mentioned that a planting delay of 90 days produced maturity delays of 54, 29, 17, and 14 days for Essex, Davis, Bragg, and Hutton , respectively. Later maturing cultivars, especially Davis, had a better seed yield performance at the 90-day planting delay than Essex.

Weaver et al. (29) evaluated effects on seed yield, plant height, and other traits of determinate and indeterminate soybean cultivars planted late in Alabama in 1986-89. The cultivars used were determinates 'Braxton' (Group VII), 'Kirby' (Group VIII) and indeterminates 'G82-8468' and 'G84-9006' from Group VIII. They noted that early July plantings caused both determinates and indeterminates to yield less than mid-June plantings. Indeterminates produced 18 % lower and determinates produced 23 % lower seed yields at early July plantings compared with mid-June plantings. Determinates produced slightly higher seed yields than indeterminates for both the planting dates, but indeterminates became taller than determinates for both planting dates. Finally, they suggested planting determinate cultivars in mid-June when doublecropping. However, when planting is delayed until early July, indeterminate cultivars would be better to prohibit the harvesting losses from inefficient combining due to shorter plants in July plantings.

Stalcup (27) reported that seed yields and qualities for conventional determinate cultivars when planted in mid-April were reduced because of earlier flowering and lack of vegetative growth. To prevent these negative effects, growers could take advantage of new long juvenile cultivars which flower 10 to 15 days later than standard cultivars in short daylengths. At the same time, long juveniles could provide farmers with planting flexibilities since they can be sowed from mid-April to late June without adverse effects on yield.

Caviness and Thomas (8) conducted a trial to investigate the effects of planting dates from April 15 to July 15 (15-day intervals) on 3 soybean cultivars, Forrest (Group V), Davis (Group VI), and Bragg (Group VII), in Arkansas. They found that early Forrest (early cultivar) produced higher yields than late Davis and Bragg (late cultivars), especially between May 15 and June 15 planting dates. However, seed yields were very similar in the plantings after June 15. They stated also that plantings earlier than May 15 or later than July 1 caused yield reductions in each cultivar.

May et al. (18) evaluated soybean response to early plantings of maturity groups ranging from III to VII in the northeast Arkansas. The plantings were in mid-April and mid-May for 2 years. They observed that the early maturity group (III and IV) cultivars when planted in mid-April matured earlier than when planted in mid-May. However, the late maturity group (V, VI, and VII) cultivars matured almost at the same time over planting dates. They also observed that seed yields for the tested maturity group cultivars were not significantly affected by different planting dates.

Board (1) studied yield components causing soybean yield reductions. Soybean cultivars from maturity Group V to VII in the southern USA were planted in early April, mid-May, and mid-June for 2 years. He reported that maximum soybean seed yields were obtained from mid-May plantings across the maturity groups. The main reason for seed yield reductions in early April and mid-June plantings was explained by decreases in the number of branches.

Board and Hall (3) investigated soybean seed yields affected by temperatures and photoperiods at planting dates between early April and mid-June. They indicated that short daylengths and warmer temperatures in early April plantings accelerated transition into flowering and consequently seed yield decreases occurred due to an incomplete vegetative period. Maturity Group VI and VII cultivars passed relatively faster through the reproductive stage compared to Group V cultivars.

Board and Settimi (2) tested preflowering and postflowering photoperiod effects on seed yield reductions in the determinate soybean cultivars from the maturity Groups V, VI, and VII. They explained that a short photoperiod both before and after flowering had a negative effect on soybean yields in the late June plantings since the branch development period, which lasts from the first flowering (R1) to the beginning of the seed development

(R5), was shortened. Short R1-R5 periods decreased yield components such as total branch length, branch number, and branch node number. Consequently, soybean seed yields were reduced. However, the main stem node number was not affected by planting dates.

Taylor and Ferguson (28) noted that some soybean growers in the Midsouth obtained higher yields from indeterminate soybean cultivars (Group III and IV) compared to the adapted determinate cultivars. The growers did their plantings in the early spring to avoid the late summer droughts.

Savoy et al. (23) tested the influence of irrigation and inter-row spacing on seed yield of the indeterminate soybean cultivar, 'Williams-82', from maturity Group III planted in mid-April in south-central Texas. They concluded that irrigation did not have any effect on seed yield of this cultivar in the early season plantings.

Kane and Grabau (15) reported that maturity Group II soybean cultivars when planted before mid-May produced the highest seed yields among the early maturing groups, but yields were affected by weather conditions such as rainfall and temperature. While rainfalls promoted vegetative and generative development, warmer temperatures had a negative effect on seed fill.

Pfeiffer (20) established an experiment with 28 genotypes from 3 maturity Groups (III, IV, and V) to determine whether there was a need for a separate breeding program for seed yield in doublecropping systems. He reported a lack of maturity group x cropping system and genotype within maturity group x cropping system interactions. He concluded that soybean breeders will not need a separate breeding program for doublecropping systems, and superior genotypes in the full-season system will also be superior in the doublecropping system.

Carter and Boerma (7) , on the other hand, showed that genotype x planting date interactions occurred, and the ranks of the soybean genotypes in the early and late June planting dates were changed. As a result, they implied that each genotype should be planted within its own favorable planting dates.

CHAPTER III

MATERIALS AND METHODS

In this study, the effects on seed yield and maturity of soybean maturity groups (Group IV, V, and VI) and planting dates between 10 May and 1 July were investigated. This study was conducted from 1958 through 1994 on a Wynona silty clay loam soil (fine-silty, mixed, thermic Cumulic Haplaquoll) at the Oklahoma Vegetable Research Station, Bixby, Oklahoma in the Uniform Soybean Tests for Southern States.

Different genotypes from soybean maturity Groups IV, V, and VI were used each year. Number of entries were 12 for each maturity group in 1958 through 1992; 16 for each maturity group in 1993 and 11, 20, and 18 for maturity Groups IV, V, and VI in 1994, respectively. Although maturity Group IV included both determinate and indeterminate genotypes, maturity Group V and VI consisted of only determinates.

