To the Graduate Council:

I am submitting herewith a thesis written by Evelyn E. Richmond entitled "Variation in Flower and Pod Abortion Among Soybean Varieties of Three Maturity Groups." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Science.

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Fred L. Allen, Major Professor

We have read this thesis
and recommend its acceptance:

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VARIATION IN FLOWER AND POD ABORTION AMONG SOYBEAN VARIETIES OF THREE MATURITY GROUPS

A Thesis

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Degree

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ABSTRACT

Six soybean (Glycine max L., Merr.) varieties were evaluated for flower and pod production and abortion on the main-stem and branches following two dates of planting. The number of flowers and pods which were produced at individual nodes on the main-stem and branches were recorded for each variety. Differences were observed among varieties for flowers and pods produced and aborted on both the main-stem and branches following both dates of planting. Abortion of flowers plus pods on a whole plant basis varied from 55 to 84 percent among varieties after the first date of planting and from 48 to 72 percent after the later planting. Following the later planting, the varieties produced fewer nodes on the main-stem and branches, branches per plant, as well as flowers and pods. In addition, the varieties produced fewer seed per plant, lower seed weights, and lower yields following the later date of planting. These results indicate that there is variation for percent abortion in soybeans.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Abortion of reproductive organs is a common phenomenon of many crops and explanations for it have been sought. Photosynthate supply has been implicated as one factor affecting fruit retention and development. Cordner (1) suggested that a capacity fruit set or load in lima beans (Phaseolus lunatus L.) was first obtained before abscission of organs began. He observed that terminal nodes were barren when fruit set and development were present at the base. Thus, he speculated that abortion of remaining structures resulted because supplies of photosynthate were not available for development of additional fruit.

Controlled flower production has been used to determine the capacity of a variety to set seed. Patterson et al. (15) concluded that boll load appears to be the primary factor governing the flowering pattern of cotton (Gossypium hirsutum L.). They found that removal of early fruiting structures resulted in later flowers developing into mature bolls. This later development delayed harvest beyond the normal time. They also observed a cycling effect in cotton which was dependent upon the intensity with which the plants were deflowered. In addition, high, early, boll-load lowered the total number of flowers produced. The authors found that in general, the early defloration increased the boll-set during a normally low boll-set period.

Abscission of reproductive organs in soybeans (Glycine max L., Merr.) is also a commonly recognized phenomenon (6, 18, 19). Certain

stresses during reproductive growth have been recognized as causes of flower and pod abortion, including capacity-set or fruit load, assimilate availability, high and low temperatures, day length and humidity.

Seasonal flowering and podding activities of two indeterminate varieties were studied by Hansen and Shibles (5). They reported abscission of a large portion of the reproductive structures. The most abundant flowering, podding and seed production occurred on nodes 5 through 15. They observed that more abscission occurred on branches and the lower portion of the main-stem. Dominguez and Hume (2) reported that 44 percent of the seeds were produced on the middle one-third of the soybean plant in early maturing varieties (maturity groups 0 and 00).

Environmental or physiological stresses which limit reproductive efficiency do not allow expression of the full genetic potential of the crop plants for which the fruit and/or seed are the harvested product. In soybeans, reproductive efficiency is the percent of mature pods produced based on the actual number of flowers initiated. Increases and decreases in reproductive efficiency have been observed by removal or intensification of an individual stress.

Hicks and Pendleton (8) showed that random removal of 60 floral buds per soybean plant resulted in no effect on the seed yield. However, complete removal of floral buds from the upper or lower two-thirds of the plant resulted in lower pod numbers and yield. They found that removal of floral buds along the mainstem was the same as no removal. However, removal of floral buds along the branches resulted in a yield reduction. Increases in seed weight were evident from both removal

schemes, however, the increases were not enough to offset the decreased per plant yield when all floral buds were removed from the branches.

Other authors have reported the same general phenomenon. McAlister and Krober (13) found no decreases in pod number at maturity with the removal of 10 percent of the pods. However, an 8 percent decrease in pod number was observed when 20 percent of the pods were removed. These authors suggest that natural pod abortion may be due to over production of pods and the lack of assimilates to bring them to full maturity.

It has been suggested that abortion of reproductive parts may be due to the lack of available assimilates during the pod filling stage (5, 19). Vegetative growth simultaneous with reproductive growth presents competitive sinks for produced assimilates with reproductive growth being the primary sink for assimilates produced (10). Johnston et al. (10) observed that by increasing the light within the canopy of the soybean plant an increase in pod number per node and seed per pod was possible. Increasing the light in the middle and bottom sections of the canopy increased the photosynthetic output. This suggested that lower leaves did not reach their photosynthetic capabilities, thus a potential for assimilate production existed but was limited by shading.

Egli and Leggett (4) determined that removal of 66 percent of the leaf area had no effect on the pod numbers. However, complete defoliation reduced the pod and seed number 93 to 96 percent. Sixty-six percent defoliation resulted in lower yield and a trend towards higher seed weight. Previous work by McAlister and Krober (13) revealed that seed yield was lowered after 40 to 80 percent of the leaves were

removed. Alteration of the source-sink ratio in favor of the source did not result in increased seed growth rate immediately. Egli and Leggett (3) suggested that the stable rate of seed growth is a result of accumulation and mobilization of storage carbohydrates. Also, it was suggested that stored carbohydrates act as a buffer for fluctuations in photosynthate supply.

The environment influences the capabilities of a plant. Originally, daylength was purported as the governing factor in the initiation and deterioration of flowering (11, 14, 20). However, this single factor did not fully explain the reproductive responses observed.

Mann and Jaworski (12) found that excessive temperatures of 40 to 60C resulted in severe pod abortion. They found that high night temperatures reduced photosynthesis and subsequently reduced pod growth. van Shaik and Probst (19) reported 43 to 81 percent flower shed during conditions of high temperature and long photoperiod. The alteration of assimilate availability suggested by Hicks and Pendleton (8) is supported by information found by Mann and Jaworski (12).

Stanfield et al. (17) observed positive correlations between high pod numbers and high temperatures in peas (Pisum sativium L.), yet the pods had lower numbers of seed, under the high temperature regime. Peters et al. (16) found that high night temperatures markedly reduced grain yields of soybeans, corn (Zea mays L.) and wheat (Triticum aestivum L. em., Thell.) and additionally shortened the effective grain filling period. Hesketh et al. (7) found that no soybean seed were set at 18C, whereas maximum bean weight was achieved at 27C. Shriveled beans were obtained at 20C.

Major et al. (11) found variability in days from planting to emergence and from emergence to flowering to be affected by temperature. They found a decrease in the time between stages of growth as a result of increasing temperature. However, they concluded that temperatures could not be used to accurately predict maturity in late maturing cultivars (maturity group V). The authors concluded that failure to accurately predict responses of a cultivar by the use of temperature suggests that additional environmental effects are involved. Hardman (6) observed higher pod set success in soybeans during the first half of the flowering period than during the second half.

Hoffman and Rawlins (9) found that constantly low or high humidities reduce seed-set in cotton. They found that cotton anthers failed to dehisce at low or high humidities. These findings suggested that constantly low or high humidities of a growth chamber or greenhouse can result in low boll set, whereas in the field intermediate humidities might allow sufficient anthesis for pollination to occur.

Zimmerman (20) reported sensitivity to temperature and humidity stress in safflower (Carthamus tinctorius L.) which affected yield. Exposure to extreme humidity ranges, 33-80 and 94-99 percent, for as little as 24 hours resulted in an 88 percent yield reduction.

Determination of differences in reproductive capacities among varieties requires data on the production of flowers and pods and the subsequent amount of aborted reproductive structures. The objectives of this study were to determine:

1. if variation in flower and pod production and abortion rates exists among six soybean varieties differing in growth habit and maturity.

2. how much flower and pod production and abortion occurs on the main stem versus branches.
3. how much of the total abortion is flowers versus pods.

CHAPTER II

MATERIALS AND METHODS

Six varieties of soybeans were planted at The University of Tennessee Plant Science Field Laboratory, Knoxville, Tennessee. The planting dates were 6 June and 2 July, 1979. The varieties were: Mitchell and K1033, indeterminate types of maturity group IV; Forrest and Essex, determinate types of maturity group V; Centennial and Pickett 71, determinate types of maturity group VI. The experiment was conducted in a randomized complete block design with three replications and four subsamples within each plot.

Each plot consisted of 3 rows, 3 meters in length seeded at a rate of 33 seeds per meter of row. The center row of each plot was selected for data collection. Four representative plants from each center row were selected and tagged for observation. Seventy-two plants from each planting date were selected. A total of 144 plants was observed for 7 weeks.

