EFFECT OF VARIETY AND DATE OF PLANTING ON YIELD AND OTHER CHARACTERISTICS IN SOYBEANS

by

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ABSTRACT

The study was carried out during 1964 at the Agricultural Research and Education Center in the Beqa'a plain, to evaluate the effect of four dates of planting and four varieties of soybeans on their yield, protein and oil content and other agronomic characters.

The seed size, the number of seeds per pod and the protein and oil percentage of soybeans were not influenced greatly by the different dates of plantings used. Higher seed yields and the greater number of pods per plant were obtained from the second date of planting made on April 18. The number of days required from sowing to flowering and to maturity decreased as the planting dates were delayed from April 4 to May 18.

The four varieties used varied widely in their agronomic characteristics. The variety Linderin produced the highest yield with the highest protein percentage in the seeds. Wabash had the tallest plants that produced small seeds low in protein and oil content. Clark excelled in the total dry matter and number of seeds per pod. Perry possessed the largest seeds with few seeds per pod.

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INTRODUCTION

The rapid increase of soybean cultivation in the world has created "a new era of its revolution" in the field of agriculture. Within a short period of 12 years from 1950 to 1962 the world production of soybeanshas increased by 89 percent with an increase of its acreage by 70 percent (20). Probably no other crop has ever become so popular in such a short period as has the soybean.

With the increase of knowledge of nutrition, people started realizing the importance of soybeansas a food and feed. Its importance is due to its high protein content and oil of high energetic value and complete digestability (35).

Regarding its origin and history, Weiss (54) stated: "The first recorded evidence of its existence is thought to be in Chinese literature in 2838 B.C., but it is considered to have been extensively cultivated in China centuries prior to this date". The soybean was considered as one of the five sacred grains which were essential to the existence of Chinese civilization (36). It was also regarded as having many medical virtues for both man and animal.

Soybean production was limited almost entirely to the Far Eastern countries until the end of the nineteenth century, afterwards it spread rapidly to different parts of the world. The leading growing countries are:- United States, China, U.S.S.R., Indonesia, Japan, Korea, Canada and Brazil. As evidenced from the FAO report in 1961-1962 (20) the biggest world production was obtained in the United States (18.5 million metric tons), the largest area was covered in China (32.5 million acres) and the highest yield of the bean was obtained in Canada (1874

pounds per acre).

In the United States it was considered as a hay crop in the early years of its production. Even in 1940, 4.8 million acres were harvested for hay which was equal to that harvested for beans (33). Gradually, the proportion of soybeans for hay was reduced. The area of soybeans has been increased from 0.19 million acres in 1920 to over 26 million acres in 1961 (13). It occupies the first place among the oil seed crops in the Western Hemisphere.

In general, the soil and climatic conditions required for the satisfactory production of soybeans are almost the same as that of corn. However, the performance of soybeans is comparatively better than corn under adverse conditions, especially when the soybeans are properly inoculated (36). Often soybeans have been described as a "poor land" crop, because of their comparatively better response to natural fertility of the soil rather than to added fertilizers (54).

Most probably the cultivated soybeans are descended from Glycine ussuriensis, a wild type that is grown in Eastern Asia. The present accepted botanical name for soybeansis Glycine max, formerly Soja max or Glycine hispida (43).

Soybeans are a new crop of Middle Eastern countries and their expansion appears to be very promising. Soybeans can supply the best source of vegetable protein to supplement the high demand for meat protein when they become fully established. As it is a new crop in this area, considerable information is needed regarding varieties, cultural practices and other factors to determine how the plant can be best adapted and grown in this area.

The purpose of the present study, therefore, was to evaluate the

effect of different dates of planting on the yield and other agronomic characters of different varieties of soybeans when grown under irrigated conditions in the central Beqa'a plain of Lebanon.

REVIEW OF LITERATURE

Soybeans are recognized as a short day plant. They are very sensitive to photoperiodism. In general, day length and soil temperature as well as the rainfall determine the best time to plant soybeans in a particular area.

The importance of improving cultural practices for this crop was emphasized by Cartter and Hartwig (13) who stated "probably no single factor is more important to soybean production than the planting date".

Environment and Date of Planting

Howell (31) stated "the soybean plant is very sensitive to changes in its environment, and its growth responses are much less fixed than might be inferred", and "environmental variation remains a major factor affecting soybean production".

Studying the effect of day and night on growth and reproduction of soybeans, Garner and Allard (23) reported that each particular variety has its own critical length of day.

In comparing the relation between day length and latitude, Johnson et al. (32) and Morse (36) stated that a particular variety is adapted to a comparatively narrower belt of north and south and a relatively wider belt of the east and west.

Weiss (54) in an extensive review of the literature reported the minimum climatic requirement for soybeans as being a 5-month growing period during which a total accumulated temperature of 2400 °C and the total precipitation of 300 mm. are required. A similar statement was reported in the Potash Pocket Book (42) which stated than an average

temperature of 75 °F is required during the summer.

Brown (9) stated that a minimum temperature of 50 °F is required for germination and growth of soybeans. Howell (31) reported that the shortest time for germination occured at a constant temperature of 86 °F, while at 68 °F the time required for germination was doubled. Cartter and Hartwig (13) stated that excess moisture or prolonged drought is likely to be injurious at the time of germination.

The effects of precipitation were studied critically by Runge and Odell (45). They reported that too much moisture at the early growing stage is detrimental, while the yield increased with the abundant rainfall during the vegetative growth, blooming period and pod filling stage. However, heavy rainfall associated with cloudiness during the early pod stage cause the young pods to drop off, and at late maturing stage causes lodging and shattering.

Morse (36) discussed the time of planting in several countries. In the Philippines he reported that higher yields of soybeans were obtained when planted during the rainy seasons than that of the crops planted in the drier season. In the United States he reported that the time of planting of soybeans extends from early spring until mid-summer depending on the variety, latitude and purpose. In the southern states, long durational varieties are planted in early April but for early varieties planting was extended as late as June. For green manure, pasture and hay soybeans may be planted even in the early part of August. In the northern states, where the growing season is limited by lower temperatures, May plantings were considered to be the best. In Manchuria, the planting time was extended from April 25 in the south to May 20 in the north. Similarly, in China the time of seeding ranges from April in the south

to as late as June in the north. In Japan, the planting time ranges from April in the southern and western regions, to as late as early June in the northern and eastern sections. In the Netherland Indies planting was done from March 15 to May 15.