Data were collected on each entry for seed yield, maturity index, and planting date. Plots were harvested with a plot cutter at full maturity after the R8 stage. Plants were threshed with a stationary plot threshing machine. One of the two center rows was evaluated for plot seed yield. The moisture of seeds was adjusted to 10-13 % moisture by drying in controlled conditions immediately after threshing. Seed yield per plot was obtained by weighing these seeds. There were three replications of each entry. Plot yield of each entry was calculated from the average of three replications and then plot seed yield of each maturity group was calculated from the average of the entries within a particular maturity group. The averaged plot seed yield was converted to seed yield as kg/ha. This procedure was repeated during a 37-year period from 1958 to 1994.

Maturity index for maturity Groups IV, V, and VI was recorded as days earlier or later than a different standard check variety for each maturity group at the Delta Branch Experiment Station, Stoneville, Mississippi. It was converted to days after 31 August. The period from planting to maturity was found by calculating the days between planting date at Bixby, Oklahoma, and maturity date at Stoneville.

All maturity groups were planted on the same date on a particular year, but planting dates changed from year to year. Planting dates ranged between 10 May to 1 July across the years. Plots consisted of four 6.1-m long rows and row spacing was 76 cm. The seeding rate was 26 seeds per meter of row. Experiments were conducted under rainfed conditions. Weeds were controlled with herbicides and/or mechanical cultivation. Treflan and Septor were used to control grasses and broadleaves, respectively. Rhizobium japonicum was applied for inoculation with the planter during planting.

A randomized complete block design (RCBD) with three replications was used for the experiments each year. However, mean yield data (average of three replications)were analyzed as a completely randomized design (CRD) for this study because individual replication data were not available.

The experiment was analyzed as a nested factorial experiment. Data were analyzed using the Statistical Analysis System (SAS), (22). Planting time periods between 9 May and 2 July were assigned to eleven groups of planting dates by dividing at 5-day intervals. Since 24-28 May and 23-27 June planting date intervals had no planting, these were not evaluated. Maturity groups and planting dates were considered as fixed effects and years as random effects. Years were nested in the grouped planting dates. The GLM procedure of the SAS was used due to unequal observations within the grouped planting dates. The significance of maturity groups and maturity group x planting date interactions were tested by using the maturity group x year nested in planting date as the error term and the significance of planting dates by using the year nested in planting date as the error term (11).

CHAPTER IV

RESULTS AND DISCUSSION

Seed Yield

The analysis of variance is shown in Table I. The main effect of soybean maturity Groups IV, V, and VI was significantly different at the 1 percent level of probability. Although planting dates resulted in reasonable differences on soybean seed yields, these differences were not significant at the 5 percent level of probability because of the large error term used to test. There was a significant interaction between maturity group and planting date for yield at the 5 percent level of probability.

Yields from maturity Groups V and VI, 2581 and 2528 kg/ha, respectively, were not significantly different, however they produced higher seed yields than the average of maturity Group IV, 2315 kg/ha (Table II). The average yields of the maturity Groups V and VI were 11 and 9 %, respectively, higher than that of the maturity Group IV (Table III).

The significant maturity group x planting date interaction may have resulted from ranking changes of the maturity groups across planting dates. For example Group VI (2875 kg/ha)yielded higher then Group V (2321 kg/ha) at the 3 to 7 June planting period, whereas Group V (2976 kg/ha) yielded higher then Group VI (2648 kg/ha) at the 18 to 22 June planting period. Carter and Boerma (7) also found the similar results.

Maturity Group IV produced lower seed yields than maturity Groups V and VI for several planting dates, especially during 19-23 May planting date where the Group IV had 48 % lower seed production than maturity Group V (Table III, Figure 1). Group IV yielded 57 % less than Group VI at the 3-7 June planting date. Group IV yields were similar to maturity Group V for the plantings from early May to mid-May. Group IV yields were similar to maturity Group VI yields for the 8-12 June, 13-17 June, 18-22 June, and 28-2 July plantings. The highest seed yield (2739 kg/ha) within Group IV genotypes was produced from the 18 to 22 June planting (Table II). However, no significant difference was found between the 9 to 13 May, 14 to 18 May, 8 to 12 June, 13 to 17 June, and 18 to 22 June plantings within maturity Group IV at the 10 percent level of probability. The best time to plant Group IV soybeans at Bixby for maximum yields appears to be mid-May (9-18 May) and mid-June (8 June- 22 June). The low yields produced from the late-May and early-June (19 May-7 June) plantings may be caused by low August rainfall resulting in excessive flower abortion.

The highest seed yields for maturity Group V were obtained from the mid-May planting (14-18 May) and mid-June plantings (13 June-22 June), (Table II, Figure 1). Although Group V produced the highest seed yields during the 18 to 22 June planting period, this yield was not significantly different from 14 to 18 May and 13 to 17 June plantings within maturity Group V at the 10 percent level of probability. The best time to plant Group V soybeans appears to be mid-May (14-18 May) and mid-June

(13 June-22 June). Maturity Group V produced about 10 % more seed than maturity Group IV and VI for late June and early July plantings (Table III). However, maturity Group V had low seed yields similar to maturity Group IV for the plantings between 19 May and 13 June.

As presented in Table II and Figure 1, maturity Group VI showed the best performance for the 14-18 May planting, but no statistical difference was detected between 14 to 18 May, 3 to 7 June, 13 to 17 June and 18 to 22 June plantings within maturity Group VI at the 10 percent level of probability. Unlike maturity Groups IV and V, higher seed yields were obtained from maturity Group VI at the early June planting. For maximum yields, Group VI soybeans may be planted in mid-May, early June, or possible in mid-June.

Overall, the highest yielding significance group included: Group IV planted 18-22 June; Group V planted 14-18 May, 13-17 June, and 18-22 June; and Group VI planted 14-18 May, 3-7 June, and 13-17 June. Almost all maturity groups showed better performance for the plantings in the first half of May and after mid-June, while seed yields decreased at the plantings in the second half of May and in early June. One exception was the 3 to 7 June planting with maturity Group VI. Soybean seed yields were more uniform from maturity Group VI genotypes compared to the other maturity groups across planting dates (Figure 2). Also, Group V genotypes produced more uniform seed yields than Group IV genotypes. The later maturity Group VI followed by Group V appear to be less affected by adverse environmental conditions compared to Group IV genotypes.