At the onset of flowering the number of flowers and pods produced at each node was counted and recorded twice a week for each selected plant. Dates of appearance of first flower and pod at any node were recorded. Individual node data were collected to distinguish differences among flowers and pods produced at nodes along the main-stem and flowers and pods produced at nodes along a branch.

The abscission rate of pods was calculated from the difference between the current and the immediately previous pod count. The total abscission of flowers was calculated as the sum of the difference

between the number of pods produced one week and the number of flowers produced the immediately previous week. Analyses of variance were conducted to determine if significant variation among varieties occurred for different characters. Duncan's New Multiple Range Test was used to determine differences among means. The data were analyzed to determine where and how much flower and pod production and abortion occurred for each variety.

Reproductive efficiency (RE) was calculated by subtracting the number of aborted flowers (AF) and pods (AP) from the total number of reproductive structures (TRS) initiated and then expressing the difference as a percent of the total reproductive structures.

$$RE = \frac{TRS - AF - AP}{TRS} \times 100$$

Reproductive consistency was defined in this study as the flower or pod production or abortion following the July planting as a percentage of the flower or pod production or abortion observed following the June planting.

Temperature and relative humidity data were collected by means of a hygrothermograph located within the plots. It was placed in the plots 18 July and removed 15 November, 1979. Data were recorded continuously during this period.

CHAPTER III

RESULTS AND DISCUSSION

Nodes Bearing Flowers Along the Main-stem and Branches

To understand the differences among varieties it is necessary to observe the profile of each variety. The differences in growth habit, main-stem node numbers, branching habit and how these change with respect to different planting dates are included in the variety profile. Each of the six varieties profile following the June and July plantings, in terms of the nodes bearing flowers along the main-stem and branches is shown in Plate 1 (in pocket).

Within the June planting the number of main-stem nodes which produced flowers ranged from 19 to 24 for the 6 soybean varieties evaluated. The largest number of main-stem nodes was produced by Mitchell and K1033, the early maturing group IV varieties. Both are indeterminate varieties which continue to produce main-stem nodes after flowering begins. The determinate varieties, Forrest, Essex, (maturity group V), Centennial and Pickett 71, (maturity group VI), had produced most of their main-stem nodes at the onset of flowering. Little difference was observed among varieties for the number of flowering nodes produced along the main-stem. Greater differences were observed among varieties for the number of flowering nodes produced along the branches than on the main-stem.

The branches produced by indeterminate varieties were located along the lower half of the plants. The upper half of the plants

produced no branches. However, the determinate varieties produced the majority of their branches along the lower two-thirds of the main-stem (Plate 1, in pocket). Thus, the determinate varieties ultimately produced more branches.

The number of flowering nodes along the branches differed among varieties (Table 1). Although the indeterminate varieties produced fewer branches, the branches had more nodes which produced flowers. The determinate varieties produced more branches but fewer nodes per branch. Essex and K1033 produced the least number of flowering sites along the branches and whole plant. The largest number of flowering sites occurred on Forrest, 151 nodes. Mitchell, Centennial and Pickett produced 120, 117 and 103 flowering sites respectively for the whole plant.

Two different types of branching habits were recognized among these varieties. Typically a single branch was initiated at a node, however occasionally two branches were initiated at the same node among the determinate varieties (Plate 1). At the lower nodes when two branches were initiated at the same node, they originated on opposite sides of the main-stem, whereas at upper nodes they originated on the same side.

Double branching was observed for all varieties except K1033 within the June planting. Less double branching was observed in all varieties following the July planting. Double branching occurred most frequently in the varieties Forrest, Centennial and Pickett although Centennial displayed very little during the July planting.

Shorter, more compact plants were established following the July planting. These plants had fewer branches and flowering nodes (Plate 1).

Table 1. Mean number of flowering nodes along the main-stem, branch and whole plant for six soybean varieties within two planting dates.

Variety	June 6 Planting			July 2 Planting		
	Main Stem	Branch	Whole Plant	Main Stem	Branch	Whole Plant
	----------no.----------					
Mitchell	24	96	120	19	50	69
K1033	21	43	64	16	46	62
Forrest	20	131	151	15	64	79
Essex	19	59	78	13	30	43
Centennial	20	97	117	16	71	87
Pickett 71	19	84	103	14	42	56

Mitchell and K1033 displayed the same pattern of development by initiating branches on the lower half of the plant. In addition double branching was observed at the lowest four nodes of K1033 whereas no double branching was observed in the June planting. The determinate varieties also followed the same pattern of main-stem and branch growth of the June planting. The decrease in the number of flowering sites reduced the potential for flowering and ultimately reduced pod production.

Flower Production and Abortion on the Lower, Middle and Upper One-thirds of the Plant Profile

The differences which occur within the profile of the plant revealed the location of production and abortion. The whole plant data was sectioned by thirds. The lower one-third included nodes 1 through 6, the middle one-third included nodes 7 through 12, and the upper one-third included nodes 13 and higher. The same scale was used for both plantings. Data from individual branches were summed for the whole branch. Each branch was labeled according to the node at which it originated.

Flower production by thirds of the plant was calculated by summing the pod production and flower abortion of thirds of the plant. Because the estimate of flower abortion on a whole plant basis is lower than flower abortion by thirds of the plant, the total flower production is higher than estimated on a whole plant basis.

To calculate flower production only flowers which were beginning to emerge from the calyx or which were fresh and fully opened were counted. Flower buds which did not have petals emerging from the calyx were not counted that particular day because it was assumed that they

would be in proper stage the next day counts were taken. Also flowers which had petals that were turning brown and shriveling were not counted because it was assumed that those had been recorded during the previous count. It is possible that flowers not yet opening on one day of counting had emerged and gone beyond a fresh blossom state by the next counting day. Thus some flowers might have been missed during counting. At best the flower abortion that is calculated is a conservative estimate of the actual flower abortion.

Flower production following the June planting was highest for the middle one-third of the plant for Mitchell, K1033 and Essex with 59.2, 56.8 and 71.3 percent respectively (Table 2). Forrest had a near even distribution of flower production between the middle and upper one-thirds of the plant with 50.8 and 46.8 percent respectively. Centennial and Pickett 71 produced the largest percent flower production on the upper-third of the plant, 56.5 and 62.0 percent respectively.

Flower production along the branches following the June planting was greatest along the lowest one-third of the plant for Mitchell, K1033 and Essex, 89.4, 96.7 and 67.9 percent respectively. Distribution of flower production in Forrest and Centennial was evenly distributed between branches on the lower and middle one-third of the plant.

Following the July planting flowers produced along the main-stem were located mainly along the middle one-third section for all varieties. Flower production on the main-stem was greater for the upper one-third than the lower one-third for varieties Mitchell, Forrest and Centennial and Pickett 71 with 22.1, 16.6, 28.3 and 15.3 percent versus 18.7, 12.4, 1.9 and 5.7 percent, respectively (Table 2). K1033 and Essex produced a

Table 2. Percent flower production and abortion by one-thirds of the plant for six soybean varieties following two dates of planting.

Variety	June 6 Planting						July 2 Planting					
	Main-Stem			Branches			Main-Stem			Branches		
	Lower Third	Middle Third	Upper Third	Lower Third	Middle Third	Upper Third	Lower Third	Middle Third	Upper Third	Lower Third	Middle Third	Upper Third
	%						%					
	Flower Production											
Mitchell	11.6	59.2	1.0	89.4	10.3	0.3	18.7	59.2	22.1	94.1	5.9	0.0
K1033	14.1	56.8	29.0	96.7	3.3	0.0	24.4	60.1	15.5	98.8	1.2	0.0
Forrest	2.4	50.8	46.8	52.0	44.8	3.1	12.4	71.0	16.6	76.6	23.4	0.0
Essex	4.3	71.3	24.4	67.9	32.1	0.0	18.2	78.1	3.6	86.7	13.3	0.0
Centennial	2.1	41.4	56.5	42.5	55.7	1.8	1.9	69.8	28.3	53.7	46.3	0.0
Pickett 71	4.8	33.2	62.0	37.8	58.8	3.4	5.7	78.9	15.3	58.9	41.0	0.0
	Flower Abortion											
Mitchell	18.8	73.7	7.6	93.7	6.2	0.0	22.7	45.4	27.2	90.0	10.0	0.0
K1033	19.7	73.2	7.0	98.6	1.4	0.0	27.1	67.9	4.9	3.3	96.6	0.0
Forrest	0.9	70.0	29.0	81.4	18.6	0.0	22.7	70.7	6.6	22.5	77.5	0.0
Essex	6.0	93.4	0.5	100.0	0.0	0.0	25.1	74.9	0.0	2.0	98.0	0.0
Centennial	3.0	50.6	46.4	55.7	44.3	0.0	2.2	77.4	20.4	45.2	54.8	0.0
Pickett 71	5.0	31.6	63.4	25.5	70.1	4.3	3.7	81.4	14.8	45.1	54.8	0.0

larger percent of the remaining flower production on the lower one-third than on the upper one-third of the main-stem, 24.4 versus 15.5 and 18.2 versus 3.6 percent respectively.