Smartt (48) reported that the best time of planting in Northern Rhodesia was from late November to early December. In Vietnam (6) the best yields were obtained from the September plantings. In Tanganyika, the Department of Agriculture (5) reported that when the planting date was delayed from December 11 to December 28, the yield of soybeans came down to 499 pounds from 795 pounds per acre.

Seed Yield

Seed yields are the most important component of soybean production. The seed yields are effected by the factors which influence the flowering and pod formation as well as the weight of the unit number of seeds. Optimum yield cannot be obtained unless the plant attains its optimum growth.

Lu and Tsai (34) conducted an experiment with 60 varieties of soybeans at 10 dates of planting and found that the yields of most of the varieties were directly proportional to the length of the growing period.

Weiss (54) stated that relatively small differences in yield occur on successive plantings throughout the first month of the frost-free date when adapted varieties are planted. Further delay in the planting date causes a greater reduction in the yield of the late varieties. Osler and Cartter (39) and Torrie and Briggs (51) also found that late plantings delayed the early varieties more than the late maturing varieties.

Dimmock and Warren (18) found that the reduction in yield was mainly due to the reduction of the number of seeds per plant rather than the seed size.

Cartter and Hartwig (13) and Johnson et al. (32) stated that usually the yield is less when a full season variety matures before the end of the growing season. They reported that in the northern regions, the highest yield can be obtained when a full season variety utilizes most of the growing season. In the southern areas late varieties have a broader range of planting dates to produce higher yields. They suggested that early varieties can be planted rather late without losing too much yield.

Feaster (21) stated that early varieties should be planted later than late varieties. When an early variety is planted early, it produces seed during the unfavourable hot and dry conditions in the summer. Highest yields from early maturing varieties can be obtained if blooming and seed formation occur immediately after the hot and dry period.

Abel (1) in the Imperial Valley of California and Caviness and Smith (15) in Arkansas, found that extremely early planting did not result in good yields. It was found that the May plantings were better than the April or the June plantings. Abel (1) and Smith et al. (49) found that the highest yields were obtained from the late and medium maturing varieties.

Garner and Allard (24) and Parker and Borthwick (40) found that the yield of Biloxi soybeans was increased with the increase of artificial light period from 8 to 13 hours.

Camper and Smith (12) found that when the planting date is delayed, the use of narrow rows with higher seeding rate can increase

the yield but not as good as the early sowing.

Uklien (52) stated that the soil moisture at 80 percent field capacity throughout the vegetative, flowering and pod filling stages increased the yield.

Dry Weight and Plant Height

The dry weight and plant height are primarily influenced by the temperature. Light plays an indirect role on these characters.

Howell and Cartter (30) found that the number of nodes and stem weight increases with the increase of temperature.

Earley and Cartter (19) found that the dry weight production was almost restricted at root temperatures as low as 12 °C and as high as 37 °C. Optimum plant heights were obtained under high light intensity and vice-versa. Morse (36) stated that the growth rate declines at a temperature above 100 °F. Brown (9) studied the rate of development with temperature and found the unit of development as follows:- 0 at 50 °F, 16 at 60 °F, 27 at 70 °F, 32 at 80 °F, 33 at 86 °F and 32.5 at 90 °F.

Brown and Chapman (10) found that the effect of temperature on the development of the soybean was highly correlated in the pre-flowering and post-flowering stage (maximum podding to maturity) rather than the actual flowering stage. The rate of development at the post-flowering stage was only half of that of the pre-flowering stage.

Garner and Allard (25, 26) stated that the differences in height from year to year from the same date of planting are mainly due to temperature fluctuations. Garner and Allard (23) stated that promoting the reproductive phases curtailed the vegetative growth.

Parker and Borthwick (40) and Garner and Allard (24) found

that, in Biloxi soybeans, dry weight and plant height were increased with the increase of photoperiod from 8 to 13 hours. Initially, the rate of growth was the same from 8 to 13 hours but the rate of growth decreased by the earlier flower initiation with the reduction of photoperiod. Greater height was obtained as the photoperiodic hours were increased further. A similar condition was found in the Peking soybean variety by Allard and Garner (3) in that the size of the leaves, plant height and dry weight were proportionately increased with the increase of photoperiod.

Vanschaik and Probst (53) found that at the higher temperatures and at longer photoperiods the plant grew faster.

Abel (1) and Caviness and Smith (15) found that extremely early planting reduced the plant height due to low soil temperature. They found greater plant heights in the May plantings than in the April or the June plantings.

Garner and Allard and other workers (6, 23, 39, 51, 54) found that the plant height decreased as the planting dates were delayed. Long durational varieties were affected more than the early varieties.

Johnson and Bernard (33) found a negative correlation between height and earliness. Morse (36) stated that with a few exceptions earliness is correlated with the size, the tallest variety being the latest.

Lodging

Caviness and Smith (15) and Torrie and Briggs (51) did not find any relationship between the planting date and lodging. They stated that severity of lodging is not associated with plant height.

Abel (1) stated that lodging decreased as the planting dates were delayed, whereas, Osler and Cartter (39) stated that delay in planting was associated with greater degree of lodging.

Johnson and Bernard (33) found a negative correlation between height and lodging resistence which is a serious problem in the south while in the north, height is limited by early maturity.

Oil and Protein

Much interest has been centered on the effect of environment on the protein and oil synthesis. Many workers found a negative correlation between oil and protein in a particular variety.

Feaster (21) did not find any appreciable effect on the oil percentage with various dates of planting, except the last date of planting which had a lower oil percentage. He found that the amount of protein had more or less a tendency to vary inversely with the oil content.

Osler and Cartter (39) and Weiss et al. (55) found that the oil percentage decreased and the protein percentage increased with the delay in planting though it was not consistent among the varieties.