Maturity

The analysis of variance is presented in Table I. Days from planting to maturity was affected by both maturity group and planting date, while maturity date (days after 31 August) was influenced by maturity group at the 1 percent level of probability. There was no significant maturity group x planting date interaction for either the time from planting to maturity or the maturity date.

The number of days from planting to maturity decreased gradually from early May plantings to early July plantings for all maturity groups (Figure 3 and 4). The planting to maturity period was 117 days for Group IV, 124 days for Group V and 131 days for Group VI (Table IV). The average days to maturity increased by seven days for each change in maturity group from Group IV to V and V to VI. Group IV always matured first followed by Group V then Group VI regardless of planting date. Within each maturity group a five day delay in planting resulted in an average six-day difference in days to maturity. Therefore, maturity date was not affected by planting date (Table V, Figure 5). The average maturity date for Group IV genotypes was 30 September (30 days after August 31). The average maturity dates for Group V and Group VI genotypes were 7 October and 15 October, respectively. There was almost no variability for maturity date within each maturity group (Figure 6). Early planting appears to add days to the vegetative stages of the soybean plant but does not add days to the critical reproductive stages of the plant. Consequently no significant correlations were detected between seed yield and maturity date or between seed yield and days to maturity.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was conducted at the Oklahoma Vegetable Research Station, Bixby, Oklahoma in the Uniform Soybean Tests for Southern States from 1958 through 1994. The objectives of this study were to evaluate the effects on soybean seed yield and maturity of planting dates and maturity groups, and to determine the optimum planting dates for each maturity group. This study included maturity groups IV, V, and VI and nine planting dates grouped at 5-day intervals between 9 May and 2 July. The characteristics measured were seed yield, maturity date, and days from planting to maturity.

Soybean maturity groups were found to be associated with significantly different yields at the 1 percent level of probability. Maturity Groups V and VI produced higher average seed yields compared to maturity Group IV across planting dates, but maturity Groups V and VI were not significantly different from one another. Although significant differences between planting dates were expected, they were not observed due to the large error term used to test at the 5 percent level of probability. A significant interaction was found between maturity group and planting date at the 5 percent level of probability. This significant maturity group x planting date interaction made the evaluation of the maturity groups within the planting dates and the planting dates within the maturity groups more important than the main effects of maturity group and planting date because the rank among maturity groups and planting dates changed across planting dates and maturity groups, respectively.

In general, maturity group IV showed lower seed yield performance than maturity Groups V and VI over planting dates. The lowest seed yields were obtained from plantings between 19 May and 8 June for maturity Group IV. However, seed yields of maturity Group IV for mid-May and mid-June plantings were comparable to those of the maturity Group V.

Maturity Groups V and VI at the highest seed yields performed differently over planting dates. Maturity Group VI produced a high seed yield at the 3-7 June planting, while maturity Group V did not. They both produced high seed yields at the 14-18 May, but maturity Group V was better for late-June plantings. Also, both maturity groups exhibited lower yields similar to maturity Group IV at the late May plantings.

Maturity groups affected significantly the days from planting to maturity and maturity date, and planting date had an effect on the days from planting to maturity. Significant maturity group x planting date interactions were not detected for either maturity characteristics.

In conclusion, soybean growers may have a relatively long period between mid-May and late-June for soybean plantings to produce optimum yields. All maturity groups may be planted in mid-May or mid- to late-June. Group V or VI genotypes yielded better than Group IV genotypes at most planting dates. Group VI genotypes appear to produce better yields than Group IV or V when planting in late-May or early-June. However, the lowest yields for all groups corresponded to these planting dates.

In order to achieve a particular maturity date, selection of the maturity group is more important than planting date. Group IV genotypes matured about 30 September, Group V - 7 October, and Group VI - 15 October regardless of planting date. Early planted soybeans did take more days from planting to maturity compared to later planted soybeans. However, the early plantings appear to just increased the vegetative period and not the reproductive period. Thus, no yield advantages were observed for early plantings compared to late planting.

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APPENDIX

TABLE I

MEAN SQUARES AND P-VALUES FOR SEED YIELD, DAYS FROM PLANTING TO MATURITY, AND DAYS AFTER 31 AUGUST

Source	d.f.	Seed Yield	Pr > F	Days to Maturity	Pr > F	Days After 31 August	Pr > F
Maturity Group (MG)	2	668131	0.0009	1696	0.0001	1746	0.0001
Planting Date (PD)	8	1220899	0.4883	4004	0.0001	5	0.9888
MG*PD	16	180413	0.0192	7	0.7247	8	0.5596
Year (PD)	28	1276281		40		26	
MG*Year (PD)	56	84571		10		9	

TABLE II

MEAN SEED YIELDS OF EACH MATURITY GROUP AND FOR EACH PLANTING DATE*

	Maturity Groups			
Planting Date	IV	V	VI	Mean (kg/ha)
9-13 May	2447 ab	2453 cde	2444 bcd	2448
14-18 May	2639 ab	2815 abc	2958 a	2804
19-23 May	1558 c	2306 ef	2172 d	2012
29-2 June	1733 c	1926 f	2309 cd	1989
3-7 June	1830 c	2321 def	2875 ab	2342
8-12 June	2417 ab	2183 ef	2322 cd	2308
13-17 June	2618 ab	2817 ab	2721 ab	2719
18-22 June	2739 a	2976 a	2648 abc	2788
28-2 July	2380 b	2647 bcd	2361 cd	2463
Mean (kg/ha)	2315	2581	2528	

* Data in the same column followed by the same letter and data in the same row underscored by the same line are not significantly different at the 10 % level of probability according to T tests (LSD).

TABLE III

RELATIVE SEED YIELDS OF GENOTYPES IN EACH MATURITY GROUP AND FOR EACH PLANTING DATE AS PERCENTAGE OF GROUP IV YIELDS

Planting Date	Maturity Groups		
	IV	V	VI
9-13 May	100	100	100
14-18 May	100	107	112
19-23 May	100	148	139
29-2 June	100	111	133
3-7 June	100	127	157
8-12 June	100	90	96
13-17 June	100	108	104
18-22 June	100	109	97
28-2 July	100	111	99
% Mean	100 b	111 a	109 a

* Means followed by the same letter are not significantly different at the 5 % level of probability according to LSD.