Flower production along the branches following the July planting was highest on those branches produced on the lower one-third of the plant in varieties Mitchell, K1033, Forrest and Essex, 94.1, 98.8, 76.6 and 86.7 percent respectively. Centennial and Pickett 71 had a more even distribution of flower production on branches between the lower and middle one-third of the plant. No flowers were initiated at the upper one-third since no branches were produced at these nodes.

Flower abortion was calculated on a whole plant basis by first totaling the flowers and pods produced within a variety week by week and then subtracting the weekly pod production from the previous week's flower production. The difference between the two weeks was considered flower abortion. If on occasion a flower was missed then more pods than flowers occurred. When averaged over the whole plant the resulting flower abortion is net abortion due to flowers which were missed. Calculation of pod abortion by thirds of the plant was done in the same manner except averaging was done only over a main-stem node or whole branch at a main-stem node. The flower abortion calculated in this manner was higher because it included only a single node for calculation. For this reason flower production and abortion were higher than the whole plant flower production and abortion which will be presented later.

The location of flower abortion along the thirds of the plants follows the same pattern as where the majority of the flowers were

produced. Flower abortion along the main-stem following the June planting was heaviest along the middle one-third of the plant in varieties Mitchell, K1033, Forrest and Essex, 73.7, 73.2, 70.0 and 93.4 percent respectively (Table 2). Pickett 71 showed the largest percent abortion along the upper one-third, 63.4 percent. Flower abortion was distributed along the middle and upper one-third of the main-stem in Centennial, 50.6 and 46.4 percent respectively.

Branch flower abortion in Centennial following the June planting was distributed between the lower and middle one-thirds of the plants, 55.7 and 44.3 percent respectively. Pickett 71 aborted the highest percent of flowers on the branches originating along the middle one-third of the plant (70.1 percent) and aborted the least on branches originating along the upper one-third (4.3 percent). All of the branch flower abortion (100 percent) occurred on branches originating along the lower one-third of the plant in the variety Essex. The other varieties, Mitchell, K1033 and Forrest exhibited most of their branch flower abortion on branches originating along the lower one-third of the plants.

Flower abortion along the main-stem was heaviest along the middle one-third of the main-stem in all varieties following the July planting. Pickett 71 aborted the largest percent with 81.4 and Mitchell aborted the lowest along the middle one-third with 45.4 percent (Table 2). The remaining flower abortion in variety Mitchell was near evenly distributed between the lower and upper thirds of the plant, 22.7 and 27.2 percent respectively. A majority of the remaining percent flower abortion occurred on the lower one-third of the plant in varieties K1033, Forrest and Essex 27.1, 22.7 and 25.1 percent respectively. The remaining

percent flower abortion in varieties Centennial and Pickett 71 occurred on the upper one-third of the plant.

Flower abortion along the branches following the July planting was located on the lower one-third for Mitchell, 90.0 percent, the middle one-third for K1033, Forrest and Essex, 96.6, 77.5 and 98.0 respectively and evenly distributed between branches on the lower and middle one-thirds of the plant for Centennial and Pickett 71 (Table 2). No abortion occurred on branches at the upper one-third since no branches were initiated at those nodes on any of the varieties following the July planting.

Flower production and abortion follow the same patterns. Flower abortion was generally higher where the majority of the flowers were produced. Most flower production and abortion occurred along the middle one-third of the plant along the main-stem. Flower production was heaviest on branches originating at the lower one-third of the plant following both plantings. Flower abortion was heavier along the middle one-third following the July planting whereas following the June planting, it was heaviest along the lower one-third of the plant.

Pod Production and Abortion on the Lower, Middle and Upper One-thirds of the Plant Profile

The major portion of the pods produced following the June planting were located on the nodes 7 through 24 (middle and upper one-thirds) (Table 3). The production of pods following the July planting was located on nodes 7 through 12 (middle one-third) along the main-stem. Of the pods set along the branches the largest percent were set along branches which originated on the lower one-third of the plant except

Table 3. Percent pod production and abortion by one-thirds of the plant for six soybean varieties following two dates of planting.

Variety	June 6 Planting						July 2 Planting					
	Main-Stem			Branches			Main-Stem			Branches		
	Lower Third	Middle Third	Upper Third	Lower Third	Middle Third	Upper Third	Lower Third	Middle Third	Upper Third	Lower Third	Middle Third	Upper Third
	%						%					
Pod Production												
Mitchell	9.7	55.4	34.9	88.9	10.5	0.4	17.9	61.2	20.9	95.1	5.0	0.0
K1033	12.4	51.8	35.8	96.5	3.5	0.0	23.3	56.7	20.0	99.3	0.8	0.0
Forrest	3.3	39.0	57.7	50.7	53.1	3.9	5.9	71.2	22.8	76.8	23.9	0.0
Essex	3.9	64.5	31.7	67.8	32.4	0.0	16.7	78.9	4.5	88.8	16.6	0.0
Centennial	1.3	32.0	66.7	30.1	65.9	3.5	1.6	60.7	37.8	53.2	47.6	0.0
Pickett 71	4.5	35.3	60.2	42.8	54.5	3.1	7.0	77.3	15.6	61.0	39.4	0.0
Pod Abortion												
Mitchell	15.9	58.3	23.9	83.9	8.7	0.4	22.8	61.4	15.7	87.3	7.8	0.0
K1033	19.5	52.9	36.4	96.9	3.0	0.0	33.3	41.5	26.5	96.1	1.3	0.0
Forrest	3.4	49.1	47.7	44.2	52.2	3.3	11.6	63.4	25.0	75.6	24.2	0.0
Essex	4.3	61.2	32.5	63.5	36.4	0.0	10.7	83.3	6.7	80.9	19.1	0.0
Centennial	0.7	24.7	71.7	32.7	63.2	3.9	3.6	60.4	36.9	50.0	50.3	0.0
Pickett 71	4.0	24.3	71.8	45.4	53.4	5.2	12.7	70.0	29.8	62.6	41.8	0.0

in Centennial and Pickett 71 where the largest percent were set along branches originating from the middle one-third of the profile.

Following the June planting Mitchell, K1033 and Essex produced the largest percent of their pods in the middle portion of the profile 55.4, 51.8 and 64.5 percent respectively. Forrest, Centennial and Pickett 71 produced most of their pods in the upper one-third with 57.7, 66.7 and 60.2 percent respectively.

Following the July planting, the largest percent of the pods produced were located along the middle one-third of the main-stem. Also, there was an increase in the percent of the pods set in the lower portion of the profile when compared to the June planting. The redistribution of the percent pods set following the July planting was due to the fewer main-stem nodes which were produced, thereby reducing the number of nodes that were included in the upper one-third of the plants.

The distribution of pods along a branch was summed over the whole branch. Mitchell, K1033 and Essex produced most of their pods along branches originating on the lower one-third of the plants, 88.9, 96.5 and 67.8 percent respectively following the June planting (Table 3). The pods were more evenly distributed for Mitchell, K1033 and Essex between the lower one-third and middle one-third of the plant, 50.7 and 53.1 percent respectively. Centennial and Pickett 71 produced most of their pods along branches originating on the middle one-third of the profile, 65.9 and 54.5 percent respectively.

Following the July planting all varieties produced most of their pods along branches on the lower one-third of the plant. The percentages ranged from 53.2 for Centennial to 99.3 for K1033. No branches were

initiated at nodes higher than twelve on any of the varieties following the July planting, thus none of them produced pods on branches in the upper one-third of the plant profile.

The percent pod abortion followed the same pattern as pods set. Along the main-stem following the June planting, the largest percent pod abortion in the varieties Mitchell, K1033 and Essex was from the middle one-third of the profile, 58.3, 52.9 and 61.2 percent respectively. Pod abortion was evenly distributed between the middle and upper one-third of the plant profile for Forrest, 49.1 and 47.7 percent respectively. In terms of percent pod abortion in the upper one-third of the profile, maturity group VI varieties, Centennial and Pickett 71 were highest with 71.7 and 71.8 percent respectively.

Pod abortion following the July planting also followed the same pattern as pod production. All varieties aborted a greater percentage of pods from the middle portion of the profile than from the lower or upper portion. K1033 aborted the least with 41.5 percent and Pickett 71 aborted the most with 70.0 percent along the middle one-third of the plant (Table 3).