Collins and Cartter (17) found that higher yields were associated with higher oil percentage. They also found that the seeds of the lower half of the plant were 0.5 percent higher in oil and one percent lower in protein content than those of the upper part of the plant.

Dimmock and Warren (18) reported that in two full season varieties, the oil percentage decreased as the planting dates were delayed. The protein content showed a slight tendency to increase with the delay of planting.

Torrie and Briggs (51) stated that the date of planting had little effect on the oil content of the early varieties, but it decreased in the late varieties with the delay in planting. They found no effect of date of planting on the protein percentage. Garner et al. (22) failed to find any relation between date of planting and oil content.

Weiss (54) reported that in the same variety of soybeans, when grown at 11 widely separated locations, the oil content varied from 12.7 to 22.1 percent and the protein varied from 32.6 to 44.3 percent in the same year. In the same field, oil and protein percentage differed by 2.9 and 4.2 percent, respectively. This indicated that climatic variation influenced the percentage of oil and protein in soybeans more than did the soil variation.

Morse (37), from an extensive review of literature, reported that, with every degree in the rise of temperature, an increase of 0.44 percent oil and 0.39 percent decrease in protein content may be expected. Soybeans grown under high temperatures prevailing in Oklahoma were higher in protein content and lower in oil content than those grown in other parts of the country.

Howell and Cartter (30) conducted a green house experiment under the controlled temperature of 70, 77 and 85 degrees Fahrenheit during the pod filling stage of soybeans and found that the average oil content of the seeds was 19.5, 20.8 and 23.2, respectively. They (29) found higher positive correlations between the oil content and the temperature when they increased the temperature for a period of 10 days, from 20 to 30 days and 30 to 40 days prior to maturity. This indicated that the temperature during this period had a great effect on oil synthesis of the soybean seeds. They also found that the maximum

temperatures were more closely correlated with oil percentage of the northern varieties, whereas, minimum temperatures were more closely correlated with oil percentages in the southern varieties.

Schwab et al. (47) indicated that the yield of soybeans was increased by 40 to 50 percent by irrigation, but the oil decreased by four percent and the protein content increased by 3.3 percent at Conesville, Iowa.

Seed Quality -

The seed quality is influenced by the environmental conditions that prevail during the time of maturation.

Cartter and Hartwig (13) stated that high temperatures and high humidity during the seed development stage produced seeds of poor quality. Very high temperatures and dry conditions may arrest the seed maturation and produce green and shrivelled seeds. Cool and dry conditions favour the production of good quality seed.

Feaster (21) stated that the date of planting had little effect on seed quality of the late maturing varieties but early varieties when planted early, produced seeds of poor quality. Abel (1) and Torrie and Briggs (51) also stated that seed quality tended to be better by delayed planting.

Rouse (44) stated that early planting produced pods closer to the ground and seed quality was lowered due to the increase in the rotting of the pods. While Greens et al. (27) stated that early planting of short season varieties, if matured before the occurence of hot and dry weather conditions produced good seeds with a high germination percentage.

Garner et al. (22) did not find any correlation between date

of planting and seed size. They concluded that seed size was heritable. Dimmock and Warren (18) and Weiss et al. found that seed size of late maturing varieties tended to be decreased with the delay in planting, but Osler and Cartter (39) did not find this relationship.

Flowering and Maturity

Many workers have found that flowering and maturity of the soybeans are greatly influenced by the photoperiodic condition and partly by temperature. Soybeans have been widely accepted as a short day plant, but varieties differ in their critical length of day.

The response of a particular variety to the day length determines the earliness and lateness of that variety. Borthwick and Parker (8) and Howell (31) stated that floral initiation of early varieties occurs for comparatively longer photoperiods than for the full-season varieties.

Howell (31), Johnson et al. (32), Morse (36) and Williams (56) stated that northern varieties have longer critical length of day than the southern varieties for flower and fruit initiation. Late maturing varieties of the south often fail to bloom in the north due to longer day length, whereas, the northern varieties in the south produce early flowering due to the short day condition.

Garner and Allard (24) observed that Peking soybeans, when germinated in a green house on March 31 and April 13, produced the first flower on May 12 (after 42 days) and July 16 (after 94 days), respectively, while Biloxi soybeans planted on the same dates did not produce flowers until September. Biloxi is considered to be an early flowering variety when planted in winter or early spring in the green house.

Morse (37) stated that the date of blooming is governed by the date of planting and photoperiodic characteristic of the variety.

Cartter and Hartwig (13) believe that the term early-, medium-, or late-maturing of soybeans are limited to a specific location when planted at a particular date. Garner and Allard (23) stated that the reproductive phase is promoted by the action of shortening the light period. Garner and Allard (26) found that the very early variety and the very late variety, when grown under the summer conditions in Washington with an artificially short day length, both behaved like early varieties by producing flowers within 20 to 25 days after germination.

Parker and Borthwick (40) observed the effect on the initiation of flowering and fruiting of Biloxi soybeans with eight different photoperiodic hours ranging from 8 to 18 hours. They found that with the increase of light hours, flowering was delayed except there was no occurance of flowers at 16 and 18 hour light period. Poor flower initiation occured at 14 and 15 hours having no formation of pods. The number of flowers increased with the increase of photoperiods from 8 to 13 hours. Allard and Garner (3) found similar results in Peking soybeans that initiation of flower was increased with the increase of light from 6 to 10 hours.

Borthwick and Parker (7) found that the minimum intensity of light for initiation of flowers in Biloxi soybeans was 100 foot candles for eight hours. In another experiment, they (8) showed that when 50 days old plants were subjected to nine different photoperiods ranging from 8 to 24 hours, flower initiation occured in seven early varieties out of 12 varieties. This indicated that darkness was not a necessary condition for the floral initiation, but none of the varieties produced any pods above 16 hours photoperiod.

Garner and Allard (26) stated that cool temperatures tended

to delay flowering. They found that summer temperatures below 75 to 77 °F caused two to three days delay in blooming for the decrease of every one degree Fahrenheit. They (25) further reported that the variations in dates of flowering from year to year, when planted on any particular date of planting, are due to the variations of the temperature.