TABLE IV

MEAN DAYS FROM PLANTING TO MATURITY OF EACH MATURITY GROUP AND FOR EACH PLANTING DATE*

Planting Date	Maturity Groups IV	V	VI	Mean (Days to Maturity)
9-13 May	148	156	161	155 a
14-18 May	134	145	153	144 b
19-23 May	132	140	146	139 b
29-2 June	125	129	135	129 c
3-7 June	118	123	133	125 cd
8-12 June	114	119	128	120 de
13-17 June	107	115	123	115 e
18-22 June	102	107	116	108 f
28-2 July	94	99	108	101 g
Mean (Days to Maturity)	117 c	124 b	131 a	

* Means followed by the same letter are not significantly different at the 5 % level of probability according to Duncan's Multiple Range Test.

TABLE V

MEAN MATURITY DATE OF EACH MATURITY GROUP AND FOR EACH PLANTING DATE*

Planting Date	Maturity Groups IV	V	VI	Mean (Days After 31 August)
9-13 May	30	38	43	37 a
14-18 May	27	38	46	37 a
19-23 May	29	37	44	37 a
29-2 June	33	37	43	37 a
3-7 June	31	36	45	37 a
8-12 June	31	36	45	37 a
13-17 June	30	39	46	39 a
18-22 June	31	36	46	38 a
28-2 July	31	36	45	38 a
Mean (Days After 31 August)	30 c	37 b	45 a	

* Means followed by the same letter are not significantly different at the 5 % level of probability according to Duncan's Multiple Range Test.

TABLE VI

MONTHLY PRECIPITATION (CM) AT BIXBY, OKLAHOMA FROM 1958 THROUGH1994

YEAR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1958	8	20.4	12.4	6.1	13.5	0.7	4.4
1959	16.3	11.2	24.2	6.6	17.2	17.4	9.8
1960	17.9	5.5	23.8	6	3.3	4.3	2.8
1961	18.8	18.3	2	4.2	16.7	7.5	8.1
1962	4	24.4	15.9	8	31.8	6.9	5.1
1963	13.2	3.1	17.3	2.8	4.3	0.1	5.7
1964	12.8	12.2	4.9	13.6	9.3	2.8	13.4
1965	7.7	7.3	6.9	11.3	6.4	0.5	0.1
1966	2.9	10	7.7	7.3	7	3.8	3.2
1967	12	13.1	11.2	8	13	11	2.2
1968	10.9	16.6	1.6	9.6	10.2	5.6	15.9
1969	7.6	9.7	2.9	4.6	2.1	17.1	2
1970	9.2	10.6	1.5	4.1	17.3	17.2	3.4
1971	10.2	7.6	12.1	4.6	35.6	15.6	2.9
1972	8.3	7.7	5.3	11.5	3.9	13.6	16.4
1973	8.2	16.7	5.2	9	20.1	10.7	15.8
1974	14.4	18.6	0.6	5.4	19	13	16.6
1975	20.5	12	3.7	11.9	8.6	3.7	8.2
1976	5.1	3.4	10.1	7	7.8	6	1.7
1977	11.5	7.1	10.7	7.3	19.4	7.2	5.5
1978	17.1	11.2	0.3	5.2	2.1	2.4	16.3
1979	11.3	14.6	8.6	8.8	2.5	6.3	12.1
1980	11.7	22.5	0.9	4	15.7	7.6	2.9
1981	13	12.1	10.4	8.3	4.8	15.7	10.5
1982	20.6	13.3	6.3	5.1	2.1	0.8	14.2
1983	18.3	6.6	0	0	4.6	24.9	7
1984	19.1	8.9	0	5.3	5	16.8	6.4
1985	9.9	18.3	4.7	5	10.7	24.1	10.9
1986	20.2	6.5	2.2	9.3	28.5	18.6	8.6
1987	24.9	9.7	14.1	9.9	8.8	4.3	8.5
1988	2.8	2.8	13.2	2	16.1	2.8	13.2
1989	11.9	20.1	5	12.4	11.9	6.8	0.1
1990	14.3	4.9	2.3	4.6	13.2	5.3	5.8
1991	14.7	10.9	8.9	4.9	17	16.3	8.5
1992	14.4	16.3	6.2	6.8	9.3	2.2	15.5
1993	19.2	3.4	1.1	5.8	21.8	6.1	5.2
1994	8.9	6.2	21.7	12.7	8.4	9.1	17.4

TABLE VII

AVERAGE TEMPERATURES (C) AT BIXBY, OKLAHOMA
FROM 1958 THROUGH 1994

YEAR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1958	21.2	25.6	27.4	26.8	24.1	16.1	11.4
1959	22.2	24.9	25.8	27	23.1	14.7	7.4
1960	19.7	25.6	26.9	26.8	24.2	19	10.6
1961	19.3	23.4	25.8	25.1	21.7	17.6	9.5
1962	23.9	24.1	27.3	27	21.7	18.8	10.3
1963	21.2	26.8	28.1	27.8	23.7	21.1	10.5
1964	21	25.2	28.6	26.8	22.4	15.3	11.4
1965	21.6	24.7	28.1	26.8	23	16.2	12.8
1966	19.6	24.6	29.2	25.1	21.4	15.8	11.3
1967	18.7	24.4	24.4	24.1	20.2	16.1	8.7
1968	18.3	24.5	26.4	26.7	20.8	15.8	8.4
1969	20.4	23.5	29.3	26.3	22.8	15.6	8.3
1970	21	23.8	26.6	28.1	23.5	14.6	7.6
1971	18.7	25.9	26	24.8	22.3	18.3	10.1
1972	19.8	25	25.5	26.8	24.6	15.5	6.2
1973	18.5	23.1	26	25.3	21.9	17.8	11
1974	21.3	22.3	28.3	24.3	17.5	16.5	9.2
1975	20.7	23.9	26.9	26.2	19.7	16.8	10.6
1976	16.9	22.9	25.6	24.9	20.6	12.7	4.7
1977	22.2	26.3	28	25.9	23	15.2	10.1
1978	18.7	24.1	28.6	26.6	23.9	14.1	8.7
1979	19.3	24	27	26.2	22.2	16.8	6.7
1980	20.4	26.3	31.1	30.3	24.9	15.9	9.7
1981	18.3	25.7	28.7	25.6	22.9	16.1	10.5
1982	19.8	22.9	28.1	27.8	21.8	16.4	9.3
1983	18.2	23.8	27.9	29.5	23.4	16.6	10
1984	19	25.7	26.8	26.9	21.5	15.8	9.3
1985	20.7	23.8	27.2	26.7	23.1	16.3	8.8
1986	20	25.8	29.1	25.6	23.5	15.9	6.3
1987	22.5	25.1	26	27.2	21.6	13.4	10.3
1988	20.4	25.2	27.3	27.7	22.4	13.9	9.4
1989	19.4	22.9	26	25.7	19.4	16.6	10.1
1990	18.1	26.6	26.9	26.8	24.1	14.3	12.4
1991	21.7	25.6	27.5	25.8	21.1	16.6	6.7
1992	18.6	22.9	26.5	23.3	21.5	15.3	8.2
1993	18.5	24.6	29	28.2	20.1	13.8	5.8
1994	18.8	26.4	25.9	24.9	20.9	17.3	10.3