The percent of pods aborted on the branches followed the same pattern as pods set following the June planting. The largest percent pod abortion on the branches of varieties Mitchell, K1033 and Essex occurred on those originating on lower one-third of the plant profile, 83.9, 96.9 and 63.5 percent respectively (Table 3). The pod abortion rates on branches originating on the lower one-third of the plant and those originating on the middle one-third of the plant were similar for the variety Forrest, 44.2 and 52.2 percent respectively. Maturity group

VI varieties, Centennial and Pickett 71 aborted the major percent of their branch pods along the middle one-third of the plants, 63.2 and 53.4 percent respectively.

Following the June planting pod abortion on the branches was highest on the lower one-third of the plant profile except in the variety Centennial. Centennial aborted an equal percentage of its pods on the lower and middle one-thirds of the plant, 50.0 and 50.3 percent respectively.

Flower Production and Abortion on the Main-stem, Branches and Whole Plant

Flower production is the basis for subsequent pod formation. Significant differences in the number of flowers produced per variety were observed in both planting dates (Table 4).

Within the June planting no significant difference in whole plant flower production was observed for Centennial, Pickett 71 and Forrest, 320.3, 341.0 and 280.7 respectively. Mitchell, K1033 and Essex produced significantly fewer flowers than the above three varieties but did not significantly differ from each other, 193.7, 146.3 and 149.6 respectively. The whole plant flower production is a combination of branch and main stem flower production.

Partitioning of flower production shows a significant difference only between the varieties Forrest and Essex, 108.5 and 70.7 respectively, for flower production along the main-stem. All other varieties were not significantly different from each other. The difference in main-stem flower production cannot be attributed to the number of main-stem nodes. Forrest and Essex differed in total main nodes by only one (Table 1, page 11). The significant difference between these two

Table 4. The mean number of flowers produced and aborted along the main-stem, branches and whole plants for six soybean varieties following two dates of planting.*

Variety			June 6 Planting** Main Stem	June 6 Planting** Branches	June 6 Planting** Whole Plant	July 2 Planting** Main Stem	July 2 Planting** Branches	July 2 Planting** Whole Plant	Reproductive Consistency*** Main Stem	Reproductive Consistency*** Branches	Reproductive Consistency*** Whole Plant
									--------- % ---------		
Mitchell	prod.	(no.)	85.7^{ab}	108.3^{bc}	193.7^{b}	53.4^{a}	57.9^{b}	111.3^{ab}	62.7	53.5	57.4
	abort.	(no.)	9.2^{b}	5.7^{c}	14.9^{b}	5.6^{c}	8.4^{a}	14.0^{b}	60.9	147.4	93.9
	abort.	(%)	(10.7)	(5.3)	(7.6)	(10.5)	(14.5)	(12.6)	98.1	273.6	165.8
K1033	prod.	(no.)	83.7^{ab}	62.6^{c}	146.3^{b}	45.1^{a}	33.5^{b}	78.7^{b}	52.0	53.5	53.8
	abort.	(no.)	15.0^{b}	5.7^{c}	20.7^{b}	5.1^{a}	5.1^{a}	10.2^{b}	34.0	89.5	49.3
	abort.	(%)	(17.9)	(9.7)	(14.1)	(11.3)	(15.2)	(13.0)	63.1	167.0	92.2
Forrest	prod.	(no.)	108.5^{a}	172.1^{b}	280.7^{a}	57.8^{a}	140.2^{a}	198.1^{a}	53.2	81.4	70.6
	abort.	(no.)	40.4^{a}	9.9^{c}	50.3^{b}	22.7^{ab}	33.3^{a}	56.1^{a}	56.2	336.4	111.5
	abort.	(%)	(37.2)	(5.7)	(17.9)	(39.3)	(23.7)	(28.3)	105.6	415.8	158.1
Essex	prod.	(no.)	70.7^{b}	79.0^{c}	149.6^{b}	43.5^{a}	45.7^{b}	89.2^{b}	61.5	57.8	59.6
	abort.	(no.)	10.6^{b}	0.0^{c}	10.6^{b}	9.9^{bc}	7.5^{a}	17.6^{ab}	93.4	-	166.0
	abort.	(%)	(15.0)	(0.0)	(7.1)	(22.7)	(16.4)	(19.7)	151.3	-	277.5
Centennial	prod.	(no.)	75.3^{ab}	245.0^{a}	320.3^{a}	65.0^{a}	61.4^{b}	130.4^{ab}	86.3	25.1	40.7
	abort.	(no.)	50.6^{a}	120.3^{a}	170.9^{a}	34.1	27.7^{a}	62.5^{a}	67.4	23.0	36.6
	abort.	(%)	(67.2)	(49.1)	(53.4)	(52.5)	(45.1)	(47.9)	78.1	91.8	89.7
Pickett 71	prod.	(no.)	99.6^{ab}	241.4^{a}	341.0^{a}	65.2^{a}	87.3^{ab}	152.6^{ab}	65.5	40.3	44.7
	abort.	(no.)	57.3^{a}	96.7^{b}	154.0^{a}	22.6^{ab}	27.6^{a}	50.2^{a}	39.4	28.5	32.6
	abort.	(%)	(57.5)	(40.0)	(45.2)	(34.7)	(31.6)	(32.9)	60.3	79.0	72.8

*Means followed by the same letter are not significantly different ($P<.05$) according to Duncan's New Multiple Range Test.

**Only means within the same column and variable can be compared.

***Percent that the July values are of the June values.

varieties apparently was due to the number of flowers they initiated per node.

Initiation of flowers along branch nodes showed significant differences among varieties. Centennial and Pickett 71 produced the largest number of flowers on the branches, 245.0 and 241.4 respectively. These two varieties differed ($P<.05$) from all other varieties. Forrest and Mitchell did not differ, with 172.1 and 108.3 flowers respectively. Mitchell also did not significantly differ from K1033 and Essex in number of flowers produced on branches, 108.3 versus 62.6 and 79.0 respectively.

The differences observed in flower production might partially be attributed to the branching habit of the plant. The double branching habit discussed earlier contributed to the production of flowering sites in all varieties except K1033. Essex displayed very little double branching, thus limiting the number of flowering sites and flower numbers. The lack of double branching occurring in K1033 might have contributed to the lower number of flowers produced.

The production of flowers per node also affected flower production. Forrest produced the largest number of flowering nodes along the branches, 131, but did not produce the largest number of flowers. The production of flowers was largest along the branches of Centennial with 245.0 flowers and 97 branch nodes. Thus a pattern of high flower counts and high node counts does not follow with these varieties.

Fewer numbers of nodes and flowers were observed on all plants within the July planting. For flowers produced on the whole plants, Forrest produced significantly more than K1033 and Essex, 198.1 versus

78.7 and 89.2 flowers respectively. Mitchell, Centennial and Pickett 71 did not significantly differ ($P<.05$) in number of flowers produced on a whole plant basis following the July planting nor did they differ from Forrest.

Partitioning of the flower production shows that no significant differences occurred among varieties for flower production along the main-stem following planting in July. Although the number of main-stem nodes producing flowers ranged from 13 to 19 among varieties, the flower production did not differ.

No significant difference was observed among the varieties Forrest, Pickett 71, Centennial and Mitchell for flowers produced on the whole plant following planting in July, 198.1, 152.6, 130.4 and 111.3 respectively (Table 4). Forrest significantly differed from K1033 and Essex, 198.1 versus 78.7 and 89.2 flowers respectively, however K1033 and Essex did not significantly differ from any of the other varieties.

Production of flowers was largest in maturity group VI in the June planting. No other pattern was observed for any other maturity group. This high flower production for maturity group VI also held true for the July planting. In maturity group V Forrest produced a significantly high number of flowers in both plantings than Essex. Flower production and abortion on Essex was very similar to that of the group IV, indeterminate varieties, Mitchell and K1033.

In this study, reproductive consistency is defined as the ability of a variety to produce a given number of flowers and pods when grown under different environmental conditions. It was calculated as the percentage that second planting (July) was of the first (June). The

June planting served as the reference point by which the percentages were calculated. This reference point was not intended as a determination of the maximum flowering capacity of the variety because an earlier or later planting would possibly result in a different reference point.

In relation to the 2 June planting date, Forrest and Essex maintained the highest levels of reproductive consistency in terms of flowers produced with 70.6 and 59.6 percent respectively. This high level of flowering consistency might be because Forrest and Essex are the two varieties studied which were highly adapted to the area.

Maturity group VI varieties flower and mature later when grown in this area. Because of the later flowering date more nodes were established prior to flowering. Thus with more nodes produced and more potential flowering sites, more flowers were initiated by these two varieties following the June planting. The lateness of the second planting resulted in a considerable difference in flowering node production and a small decrease in mean number of flowers per node.

The lowest flowering consistency was observed in Centennial and Pickett 71, 40.7 and 44.7 percent respectively. The low percentages might have resulted because of the large number of flowering nodes and flowers initiated in the June planting. Fewer nodes bearing flowers were produced following the July planting thus reducing the potential number of flowers possible.