Vanschaik and Probst (53) studied the effects of photoperiods and temperatures on flowering and fruiting of Midwest and Clark varieties. They found that as the temperature increased from 60 to 90 °F profuse and early flowering was initiated. With the increase in day length from 12 to 20 hours, flowering was delayed and the number of flowers were increased up to a specific period of light at a particular temperature for each variety. However, the percentage of flower and pod shedding was increased with the increase of temperatures and photoperiods. Initiation of the pods occurred earlier at 70 °F than either at 60 °F or above 70 °F.

Brown (9) interpretated the experiment of Vanschaik and Probst (53) by counting the reciprocal hours of night and found that at a particular temperature, cumulative hours of night of each variety was almost the same from planting to flowering, when photoperiod varied from 12 to 16 hours (i.e. 12 to 8 hours dark period).

Parker and Borthwick (41) found that temperature during the dark period produced great differences in flower initiation. Flowering was limited at a temperature of 55 °F while good floral initiation occurred at 65 °F only, with the rise of 10 °F during the dark period.

Brown and Chapman (10) reported that available moisture as well as the temperature correlated with the development rate of the flowering period. Moisture stress retarded the flowering period.

Abel (1) found that the number of days from planting to flowering

were reduced in late varieties rather than early varieties in successive planting, but the period from flowering to maturity was more in the early varieties than the late varieties.

Brown and Owen (11) found in the Mandarin variety that with a delay of 45 days, the period from planting to flowering was reduced by 28 to 35 days, while flowering to maturity was almost constant at about 66 days.

Caviness and Smith (14, 15) found that when planting was delayed by one month, maturity was delayed by more than two weeks in early varieties, whereas, in the late varieties it was delayed by three to seven days.

Torrie and Briggs (51) reported that maturity was delayed by one day for two days delay in planting. Morse (36) found three to four days delay in maturity for every 11 days delay in planting.

Cartter and Hartwig (13) concluded that in the Midwest, the average maturity date is retarded by one day for every three days delay in planting, although some varieties behaved differently.

Caviness and Walter (16) stated that soybeans usually mature earlier in the years of deficit soil moisture.

MATERIALS AND METHODS

The experiment on planting dates of soybean was carried out during the year 1964 at the Agricultural Research and Education Center of the American University of Beirut located in the Beqa'a plain 80 kilometers east of Beirut, Lebanon.

The soil was characterized according to Salib (46), as high in clay content, medium to low in organic matter, as well as nitrogen and quite variable in phosphorus and adequate as to exchangeable potassium. It is alkaline in reaction and calcareous with a pH of about 8.0.

Four improved varieties of soybeans, Clark, Linderin, Perry and Wabash, were included in this study. Clark was developed from a backcross of Lincoln X (Lincoln X Richard) (38). It has a reputation of superior performance in yield, lodging resistence, oil and protein content. Linderin is a new variety derived from a cross between Mandarin and Lincoln (5). It is regarded as being early in maturity and high yielding with high oil content of the seed. Perry and Wabash are the medium and late maturing varieties. Their performance was found to be superior in many places in the United States. All these varieties have been tested in the soybean varietal trials at the Agricultural Research and Education Center. They were found to be most adapted to the Beqa'a conditions, though considerable variations in the yield from year to year have been obtained (57).

Four dates of planting were selected on April 4, April 18, May 3 and May 18. The average monthly temperature and rainfall data of the central Beqa'a plain, from March to October for 1964 and average for other years since 1956, are shown in the appendix (Table 19). It is

evident from the data that there were large temperature deviations from the average during the early part of 1964. Though the average air temperatures of March and April of 1964 were 9.1 °C and 9.6 °C, respectively, the average soil-temperatures during these periods, at a depth of five centimeters on bare land, were 11.8 °C and 15.2 °C, respectively. The selection of the first date of planting at the early part of April in 1964 was quite justifiable as the soil was warm enough for good germination of the seeds.

The experimental plots were fertilized with a uniform application of 12 kg. of nitrogen in the form of ammonium sulfo-nitrate and 20 kg. of P_2O_5 in the form of superphosphate per dunum. The fertilizers were broadcast and disced into the soil before planting time. The plots received an additional amount of nitrogen at the rate of four kilograms per dunum as a side dressing in July.

Heptachlor was applied to the soil before planting to control cut worms. Metasystox was sprayed in the early part of August as a preventive measure against the leaf hoppers. However, diseases and insects were never a serious problem in the field.

The experimental plots were irrigated every week throughout the growing season. Sprinklers were used during the early season and later after the middle of June, furrow irrigations were done. The plots were kept free from weeds by regular weeding.

The experiment was laid out on a split-plot design with four replications having the dates of plantings as the main plots and the varieties as the sub-plots. Each sub-plot was made of four rows, five meters long and 50 cms. apart. The seeding rates were adjusted to obtain a uniform stand of about 165 plants per row. A laboratory germination

percentage for each variety was determined for determining the number of seeds planted per row. Scarification was done prior to each date of planting in the case of Linderin which contained 34 percent of hard seeds. The seeds of all varieties were inoculated by a commercial inoculum immediately before planting.

The data were collected from the central two rows of each sub-plot separately. Dates of flowering and pod-formation were recorded at the 50 percent blooming and podding stages. The date of maturity was recorded at the time of harvesting when most of the pods were fully matured and before any shattering took place. At the full maturing stage, four plants were selected at random from each sub-plot as the representative sample to determine the average height, the average number of seeds and the average pods per plant.

The two central rows of each sub-plot were harvested leaving one-half meter on both the ends to eliminate the border effect. The total dry weight including pods and stems were recorded after three weeks of sun curing. The seed yield and the weight of 1000 seeds were recorded on the same date after threshing and cleaning. The total dry weight and seed yield were reported in kilograms per dunum.

For protein and oil determination of the seeds, a representative sample from each sub-plot was dried, ground and weighed for analysis. The modified Kjeldahl method was followed to determine the protein percentage (28). Each sample was done in duplicate and if the results of duplicates differed from the mean sample by six percent or more it was repeated (2). The dry extraction method was used to determine the oil content (2, 28). It involved a continuous extraction of the fat soluble substances from the thoroughly dried soybean-meal by means of an anhydrous

solvent-ether. The percentages of protein and oil in the seeds were calculated on the moisture-free basis.