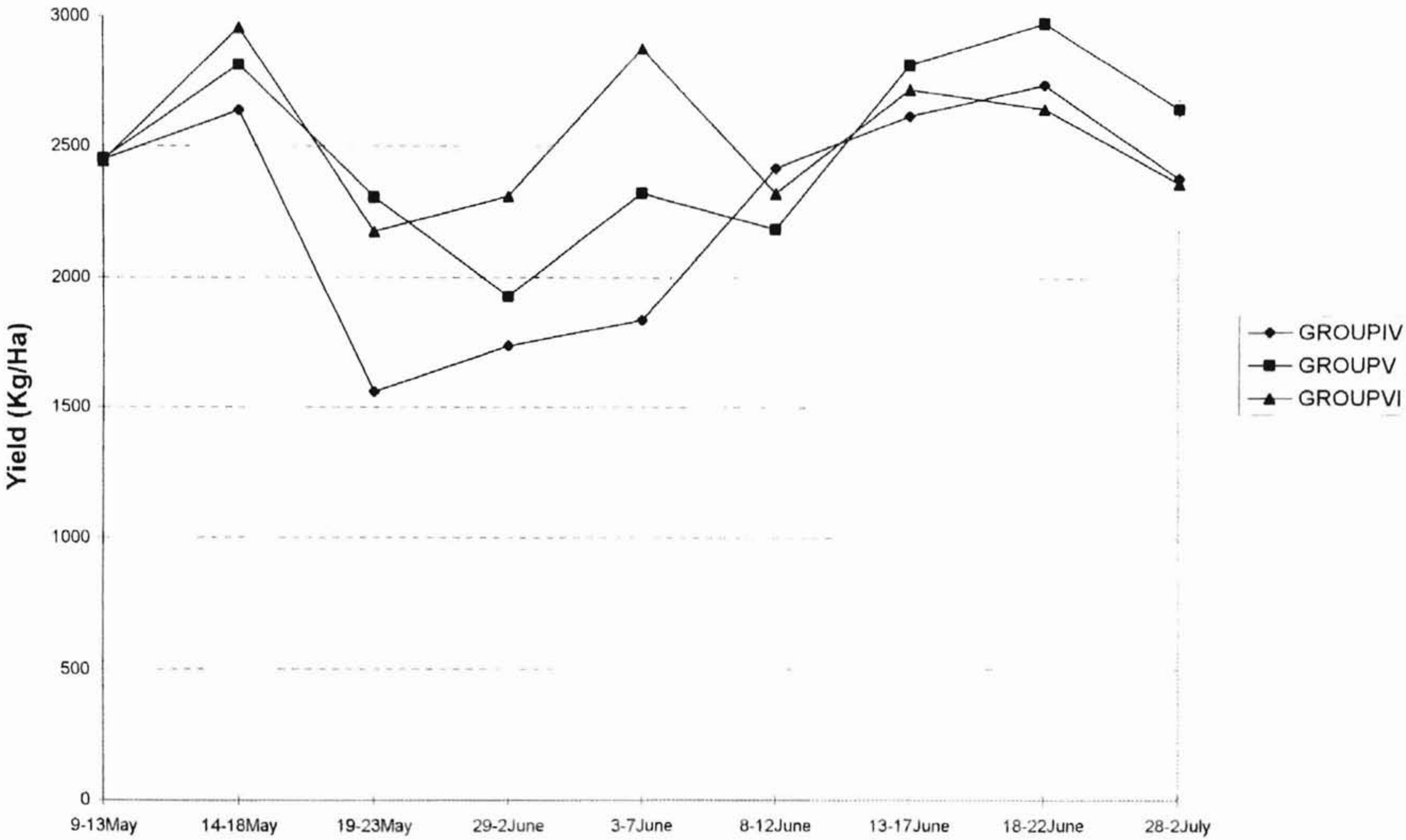

Figure 1. Effects on Seed Yield of Maturity Groups IV, V, and VI at Different Planting Dates