Considerable reduction of the number of flowering nodes did not occur in the variety K1033 (Table 1, page 11). In the June planting K1033 had a total of 64 flowering nodes. In the July planting 62 were present. However, K1033 produced only 53.8 percent of the flowers after

the July planting that it produced after the June planting (Table 4). The reduction in flower number was too great to be accounted for by two nodes. Thus, a lower mean number of flowers per node was evident after the July planting for K1033. Mitchell and K1033 initiated 57.4 and 53.8 percent of the number of flowers they initiated in the June planting. The indeterminate growth habit possibly enabled these varieties to maintain a more consistent level of flowering when compared to the determinate varieties. Although the two maturity group IV varieties began flowering first, they are indeterminate and thus contained to grow vegetatively while flowering. According to Egli and Leggett (3), the determinate varieties obtain 77-80 percent of their vegetative material by the onset of flowering. In the July planting flowering began before the plants were as large as the plants in the June planting.

As mentioned earlier flowering consistency was based on the number of flowers produced following planting in June. The decrease in the number of branches being produced and the decrease in number of nodes producing flowers on the branches coupled with fewer nodes producing flowers on the main-stem resulted in fewer total flowers being produced by all the varieties when planted in July compared to June.

Flower abortion is defined as the loss of a flower. Total flower abortion was determined by summing the positive differences obtained by subtracting the pod production of one week from the flower production of the previous week. If more pods were produced one week than flowers produced the previous week, negative flower abortion was calculated. Negative flower abortion is evidence of a missed flower. The mean number of missed flowers per variety was added to the total number of flowers counted to obtain a total number of flowers produced.

Flower abortion following the June planting was greater when compared to the number of flowers aborted following the July planting. However, when compared as percents of the flowers initiated flower abortion was occasionally greater following the June planting. Distribution of flower abortion was equally distributed between the branches and main-stem following the July planting whereas in the June planting it was generally heavier along the main-stem.

Within the June planting, Centennial and Pickett 71 aborted the largest number of flowers over the whole plant, 170.9 and 154.0 respectively (Table 4, page 22). These two varieties differed significantly from all other varieties when compared on a whole plant basis. Partitioning of the data shows differences among the varieties in flowers aborted along the main-stem and branches.

Results from the June planting showed no significant differences in flower aborted on the main-stem among the varieties Pickett 71, Centennial and Forrest. However, these varieties aborted a significantly higher number and percentage of flowers along the main-stem than did Mitchell, K1033 and Essex (Table 4, page 22). The abortion of flowers produced along the main-stem does not follow the same pattern as flower production. The varieties Forrest, Centennial and Pickett 71 aborted approximately 50 percent (range of 37-67 percent) of the flowers produced along the main-stem while Mitchell, K1033 and Essex aborted approximately 15 percent (range of 11-18 percent) of their main-stem flowers.

Abortion of flowers was also high along the branches of Centennial and Pickett 71. Centennial and Pickett 71 were significantly different from all other varieties within the June planting with 120.3 (49.1

percent) and 96.7 (40 percent) respectively flowers aborted along the branches. All other varieties were not significantly different for flowers aborted on the branches. They ranged in from 0 to 9.1 percent aborted.

The differences observed for flower abortion follows the differences observed for flower production. On a whole plant basis, Centennial and Pickett 71 produced more flowers than the other four varieties but they also aborted a greater percentage of the flowers they produced (53.4 and 45.2 percent respectively). The other varieties aborted flowers with a range of 7.1 to 17.9 percent.

The July planting resulted in a general decrease in the number of flowers aborted, however for three of the varieties, Mitchell, Forrest and Essex, the percent flower abortion was generally higher (Table 4. page 22). On the other hand, the percent flower abortion of Centennial and Pickett 71 was slightly less for the July planting than for the June planting. Significant differences among varieties for flower abortion observed on the whole plant from the July planting can be attributed to the differences observed in flower abortion along the main-stem. Centennial, Pickett 71 and Forrest did not differ ($P<.05$) in flowers aborted along the main-stem, 34.1, 22.6 and 22.7 respectively. Forrest and Pickett 71 did not differ from Essex which aborted 9.9 flowers along the main-stem. Mitchell, K1033 and Essex did not differ in main-stem flower abortion, 12.6, 13.0 and 17.6 flowers, respectively. No significant differences were observed for flower abortion along the branches in the July planting.

The significant difference in flower abortion for maturity group VI varieties Centennial and Pickett 71 might be attributed to the lateness of flowering and the over production of flowers. Maturity group IV varieties Mitchell and K1033 maintained a level of abortion equal to Forrest and Essex in the June planting. The indeterminate growth habit of Mitchell and K1033 allowed vegetative growth although flowering began early in the season. The lateness of the July planting resulted in a fewer number of flowers produced and aborted.

The reproductive consistency defined earlier as the ability of a variety to produce a given number of flowers and pods under changing environmental conditions also concerns aborted flowers. As whole plants more flowers were aborted following the July planting when compared to the June planting in the varieties Forrest and Essex, 111.5 and 166.0 percent respectively. Less than 50 percent as much abortion occurred in the July planting in the varieties K1033, Centennial and Pickett 71, 49.3, 36.6, 32.6 flowers aborted respectively.

There was consistently less abortion along the main-stem in the July planting among all varieties than in the June planting. However, along the branches Mitchell and Forrest aborted more flowers with 147.4 and 336.4 percent respectively. Abortion of flowers along branches in the varieties Centennial and Pickett 71 was lowest with 23.0 and 28.5 percent.

Comparisons of the percents of abortion show that all varieties except Centennial and Pickett 71 aborted a greater percentage of flowers along the main-stem or branches following the July planting. Centennial and Pickett 71 aborted less flowers on a whole plant basis in the July planting resulting in 89.7 and 92.8 percent reproductive efficiency.

Pod Production and Abortion on the Main-stem, Branches and Whole Plant

Following the June planting, these soybean varieties did not differ in the number of pods produced on the main-stem or on a whole plant basis. However, there were significant differences among varieties in the number of pods produced on the branches. Following the July planting, varieties did not differ in the number of pods produced on branches or on a whole plant basis. Comparing the pod production of varieties following planting in June versus planting in July, all varieties produced more pods on the main-stem, branches and whole plant after the June planting than when planted in July. K1033 produced significantly fewer pods along the branches, following the June planting than Forrest and Pickett 71, 56.8 versus 162.2 and 144.7 respectively (Table 5). No significant differences were observed among the other varieties. The high number of branch pods in the variety Forrest might be due to the double branching habit. The initiation of two branches at the same node increased the number of flowering sites, as well as the potential for flowers and pods. The double branching habit was not observed in K1033 in the June planting. This was the only variety which significantly differed from Forrest.

Following the July planting the double branching habit was observed on two lower nodes of K1033 (Plate 1, in pocket). Forrest maintained the double branching habit in the July planting which resulted in it producing more pods ($P<.05$) on the branches than the other five varieties. When observed as whole plants, Forrest did not significantly differ from Mitchell or Pickett 71, 142.0 compared to

Table 5. The mean number of pods produced and aborted along the main-stem, branches and whole plant for six soybean varieties within two planting dates.*