Statistical methods appropriate to the split-plot design were used to analyse the data (50). Analysis of variance, F test and 't' test were calculated to appraise the significance of the results.

RESULTS AND DISCUSSION

The purpose of this experiment was to evaluate the effect of the various dates of planting of four adapted varieties of soybeans on their seed yield, total dry weight (stems, seeds and pods), protein and oil percentages of the seeds, plant height, number of days from planting to flowering, weight of 1000 seeds, number of pods per plant and number of grains per pod. The data are presented in Tables 1 to 9 on the characters mentioned above. The analyses of the variances are given in Table 10 to 18 in the appendix. The L.S.D. figures at the five percent and one percent levels are shown at the bottom of each table (Table 1 to 9) only for those treatments which were found to be significant. The number of days from planting to maturity with demarcation of flowering and pod formation stages are presented in the form of a histogram in Fig. 1.

Seed Yield

The average grain yield of the soybeans was found not to be influenced significantly by the various dates of planting as shown in Table 1. However, every variety produced the most seed when planted on April 18, except Linderin which yielded the highest from the planting made on April 4. The crop planted on April 18 gave the highest average yield of 190.5 kg. per dunum. The average yield of the four varieties was reduced by 12.6 kg. per dunum when planted a fortnight earlier or later than April 18. The lowest yields were obtained from the May 18 plantings. In Arkansas, Caviness and Smith (15) found that the May planting was better for yield than the April or June plantings. The different varieties used in this study, however, did not respond

Table 1. Average seed yield of soybeans in kg. per dunum as affected by date of planting and variety in 1964.

Variety	Date of planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	226.1	234.4	208.6	180.5	212.4
Linderin	220.6	215.3	208.7	211.4	214.0
Perry	139.2	164.3	146.5	143.3	148.3
Wabash	125.6	148.2	147.9	134.7	139.1
Date Mean	177.9	190.5	177.9	167.5	

	L.S.D. (5%)	L.S.D. (1%)
Varieties	20.3	27.2

Means

Varieties	Wabash	Perry	Clark	Linderin
	139.1	148.3	212.4	214.0+

+Treatment means underlined by the same line do not differ significantly from each other at 5% level.

similarly. Little reduction in yield was found in Linderin as affected by delay in planting, whereas, the yield of Clark was reduced considerably when planted after April 18.

Significant differences were found in the seed yield among the four varieties. Linderin and Clark produced the highest yield at each of the four planting dates. The difference in the yield of Perry and Wabash was not significant, but the yields of both of these varieties were significantly lower than that of Linderin or Clark. Wabash produced the lowest yield. A similar sequence of the yield of Clark, Perry and Wabash was found in several stations in Illinois as reported by Osler and Woodworth (38).

Total Dry Weight (stems, pods and seeds)

Significant differences in the total dry weight of the soybeans were not obtained on the various dates of planting as shown in Table 2. The highest dry weights were obtained from the crop planted on April 4 (627.8 kg. per dunum). The dry weight tended to decrease as the planting dates were delayed until May 3. The reason for this limited growth may be due to the reduction of the period from germination to flowering as caused by the delay in planting. The number of days from planting to flowering of April 4 and April 18 plantings was about the same (Table 6) but the germination of the April 18 planting was delayed as a result of unfavourable soil condition at sowing time.

The varieties differed significantly in their total dry weight production as can be seen from Table 2. Clark produced the highest amount of total dry weight, 673.0 kg. per dunum. Linderin produced the lowest total dry weight, 490.8 kg. per dunum. Perry and Wabash were

Table 2. Average total weight (dry stems, pods and seeds) of soybeans in kg. per dunum as affected by date of planting and variety in 1964.

Variety	Date of planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	687.5	694.4	669.4	640.6	673.0
Linderin	510.6	466.3	471.3	515.0	490.8
Perry	670.0	576.9	571.3	596.3	603.6
Wabash	643.1	591.3	553.1	580.0	591.9
Date Mean	627.8	582.2	566.3	583.0	

	L.S.D. (5%)	L.S.D. (1%)
Varieties	44.3	59.4

Means

Varieties	Linderin	Wabash	Perry	Clark
	490.8	591.9	603.6+	673.0

+Treatment means underlined by the same line do not differ significantly from each other at 5% level.

intermediate in dry weight production and the difference between these two was not significant.

Protein Percentage

The protein percentage of the seed was not affected significantly by the dates of planting studied as noted in Table 3. The crop planted on April 18 and May 18 contained 33.6 percent protein, while the protein content of the seeds obtained from the April 4 and May 3 planting was 33.4 and 32.8 percent, respectively. Torrie and Briggs (51) and Weiss (54) did not find any effect of different dates of planting on the protein percentage in soybeans.

The varieties differed significantly on the protein percentage in the seed as shown in Table 3. The highest protein percentage in the seed was obtained from Linderin, 34.2 percent, and the lowest from Wabash, 32.4 percent. In examining the plants in the field, it was observed that nitrogen deficiency symptoms were present in the leaves of Linderin, while Wabash produced leaves with deep green color and free from nitrogen deficiency. This would indicate that the variety Linderin was a heavier nitrogen feeder than Wabash. The varieties Clark and Perry contained an average of 33.2 and 33.6 percent protein in the seed. A similar relationship in protein content was obtained by Osler and Woodworth (38) with the varieties Perry, Clark, and Wabash when grown in Illinois.

Oil Percentage

The oil percentage of the soybean seeds was not influenced appreciably by the various dates of planting as shown in Table 4. Only the first date of planting (April 4) produced seeds with a higher oil content (23.7 percent). The oil percentages obtained from the soybeans

Table 3. Average protein percentage of dry seed of soybeans as affected by date of planting and variety in 1964.