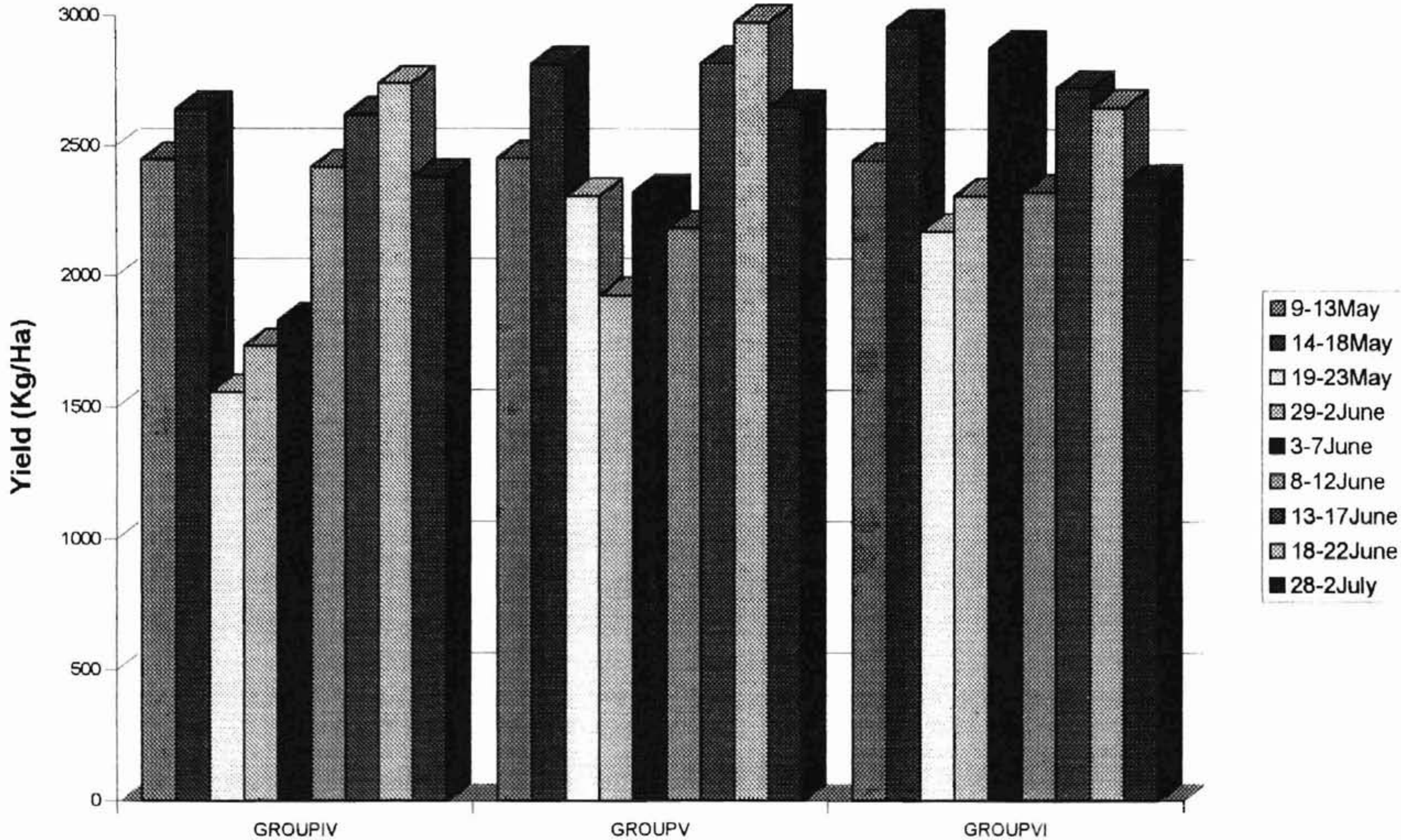

Figure 2. Effects on Seed Yield of Maturity Groups IV, V, and VI at Different Planting Dates

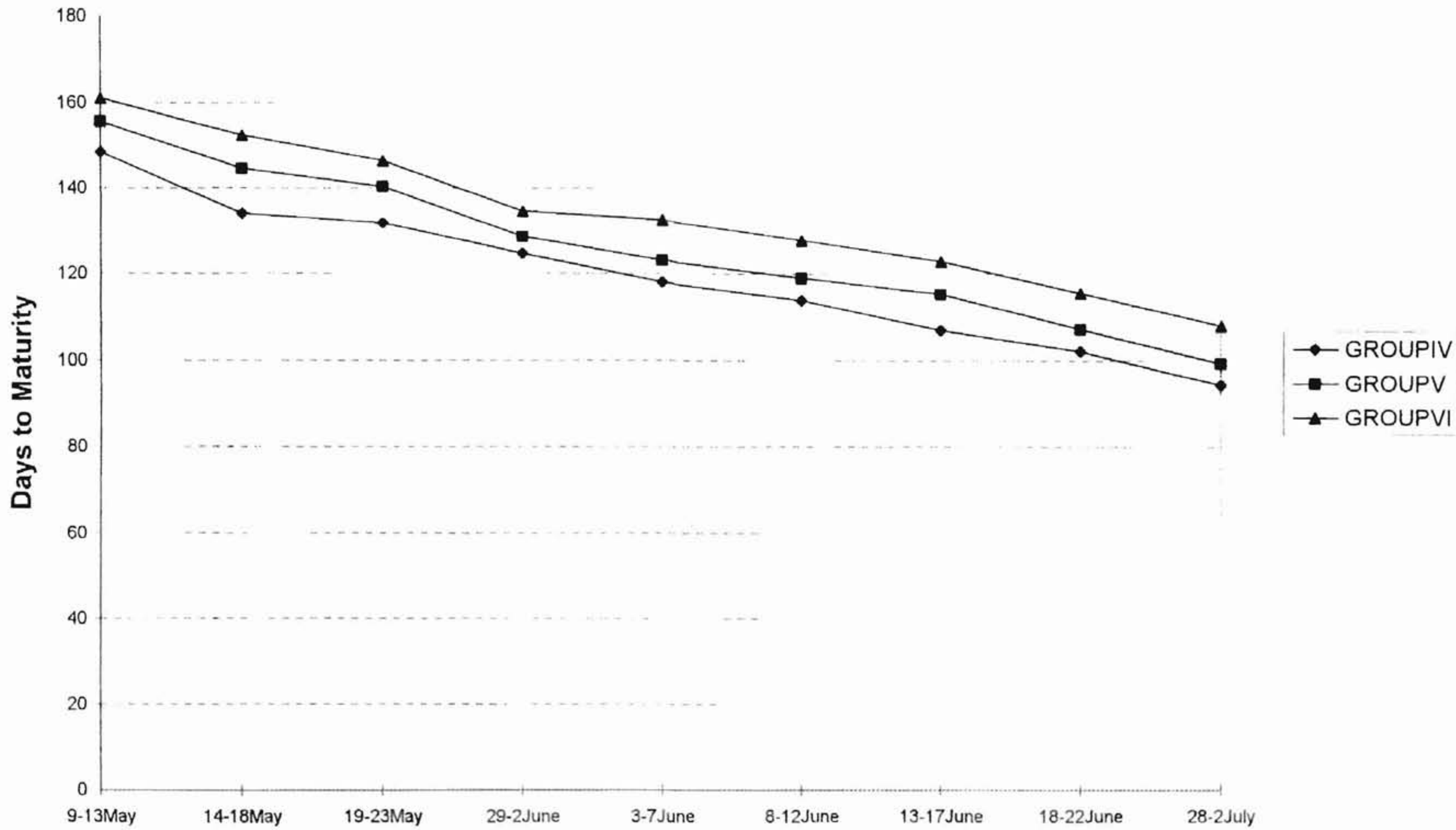

Figure 3. Effects on Days From Planting to Maturity of Maturity Groups IV, V, and VI at Different Planting Dates