Variety		June 6 Planting** Main Stem	June 6 Planting** Branches	June 6 Planting** Whole Plant	July 2 Planting** Main Stem	July 2 Planting** Branches	July 2 Planting** Whole Plant	Reproductive Consistency*** Main Stem	Reproductive Consistency*** Branches	Reproductive Consistency*** Whole Plant
								%		
Mitchell	prod. (no.)	76.2^{a}_{ab}	102.6^{ab}_{bc}	178.7^{a}_{b}	47.8^{a}_{a}	49.5^{b}_{b}	97.3^{ab}_{ab}	62.7	48.2	54.4
	abort. (no.)	31.4^{ab}	60.2^{bc}	91.6^{b}	17.5^{a}	23.0^{b}	40.5^{ab}	55.7	38.2	44.2
	abort. (%)	(41.2)	(58.7)	(51.2)	(36.7)	(46.5)	(41.6)	89.1	79.2	81.2
K1033	prod. (no.)	68.7^{a}_{ab}	56.8^{b}_{c}	125.5^{a}_{b}	40.0^{a}_{a}	28.6^{b}_{b}	68.6^{b}_{b}	58.2	50.3	54.7
	abort. (no.)	29.1^{ab}	34.8^{c}	63.9^{b}	14.7^{a}	13.0^{b}	27.7^{b}	50.5	37.3	43.3
	abort. (%)	(42.3)	(61.3)	(50.9)	(36.7)	(45.4)	(40.4)	86.7	74.1	79.3
Forrest	prod. (no.)	68.2^{a}_{a}	162.2^{a}_{a}	230.4^{a}_{a}	35.1^{a}_{a}	106.9^{a}_{a}	142.0^{a}_{a}	51.4	65.9	61.6
	abort. (no.)	35.2^{a}	103.8^{a}	139.1^{a}	11.2^{a}	49.2^{a}	60.5^{a}	31.8	47.3	43.4
	abort. (%)	(51.6)	(64.0)	(60.4)	(31.9)	(46.0)	(42.6)	90.6	71.9	70.5
Essex	prod. (no.)	60.0^{a}_{ab}	79.0^{ab}_{bc}	139.0^{a}_{b}	33.6^{a}_{a}	38.0^{b}_{b}	71.6^{b}_{b}	56.0	48.1	51.5
	abort. (no.)	28.9^{ab}	43.9^{bc}	72.8^{b}	9.3^{a}	17.3^{b}	26.7^{b}	32.2	39.4	36.7
	abort. (%)	(48.2)	(55.6)	(52.4)	(27.7)	(45.5)	(37.2)	57.4	81.8	71.0
Centennial	prod. (no.)	58.1^{a}_{ab}	124.7^{ab}_{ab}	182.8^{a}_{b}	30.9^{a}_{a}	33.8^{b}_{b}	64.7^{b}_{b}	53.2	27.1	35.4
	abort. (no.)	23.0^{ab}	74.4^{ab}	97.4^{b}	13.8^{a}	17.4^{b}	31.2^{b}	60.0	23.3	32.0
	abort. (%)	(39.6)	(59.7)	(53.3)	(44.7)	(51.5)	(48.2)	112.9	86.3	90.4
Pickett 71	prod. (no.)	42.2^{a}_{b}	144.7^{a}_{ab}	187.0^{a}_{b}	42.7^{a}_{a}	59.7^{b}_{ab}	102.3^{ab}_{ab}	101.2	29.5	54.7
	abort. (no.)	20.6^{b}	77.6^{ab}	98.1^{b}	17.6^{a}	31.3^{ab}	48.9^{ab}	85.4	40.3	49.8
	abort. (%)	(48.8)	(53.6)	(52.4)	(41.2)	(52.4)	(47.8)	85.4	97.8	91.2

*Means followed by the same letter are not significantly different ($P<.05$) according to Duncan's New Multiple Range Test.

**Only means within the same column and variable can be compared.

***Percent that the July values are of the June values.

102.3 and 97.3 pods respectively. Forrest produced significantly more pods than K1033, Essex and Centennial, 142.0 versus 68.6, 71.6 and 64.7 respectively.

The lack of significant differences in pods produced along the main-stem might be due to the lack of differences in the number of nodes produced along the main-stem. The differences in pod production along the branches appear to be due to the variation in nodes along the branches as well as the number of flowers produced per node.

Patterns of pod production show that Forrest, Centennial and Pickett 71 produce approximately 70 percent of their pods on the branches. Mitchell, K1033 and Essex equally distribute the pod load between the main-stem and branches. In the July planting pod distribution was equally divided between the main-stem and branches except in Forrest where 75 percent of the pods were produced along the branches. The distribution pattern of pods was not confined to any particular maturity group or growth habit.

In general the varieties produced fewer pods in the July planting when compared to pod production in the June planting for main-stem, branches and whole plants (Table 5). The reduction in pod number is partially due to the reduction in the number of nodes producing flowers and thus reducing the potential pod production. Fewer nodes did not always account for the reduction in pods. K1033 produced the same number of nodes in both planting dates (Table 1, page 11) but produced fewer flowers during the July planting (Table 2, page 14).

When expressed as a percent of the June planting, the reproductive consistency for branches was generally lower than the main-stem for the

July planting. As whole plants the largest reproductive consistency was expressed by Forrest, 61.6 percent. Centennial had the lowest reproductive consistency, 35.4 percent. Mitchell, K1033, Essex and Pickett 71 were grouped together with 54.4, 54.7, 51.5 and 54.7 percent respectively.

Maturity group VI varieties, Centennial and Pickett 71 were lowest in reproductive consistency along the branches with 27.1 and 29.5 percent respectively. The variety with the highest reproductive efficiency on branches was Forrest with 65.9 percent. Mitchell, K1033 and Essex were similar with 48.2, 50.3 and 48.1 percent respectively.

Along the main-stem Pickett 71 had the highest reproductive consistency with 101.2 percent. Forrest displayed the lowest reproductive consistency along the main-stem with 51.4 percent. Mitchell, K1033, Essex and Centennial were similar with 62.7, 58.2, 56.0 and 53.2 percent respectively.

The loss of a pod which began to develop is defined as pod abortion. Any pods which were counted but were not present during the following count day were considered to have been aborted.

A larger percent of the pods produced in the June planting were aborted when compared to the July planting (Table 5). Significant differences were observed for pod abortion along the branches and whole plant following both plantings. No significant differences were observed for pods aborted along the main-stem in either planting.

The number of pods which aborted for the whole plant showed that Forrest (139.1 pods, 60.4 percent) had significantly greater pod abortion than all other varieties in the June planting. They ranged

from 63.9 (50.9 percent) for K1033 to 98.1 (52.4 percent) pods aborted for Pickett 71. None of the other varieties differed from each other in the June planting.

Partitioning the whole plant pod abortion in the June planting into main-stem and branch data showed that the greatest amount of variation occurred along the branches. Forrest aborted the largest number of pods along branches with 103.8 and did not significantly differ from Centennial and Pickett 71, 77.4 and 77.6 pods respectively. Essex and Mitchell did not differ significantly from Centennial and Pickett 71. Essex and Mitchell did not differ from K1033 which aborted the least number of pods, 34.8. The differences among varieties for pods aborted along the branches accounts for the variation which occurred among varieties for pods aborted on the whole plant. The percent pod abortion along the branches showed a range of 53.6 percent for Pickett 71 to 64 percent for Forrest.

Considering only the main-stem, Forrest aborted significantly more pods (35.2) than Pickett 71 (20.6). All other varieties did not significantly differ in pod abortion along the main-stem in the June planting.

Within the July planting Forrest did not differ from Pickett 71 and Mitchell for pods aborted on the whole plant, 60.5 versus 48.9 and 40.5 respectively. Pickett 71 and Mitchell did not significantly differ from any of the other varieties for whole plant pod abortion. The largest percent pod abortion for the whole plant was expressed by Centennial, 48.2 percent, and the lowest percent was for Essex, 37.2 percent. All other varieties ranged between those two values.

No significant differences were observed for pods aborted along the main-stem within the July planting. Along the branches, Forrest aborted more pods than any of the other varieties with 49.2 pods (46.0 percent) aborted. The other varieties ranged from K1033 with 13.0 to Pickett 71 with 31.3 pods aborted. As percents of the pods produced Forrest and K1033 did not differ for pods aborted, 46.0 and 45.4 percent respectively. All the percent pod abortions along the branches of the different varieties for the July planting ranged between 45 to 53 percent.

The percent pods aborted in respect to the number of pods produced showed little variation. Those plants which produced a large number of pods also aborted a large number of pods. On the other hand, the varieties which initially produced fewer pods had similar percent pod abortion to those that produced higher numbers of pods.

The number of pods aborted on the whole plant following the July planting as a percentage of those aborted following the June planting was consistently lower for all six varieties. Centennial aborted 32.0 percent of the number of pods following July planting than it did following the June planting (Table 5). Pickett 71 had the highest number of aborted pods following July planting as a percentage of the June planting with 49.8 percent. The other four varieties ranged from the high thirties to the mid-forties for the number of pods aborted in July as a percentage of those aborted in June.

In terms of the number of pods aborted along the main-stem in July as a percentage of those aborted along the main-stem in June, the maturity group VI varieties, Centennial and Pickett 71, has the highest percentages with 60.0 and 85.4 respectively. The lowest two percents

were observed in maturity group V varieties Forrest and Essex, 31.8 and 32.2 percent respectively. Maturity group IV varieties Mitchell and K1033 aborted 55.7 and 50.5 percent respectively as many pods following July planting as they did following planting in June. Not only was the number of pods produced and the number aborted less in the July planting than in the June planting, but the percent of the pods which aborted also was generally less in the July than in the June planting. The only exception was Centennial in which the percent pod abortion on the main-stem in the July planting was 112 percent of that in the June planting (Table 5, page 31). Percent pod abortion on the main-stem of Mitchell, K1033, Forrest and Pickett 71 following the July planting ranged from 85 to 91 percent of that observed in the June planting. Essex was lowest with only 57.4 percent as much abortion on the main-stem in the July planting as in the June planting.