Variety	Date of Planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	33.1	32.6	33.6	33.6	33.2
Linderin	34.2	34.6	33.7	34.4	34.2
Perry	34.2	33.8	32.6	33.6	33.6
Wabash	32.3	33.2	31.1	32.8	32.4
Date Mean	33.4	33.6	32.8	33.6	

	L.S.D. (5%)	L.S.D. (1%)
Varieties	0.97	1.30

Means

Varieties	Wabash	Clark	Perry	Linderin
	32.4	33.2	33.6	34.2+

+Treatment means underlined by the same line do not differ significantly from each other at 5% level.

Table 4. Average oil percentage of dry seed of soybeans as affected by date of planting and variety in 1964.

Variety	Date of planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	23.4	23.5	23.4	23.4	23.4
Linderin	23.8	22.8	23.4	23.4	23.4
Perry	24.0	22.8	23.4	23.4	23.4
Wabash	23.5	22.6	22.0	22.3	22.6
Date Mean	23.7	23.0	23.0	23.1	

	L.S.D. (5%)	L.S.D. (1%)
Varieties	0.42	0.56

Means

Varieties	Wabash	Clark	Linderin	Perry
	22.6	23.4	23.4	23.4 +

+Treatment means underlined by the same line do not differ significantly from each other at 5% level.

grown at the other dates of planting were almost similar. Howell and Cartter (29, 30) found that high day temperatures were associated with high oil content in soybeans. The meteorological data of the Agricultural Research and Education Center recorded higher temperatures from the mid-August to early September, which was the pod filling stage of the soybeans planted on April 4. The temperature was lower during the rest of the month of September with considerable fluctuation in the temperature from day to day. This might result in the somewhat lower oil percentages in the soybeans obtained from the later plantings as the temperatures during the pod-filling period was cooler. Garner et al. (22) did not find any appreciable effect of dates of planting on oil content except that the latest date of planting had a lower oil percentage.

The varieties of soybeans used in the study differed significantly in their oil content. Wabash produced seed containing the lowest percentage of oil (22.6 percent), while the varieties Clark, Perry and Linderin contained 23.4 percent oil.

Plant Height

The plant height of the soybeans was influenced only slightly by the various dates of plantings as shown in Table 5. There was, however, a definite trend of decreasing plant height as the planting dates were delayed from April 4 to May 3. Probably the reduction in plant height was due to the reduction of the growing period as reported by many workers (1, 26, 39, 51, 54). Increased plant height was measured in all of the varieties that were planted on May 18. A possible explanation for this might be due to the comparative higher temperature that occurred from the beginning of the growing season. Such a response of

Table 5. Average plant height in cms. of soybeans as affected by date of planting and variety in 1964.

Variety	Date of planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	132.4	131.2	131.2	147.9	135.7
Linderin	115.7	104.5	104.3	109.3	108.4
Perry	159.6	146.8	137.7	141.0	146.3
Wabash	158.0	160.7	143.1	163.5	156.3
Date Mean	141.4	135.8	129.1	140.4	

	L.S.D. (5%)	L.S.D. (1%)
Varieties	8.7	11.7

Means

Varieties	Linderin	Clark	Perry	Wabash
	108.4	135.7	146.3	156.3

a higher growth rate at higher temperature has been shown by Brown (9). The average total dry weight (Table 2) of the soybean plants responded similarly as did the average plant heights to the different dates of planting.

The varieties differed greatly as to plant height as noted in Table 5. The tallest variety was Wabash with an average height of 156.3 cms., while Linderin was the shortest variety, 108.4 cms. Similar sequence in plant height was obtained by Osler and Woodworth (38) with the varieties Clark, Perry and Wabash grown in Illinois.

Days from Planting to Flowering

Significant differences were obtained in the number of days from planting to flowering in soybeans influenced by the various dates of plantings as reported in Table 6. With the delay in planting dates, the flowering was also delayed, but the differences in the dates of flowering were smaller than the corresponding differences in dates of planting. The average dates of flowering of the soybeans planted on April 4, April 18, May 3 and May 18 were July 15, July 29, July 31 and August 9, respectively. It will be noted that soybeans planted on April 18 and May 3 flowered only two days apart. The apparent delay in flowering of the soybean for the April 18 plantings was probably due to the delay in germination that resulted from the 5.6 mm. of rainfall on April 17 which made the soil unfavourable for good sowing. On the basis of the averages, 20 days were reduced from planting to flowering for the 45 days delay in planting, though the reduction due to delay in the plantings were not the same in all of the varieties. Clark and Linderin were affected less than Perry and Wabash. The reduction in the number of days required from planting

Table 6. Average number of days from planting to flowering of soybeans as affected by date of planting and variety in 1964.

Variety	Date of planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	96.8	99.8	90.8	85.8	93.2
Linderin	91.0	89.0	79.5	75.0	83.6
Perry	106.2	107.8	90.0	81.5	96.3
Wabash	114.2	112.8	94.8	87.5	102.3
Date Mean	102.1	102.3	88.8	82.6	

	L.S.D. (5%)	L.S.D. (1%)
Varieties	2.7	3.6
Dates	2.9	4.1

Means

Varieties	Linderin	Clark	Perry	Wabash
	83.6	93.2	96.3	102.3
Dates	May 18	May 3	April 4	April 18
	82.6	88.8	102.1	102.3 +

+Treatment means underlined by the same line do not differ significantly from each other at 5% level.

to flowering is in agreement with that found by many other investigators (1, 11, 14, 15, 36, 39).

The varieties differed in number of days required from planting to flowering as shown in Table 6. Linderin required a minimum time to produce flower (83.6 days) and Wabash took the longest time to come into flowering (102.3 days).

There was a significant interaction between planting dates and the number of days from planting to flowering as shown in Table 15. The variety Clark, when planted on April 4, took less time to produce flowers (96.8 days) than Perry (106.2 days), whereas, on the last date of planting (May 18), Perry required only 81.5 days and Clark 85.8 days from planting to flowering.

Days from Planting to Maturity

The days required from planting to flowering, to pod formation and to maturity are illustrated by a histogram and shown in Figure 1. The average number of days required from planting to maturity was 178, 172, 156 and 145 days when planted on April 4, April 18, May 3 and May 18, respectively. The average number of days for the soybean varieties to mature was reduced by 33 days when planted on May 18 as compared to the sowings made 45 days earlier on April 4.