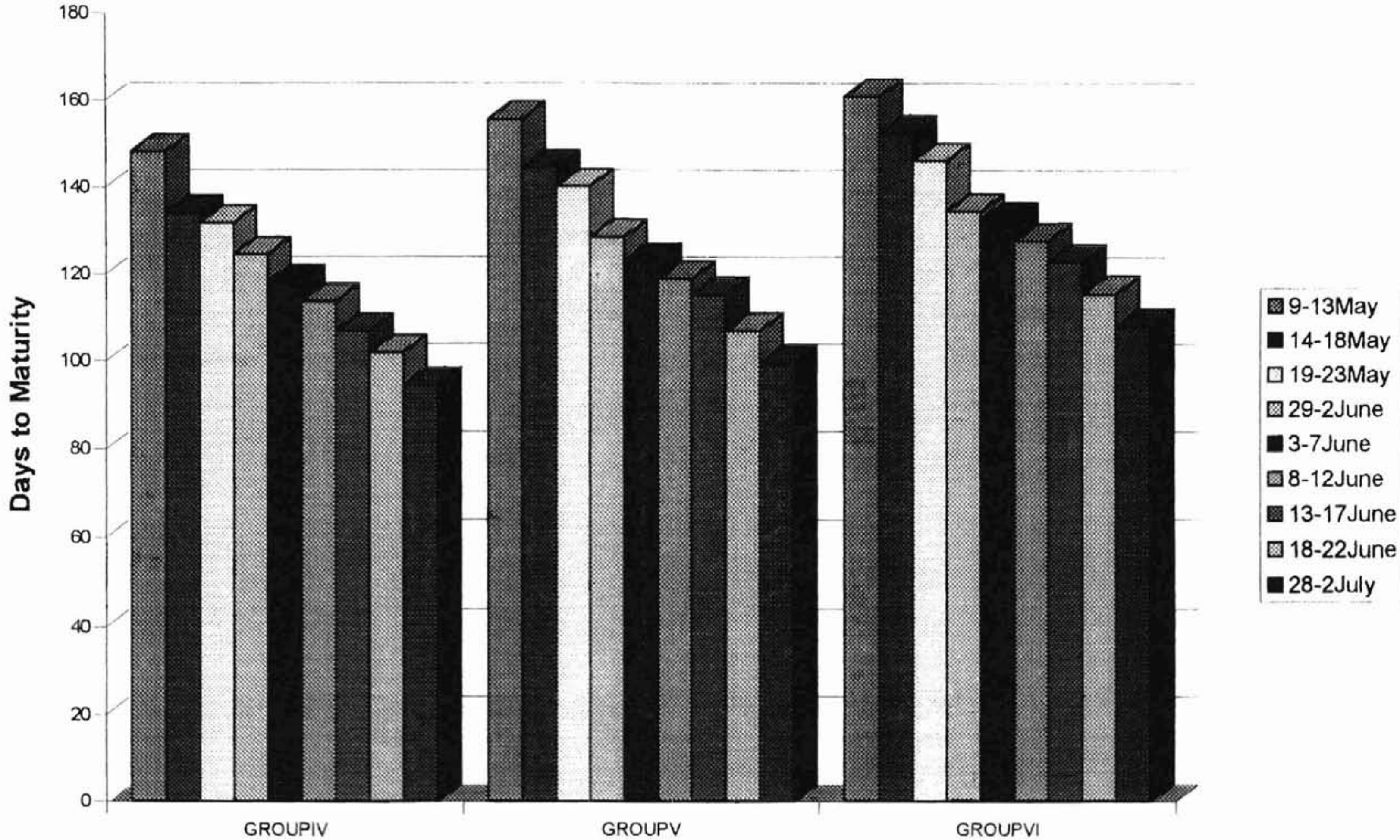

Figure 4. Effects on Days From Planting to Maturity of Maturity Groups IV, V, and VI at Different Planting Dates