Percent abortion of pods on the branches after the July planting for five of the six varieties ranged from approximately 72 to 86 percent as much as after the June planting (Table 5, page 31). Centennial was the only variety that had approximately the same percent abortion of pods on the branches in both plantings (97.8 percent).

When compared on a whole plant basis, Centennial and Pickett 71 had about 90 percent of the rate of abortion in the July planting as in the June planting. For Essex, Forrest, K1033 and Mitchell, the rate of pod abortion in the July planting ranged from 72 to 80 percent of that observed in the June planting.

Flower Versus Pod Abortion on the Main-stem, Branches and Whole Plant

Percent total abortion was calculated as the percent of the reproductive structures which were aborted as flowers and as pods combined. The percent total abortion for each variety on the main-stem, branches and as whole plant for both plantings was partitioned into that which occurred as flower abortion and that which occurred as pod abortion. These values are presented in Table 6. Total abortion was higher following the June planting compared to the July planting.

The percent total abortion for the whole plant following both plantings was highest in the varieties Centennial and Pickett 71. Essex aborted a percentage similar to the indeterminate varieties Mitchell and K1033 with 55.8, 54.9 and 57.8 percent respectively following the June planting and 49.6, 49.0 and 48.2 percent respectively following the July planting. Forrest was mid-range between the indeterminate varieties Mitchell and K1033 and the determinate varieties Centennial and Pickett 71. On a whole plant basis, more pods than flowers were aborted except for the varieties Centennial and Pickett 71 in which more flowers than pods were aborted following both plantings.

Along the main-stem a larger portion of the aborted structures were flowers rather than pods in varieties Forrest, Centennial and Pickett 71 whereas Mitchell, K1033 and Essex aborted a larger percent as pods following the June planting. Following the July planting Mitchell and K1033 again aborted more pods than flowers on the main-stem whereas the reverse was true for three of the other four varieties. Essex aborted about equal percentages of flowers and pods on the main-stem following the July planting.

Table 6. Percent of the reproductive structures aborted as flowers versus pods along the main-stem, branches and whole plant of six soybean varieties following two dates of planting.

Variety		June 6 Planting			July 2 Planting		
		Main-Stem	Branches	Whole Plant	Main-Stem	Branches	Whole Plant
		%			%		
Mitchell	Flowers	10.7	5.3	7.6	10.5	14.5	12.6
	Pods	36.7	55.6	47.3	32.8	39.7	36.4
	Total	(47.4)	(60.9)	(54.9)	(43.3)	(54.2)	(49.0)
Kl033	Flowers	17.9	9.1	14.1	11.3	15.2	13.0
	Pods	34.8	55.6	43.7	32.6	38.8	35.2
	Total	(52.7)	(64.7)	(57.8)	(43.9)	(54.0)	(48.2)
Forrest	Flowers	37.2	5.7	17.9	39.3	23.7	28.3
	Pods	32.4	60.3	49.5	19.4	35.1	30.5
	Total	(69.6)	(66.0)	(67.4)	(58.7)	(50.3)	(58.8)
Essex	Flowers	15.0	0.0	7.1	22.7	16.4	19.7
	Pods	40.9	55.6	48.7	21.4	37.8	29.9
	Total	(55.9)	(55.6)	(55.8)	(44.1)	(54.2)	(49.6)
Centennial	Flowers	67.2	49.1	53.4	52.5	45.1	47.9
	Pods	30.5	32.2	30.4	21.2	26.8	23.9
	Total	(97.7)	(81.3)	(83.8)	(73.7)	(71.9)	(71.8)
Pickett 71	Flowers	57.5	40.0	45.2	34.7	31.6	32.9
	Pods	20.6	32.1	28.8	27.0	35.8	32.0
	Total	(78.1)	(72.1)	(74.0)	(61.7)	(67.4)	(64.9)

The percent total abortion along the main-stem ranged between Mitchell with 47 percent and Centennial with 97 percent following the June planting. Following the July planting a reduction in the percent total abortion occurred on all varieties and again Mitchell was lowest with 43 percent and Centennial was highest with 74 percent.

Along the branches, pod abortion accounted for more of the total abortion than did flower abortion except for the varieties Centennial and Pickett 71 which aborted a larger portion as flowers following both plantings. Following the June planting Centennial and Pickett 71 aborted the largest percent of their total reproductive structures (flowers plus pods) with 81 and 72 percent respectively. All other varieties aborted between 55 and 64 percent of their reproductive structures initiated along the branches. Following the July planting Centennial and Pickett 71 aborted the largest percent of the reproductive structures with 72 and 67 percent respectively. Mitchell, K1033 and Essex all aborted 54 percent and Forrest aborted 50 percent of the reproductive structures initiated along the branches following the July planting.

Reproductive Efficiency on the Main-stem, Branches and Whole Plant

The percentage of initiated reproductive organs (flowers and pods) which are brought to maturity was designated as reproductive efficiency. Those reproductive organs which were lost as flowers or pods reduced the level of reproductive efficiency. The level of reproductive efficiency in both plantings is shown in Table 7.

The efficiency of all varieties was lower in the June planting than in the July planting for the main-stem and branches as well as whole

Table 7. Reproductive efficiency of six soybean varieties along the main-stem, branches and whole plant within two planting dates.*

Variety	June 6 Planting			July 2 Planting		
	Main Stem	Branches	Whole Plant	Main Stem	Branches	Whole Plant
	%			%		
Mitchell	52.6	39.1	45.0	56.7	45.7	51.0
K1033	47.3	35.3	42.2	56.1	46.0	51.8
Forrest	30.3	33.9	32.5	41.3	41.1	41.1
Essex	44.1	44.4	44.2	55.8	45.7	50.3
Centennial	2.2	20.5	16.2	26.3	26.5	28.1
Pickett 71	21.8	27.8	26.1	38.3	32.5	35.1

*Reproductive efficiency was defined in this study as the percent of the reproductive structures initiated which were brought to maturity.

plant. The highest levels of reproductive efficiency in the June planting occurred in Mitchell, K1033 and Essex, 45.0, 42.2 and 44.2 percent respectively. The lower range of reproductive efficiency on a whole plant basis was in Centennial and Pickett 71 with 16.2 and 26.1 percent efficiency. Forrest was mid-range with 32.5 percent efficiency.

The July planting resulted in higher rates of reproductive efficiency for the main-stem, branches and whole plant. Mitchell, K1033 and Essex were highest with 51.0, 51.8 and 50.3 percent respectively. Centennial and Pickett 71 were the lowest in the July planting with 28.1 and 35.1 percent respectively. Forrest was mid-range again with 41.1 percent efficiency.

The higher efficiencies in the July planting might be due to the lower initial number of flowers initiated and thus lower numbers of flowers aborted.

Mitchell and K1033 were more efficient in producing pods along the main-stem than the branches in both plantings. Equal amounts of efficiency were observed in Forrest and Pickett 71 in both planting dates. Centennial expressed equal reproductive efficiency on the main-stem and branches following the July planting, but higher efficiency on the branches than the main-stem following the June planting. The reproductive efficiency of Essex was similar to Mitchell and K1033 following the July planting in that it was more efficient in setting pods on the main-stem than on the branches. However, following the June planting Essex was equally efficient at setting pods on main-stem as on branches.

The reduction of reproductive efficiency during the June planting could possibly have been due to an overproduction of flowers.

Subsequently the plants could not supply the necessary assimilates for all the flowers and pods that were initiated and the result was aborted organs.

Seed Yield, Weight and Number

Following the June planting Forrest had the highest seed yield with 64.2 q/ha followed by the maturity group IV varieties, Mitchell and Kl033, with 63.3 and 51.7 q/ha respectively (Table 8). Essex which is the same maturity group as Forrest, yielded lower than the maturity group IV varieties, Centennial and Pickett 71, 27.3 versus 47.0 and 36.2 q/ha respectively.

Variation for yield following the July planting showed that Forrest yielded the highest with 42.2 q/ha followed by Mitchell and Pickett 71 with 33.2 and 24.9 q/ha respectively. Kl033 and Essex did not differ with 22.1 and 22.3 respectively. The lowest yield was for Centennial with 15.6 q/ha.

Following both plantings Forrest produced the highest yield. However, Forrest did not produce the highest number of seed following the June planting. Comparing Mitchell and Forrest following the June planting, it can be seen that a lower yield resulted although higher numbers of seed were set per plant in the variety Mitchell. The lower weight of 100 seed accounts for the resulting lower yield in Mitchell versus Forrest, 63.3 and 64.2 q/ha respectively.

Following the July planting Forrest produced a higher yield than Mitchell, 42.2 and 33.2 q/ha respectively, even though the seed weight of Forrest was lower than that of Mitchell, 11.4 and 13.8 grams respectively. The higher seed number of Forrest compensated for the lower

Table 8. Seed yield, number and weight of six soybean varieties following two dates of planting.