The average number of days from planting to maturity for Linderin, Clark, Wabash and Perry was 143, 165, 170 and 174 days, respectively. Though Perry produced flowers six days earlier than Wabash, its date of maturity was delayed on the average by four days.

Weight of 1000 Seeds

The size of the soybean seeds was not affected greatly by the

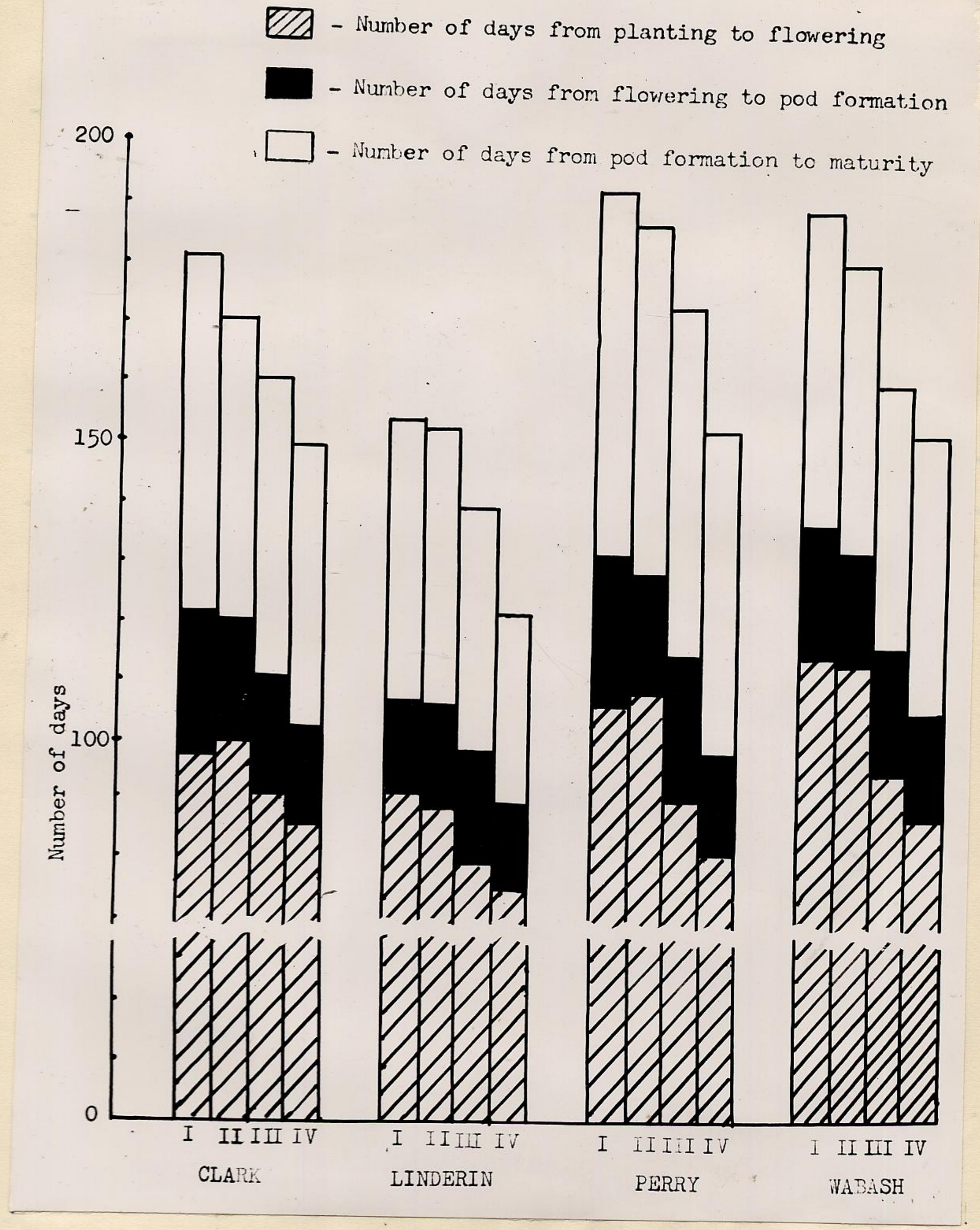

Figure 1. Days from planting to flowering, to pod formation and to maturity of soybean varieties sown at four dates in 1964. (I, II, III and IV - April 4, April 18, May 3 and May 18 planting dates, respectively).

Table 7. Average weight in grams of 1000 kernels of soybeans as affected by date of planting and variety in 1964.

Variety	Date of planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	137.9	145.4	140.5	137.9	140.4
Linderin	140.6	138.3	147.3	146.1	143.1
Perry	133.3	153.0	151.3	146.8	146.1
Wabash	123.8	138.3	127.3	139.8	132.2
Date Mean	133.8	143.7	141.6	142.6	

	L.S.D. (5%)	L.S.D. (1%)
Varieties	7.6	10.2

Means

Varieties	Wabash	Clark	Linderin	Perry
	132.2	140.4	143.1	146.1 +

+Treatment means underlined by the same line do not differ significantly from each other at 5% level.

various dates of planting studied as noted in Table 7. The smallest seeds were obtained from the crop planted on April 4. This was probably due to the high temperatures occuring during the period of seed formation. The soybean plants obtained from the plantings made after April 4 produced larger seeds. Osler and Cartter (39) did not find any appreciable effect of date of planting on the seed-weight in soybeans.

The 1000 seed weight of Wabash was appreciably lower (132.2 gms.) than was that of any other variety in this study. Perry had the largest seeds with an average weight of 146.1 gms. per 1000 seeds. A similar sequence in seed-weight was obtained by Osler and Woodworth (38) with the varieties Perry, Clark and Wabash grown in Illinois.

Number of Pods per Plant

The highest average number of pods per plant (31.2) was obtained from the soybeans planted on April 18 as shown in Table 8. A possible reason for this may be the effect of high day temperatures occuring during the comparative longer photoperiods at the time of flowering and pod formation. This view coincides with the findings of VanSchaik and Probst (53). On the other hand a possible reason for getting fewer pods per plant from the soybeans planted on May 3 was due to the smaller size of the plants (Tables 2 and 5).