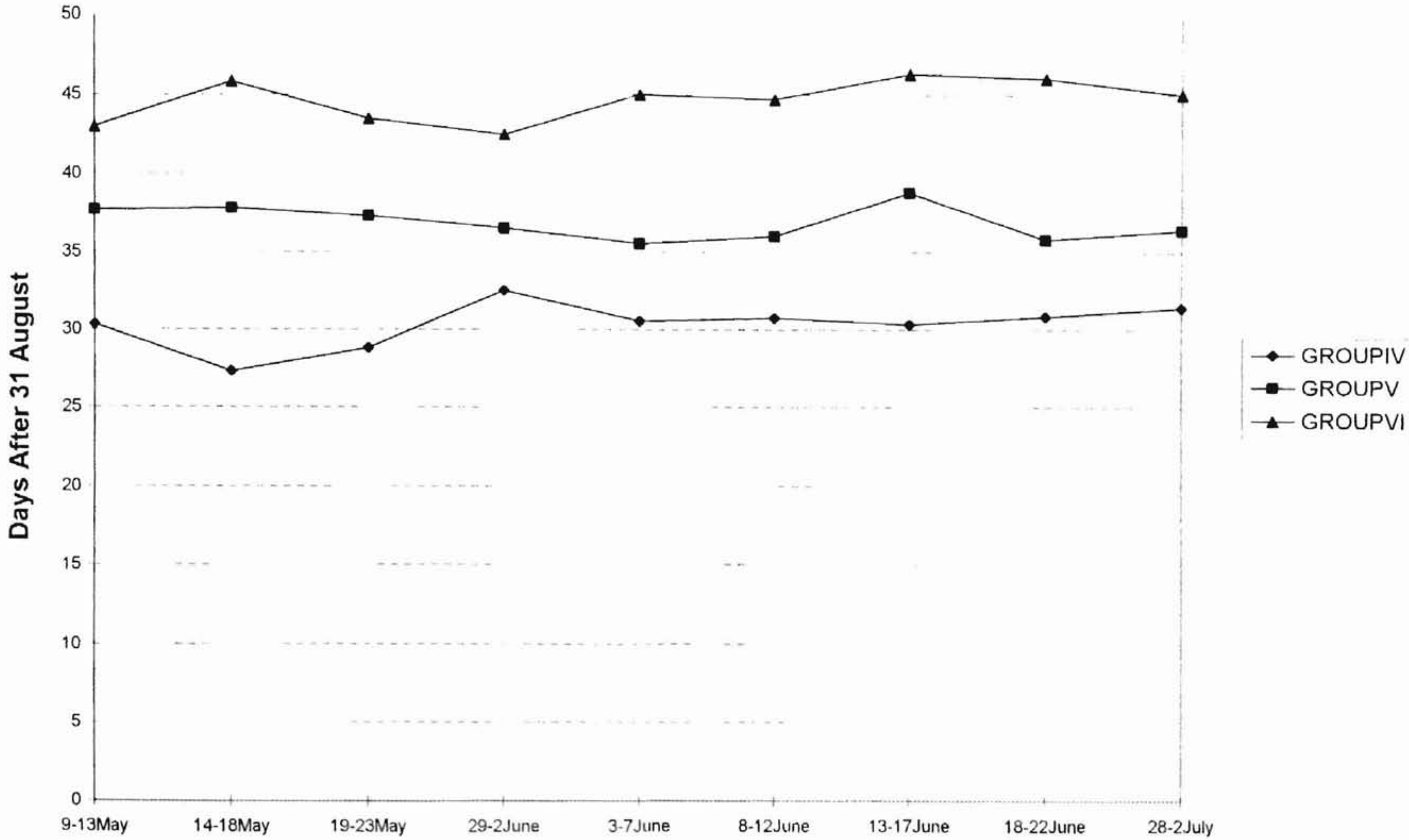

Figure 5. Effects on Maturity Date of Maturity Groups IV, V, and VI at Different Planting Dates

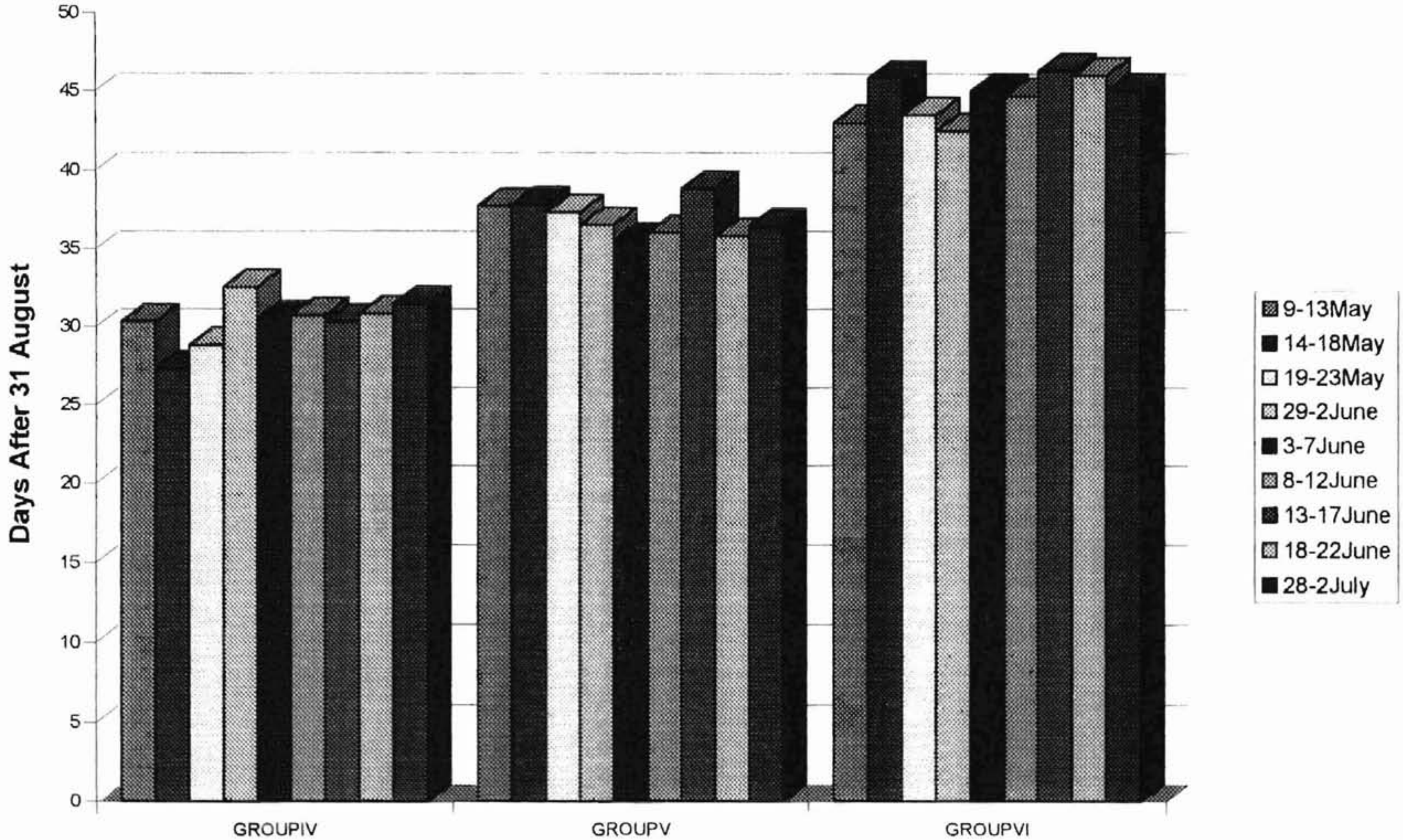

Figure 6. Effects on Maturity Date of Maturity Groups IV, V, and VI at Different Planting Dates

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