Variety	June 6 Planting			July 2 Planting		
	Yield	Seed Per Plant	Weight of 100 Seed	Yield	Seed Per Plant	Weight of 100 Seed
	-q/ha-	-no.-	-g-	-q/ha-	-no.-	-g-
Mitchell	63.3	177	14.3	33.2	96	13.8
K1033	51.7	113	17.9	22.1	55	16.1
Forrest	64.2	125	14.7	42.2	145	11.4
Essex	27.3	81	13.4	22.3	71	12.5
Centennial	47.0	120	14.3	15.6	53	11.6
Pickett 71	36.2	104	13.9	24.9	85	12.6

seed weight. The combination of the fewer seed per plant and lower seed weight following the July planting resulted in lower yields for all six varieties.

Following the June planting K1033 had the highest weight of 100 seed with 17.9 grams. All the other varieties ranged between 13.4 grams for Essex to 14.7 grams per 100 seed for Forrest. A reduction in the weight of 100 seed was observed following the July planting in all varieties. K1033 was again the highest with 16.1 grams per 100 seed. The other varieties ranged between 11.4 and 13.8 grams.

The reduction in seed number following the July planting was similar to the pattern of pod production and abortion. A larger number of pods was harvested following the June planting versus the July planting. Forrest produced fewer pods but more seeds per pod in the July planting than in the June planting. The lowering of seed number per plant in all varieties was a result of reduction in the number of pods produced and harvested following the July planting.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The six soybean varieties evaluated in this study differed significantly in the number of flowers and pods which were produced and aborted following the June and July dates of planting. In production of flowers, Forrest did not significantly differ from Centennial or Pickett 71 following the June planting nor from Centennial, Pickett 71 and Mitchell following the July planting. Centennial and Pickett 71 significantly differed from all other varieties for flower abortion following the June planting. Maturity group IV varieties Mitchell and K1033 aborted significantly fewer flowers than all other varieties which did not significantly differ from each other following the July planting.

Varieties did not differ in number of pods which they produced on a whole plant basis following the June planting. However, significant differences were observed among varieties for pod production along the branches following the June planting. K1033 produced significantly fewer pods than any other variety along the branches. Pod production following the July planting showed that Mitchell, Forrest and Pickett 71 produced significantly more pods than K1033, Essex and Centennial on a whole plant basis. Following the June planting Forrest aborted significantly more pods on a whole plant basis than all other varieties. Following the July planting Forrest, Pickett 71 and Mitchell did not differ significantly from each other in pods aborted on a whole plant basis but they did abort significantly more pods than K1033, Essex and Centennial.

The two dates of planting had significant effects on the variety profiles in terms of the number of nodes bearing flowers and pods along the main-stem and branches. In general the varieties produced more nodes bearing flowers and pods along the main-stem and branches following the June planting than following the July planting. Fewer branches were initiated following the July planting as well as a reduction in the number of nodes along the branches. The reduction in flowering nodes could possibly account for the reduction in flower and pod number observed following the July planting. Double branching or the initiation of two branches at the same node was most prevalent following the June planting in the variety Forrest. Following the July planting shorter, more compact plants were observed with double branching at fewer nodes.

Following the June planting, flower and pod production was heavier on the branches than main-stem with the exception of K1033 which produced more flowers and pods along the main-stem. Following the July planting flower production was again heavier on the main-stem than branches for K1033, more equally distributed for Mitchell, Essex and Centennial and heavier on the branches than main-stem for Forrest and Pickett 71. The percent flower abortion did not follow the same pattern as flower production. Percent flower abortion following the June planting was higher along the main-stem than branches for all varieties. The highest percent abortion along the main-stem occurred in Centennial and Pickett 71, 67 and 57 percent respectively. However, percent flower abortion was higher along the main-stem than branches for all varieties except Mitchell (14 versus 10 percent) and K1033 (15 versus 11 percent) following the July planting.

Following both plantings pod production was heavier along the branches than main-stem in all varieties except K1033. No significant differences were observed for pod production along the main-stem following either planting. Following the June planting, Forrest produced significantly more pods than K1033 along the branches.

Percent pod abortion was heavier along the branches than main-stem for both plantings. The heaviest pod abortion along the branches occurred in Forrest (64 percent) following June planting and in Pickett 71 (52 percent) following July planting. The other varieties ranged from 53 to 61 percent following the June planting and 45 to 51 percent following the July planting for pod abortion along the branches.

By partitioning the plant profile of the varieties into thirds (lower, middle and upper), the results indicate that flower production along the main-stem was heaviest along the middle one-third of the plants for Mitchell, K1033, Forrest and Essex following the June planting and all varieties following the July planting. Pickett 71 produced about equal percentages of its flowers in the middle and upper one-thirds following the June planting. Centennial more equally distributed the percent flower production between the middle and upper one-third. Flower abortion followed the same pattern as flower production by the thirds of the plant.

Flower production on branches following both plantings was heaviest along the branches on the lower one-third of the plants except for Centennial and Pickett 71 which produced a larger proportion of flowers on branches originating along the middle one-third of the plant following the June planting. Flower abortion along the branches followed the same pattern as flower production for both plantings.

Pod production along the main-stem was heaviest along the middle and upper one-thirds of the plant following the June planting. Following the July planting pod production was heaviest along the lower one-third of the main-stem. The greatest amount of pod abortion occurred on the same thirds of the main-stem which had the highest pod production.

Pod production along the branches was concentrated on branches produced along the lower one-third of the plant except for Centennial and Pickett 71 in which pods were about equally prevalent on branches along the lower and middle one-thirds of the canopy following both plantings. Pod abortion followed the same pattern.

The percent total abortion following both plantings was highest in varieties Centennial and Pickett 71 and lowest in Mitchell following the June planting and K1033 following the July planting. Essex aborted a percentage similar to the indeterminate varieties following both plantings. Forrest was mid-range between the indeterminate varieties Mitchell and K1033 and the determinate varieties Centennial and Pickett 71. On a whole plant basis, pod abortion accounted for more of the total abortion than did flower abortion following both plantings except for the varieties Centennial and Pickett 71. These two varieties aborted more flowers than pods. By partitioning total abortion into that which occurred on the main-stem versus branches, Forrest aborted a larger percent as flowers than pods along the main-stem following both plantings. On the other hand, Essex aborted more flowers than pods along the main-stem only following the July planting. Centennial and Pickett 71 aborted a higher percent of flowers than pods along the main-stem following both plantings. Centennial aborted more flowers than pods along the branches

following both plantings whereas the same was true for Pickett 71 only after the June planting.

Essex, a determinate group V variety, performed similar to the indeterminate maturity group IV varieties, Mitchell and Kl033, for patterns of flower production and abortion. Forrest which is also a determinate variety of maturity group V performed differently than all other varieties. Centennial and Pickett 71, both determinate, maturity group VI varieties, performed most similar to each other for number of flowers produced and aborted. No trend for pods produced or aborted was observed for among maturity groups.

A lower yield, and seed weight, was observed for all varieties following the July planting compared to the June planting. A reduction in the number of seed per plant was observed following the July planting compared to the June planting in all varieties except Forrest. The reduction in seed number and seed weight following the July planting accounts for the reduction in yield. Although more seed were produced following the July planting for Forrest the reduction in seed weight was enough to reduce yield.

In conclusion, variation does exist in flower and pod production and abortion among the six soybean varieties. Differences do not follow patterns of growth habit or maturity.

More flowers and pods were produced by all six varieties following the June planting than following the July planting. The varieties also aborted a larger percent of their flowers and pods following the June planting than after the July planting.

Fewer nodes were produced along the main-stem as well as branches following the July planting compared to the June planting. This resulted in fewer fruiting sites and fewer flowers and pods being produced.

By partitioning the plant canopy profile into one-thirds, the greatest concentration of flower and pod production as well as abortion following the July planting was along the middle one-third of the main-stem. On the branches the greatest concentration was on those originating along the lower one-third of the plant profile. Contrasting this with the June planting, the more extensive growth resulted in more flower and pod production and abortion along the upper one-third of the main-stem. No change was observed for location of production and abortion along the branches.

More of the total abortion occurred as pods than as flowers following both plantings except in the varieties Centennial and Pickett 71 in which more of the total abortion occurred as flowers.

Higher reproductive efficiency was observed following the July planting because of lower rates of abortion. However, those varieties which produced large numbers of pods did not produce the highest yield. Neither did those varieties with the highest reproductive efficiency have the highest yields. Lower seed weights were observed when higher numbers of seed were produced. Thus, the combination of lower seed weights and fewer seed resulted in lower yields following the July planting.

Because variation exists among soybean varieties in flower and pod production and abortion the potential for increasing the reproductive efficiency of soybeans appears to be one logical approach to improving yield.

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