The varieties used in this study varied very little as to the number of pods per plant.

Number of Seeds per Pod

The number of seeds per pod was not influenced significantly by the different dates of planting as shown in Table 9. Significant differences in the number of seeds per pod were found among the

Table 8. Average number of pods per plant of soybeans as affected by date of planting and variety in 1964.

Variety	Date of planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	22.6	32.1	22.4	24.4	25.4
Linderin	26.9	37.1	22.9	24.8	27.9
Perry	26.4	28.6	21.3	23.8	25.0
Wabash	28.8	26.9	23.0	25.4	26.0
Date Mean	26.2	31.2	22.4	24.6	

	L.S.D. (5%)	L.S.D. (1%)
Dates	4.5	6.4

Means

Dates	May 3	May 18	April 4	April 18
	22.4	24.6	26.2 +	31.2

+Treatment means underlined by the same line do not differ significantly by each other at 5% level.

Table 9. Average seeds per pod of soybean as affected by dates of planting and variety in 1964.

Variety	Date of planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	2.53	2.64	2.54	2.41	2.53
Linderin	2.39	2.35	2.35	2.48	2.39
Perry	2.19	2.28	2.30	2.26	2.26
Wabash	2.43	2.48	2.53	2.43	2.47
Date Mean	2.38	2.44	2.43	2.39	

	L.S.D. (5%)	L.S.D. (1%)
Varieties	0.09	0.13

Means

Varieties	Perry	Linderin	Wabash	Clark
	2.26	2.39	2.47	2.53 +

+Treatment means underlined by the same line do not differ significantly from each other at 5% level.

varieties. Clark and Wabash produced the highest number of seeds per pod, 2.53 and 2.47, respectively. Perry produced the lowest number of seeds per pod, 2.26.

Lodging of Plants

Lodged plants were observed in the field where the soil fertility was at a higher level. The May 18 plantings showed a greater number of lodged plants than the other dates of plantings used in this study.

Among the varieties studied, Linderin as well as Clark were comparatively resistant to lodging. Perry was intermediate in lodging behaviour and Wabash was found to be susceptible to lodging. It was observed that most of the lodged plants did tend to become erect at the time of maturity when the leaves were shed from the plant.

Cumulative Daily Temperatures

The cumulative daily temperatures (^{o}C) for the period from planting to maturity for the soybean varieties were calculated and are reported in Table 20. The total cumulative temperatures involving the four dates of planting varied from 3287 ^{o}C for April 18 to 3040 ^{o}C for the May 18 plantings. Soybean plants, from the plantings made in April which were subjected to higher cumulative temperatures, required more days to flower and to mature than the plants grown from the May plantings that received less cumulative temperatures (Table 6 and Figure 1). The early maturing variety, Linderin (Figure 1) received less total cumulative temperatures (2807 ^{o}C) than the three later maturing varieties (3222 ^{o}C to 3382 ^{o}C).

SUMMARY AND CONCLUSIONS

The experiment was conducted in 1964 at the Agricultural Research and Education Center, Beqa'a plain, to evaluate the effect of four dates of planting and four varieties on the yield, protein and oil content, and other agronomic characters. Four dates of planting, April 4 and 18, May 3 and 18 and the four varieties, Clark, Linderin, Perry and Wabash, were employed in this experiment.

The various dates of planting influenced the yield only slightly, with the April 18 plantings producing the larger amount of seed per dunum. The seed yield of Linderin and Clark were significantly higher than that of Perry and Wabash.

The total dry weight of the plant and the plant height were not influenced significantly by the different dates of planting, but a gradual decrease in the dry weight and plant height was observed as the planting dates were delayed until May 3. The plant height as well as the total dry weight of the soybean plants increased again on the last date of planting on May 18. Significant differences in dry weight and plant height were observed among the varieties. The greatest total dry weight was obtained with the variety Clark, while Wabash was found to have the tallest plants. Linderin was the shortest variety and produced the least total dry weight.

The 1000 seed-weight and the number of seeds per pod were not influenced greatly by the various dates of plantings used. The variety Perry produced the largest seeds while the average seed size of Wabash was the smallest. The greatest number of seeds per pod was obtained from

Clark, while Perry gave the smallest number of seeds per pod.

The four varieties used in this study did not differ much in the number of pods per plant. The greatest number of pods per plant was obtained from the soybeans planted on April 18.

A gradual decrease was found in the number of days required from planting to flowering as well as to maturity of soybeans planted from April 4 to May 18. On an average the number of days from planting to flowering and to maturity was reduced by 20 and 33 days, respectively, during the 45 days delay in planting. The time required for flowering and maturity was more in the varieties Perry and Wabash than in Clark and Linderin. Wabash required the maximum time to produce flowers but it matured earlier than Perry. Linderin was the earliest both in date of flowering and in maturity.

Protein and oil content of the soybean seeds were influenced only slightly by the various dates of planting studied. The varieties differed significantly in both oil and protein content. Linderin had the highest protein percentage of 34.2 and Wabash contained the lowest with 32.2 percent. The seeds of Wabash contained 22.6 percent of oil while the other varieties contained 23.4 percent oil.

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APPENDIX

Table 10. Analysis of variance for seed yield of soybeans.

Source	D.F.	M.S.	F
Dates of planting	3	1427.22	0.72
Replications	3	1970.35	0.99
Error (a)	9	1993.33	
Varieties	3	25978.98	32.35++
Varieties x Dates	9	639.74	0.80
Error (b)	36	803.04	

Table 11. Analysis of variance for dry weight of soybeans.

Source	D.F.	M.S.	F
Dates of planting	3	11222.23	0.95
Replications	3	8069.92	0.68
Error (a)	9	11787.30	
Varieties	3	90220.44	23.69++
Varieties x Dates	9	2563.81	0.67
Error (b)	36	3808.53	

++ Denotes F value significant at the 1% level.

Table 12. Analysis of variance for protein percentage in seeds of soybeans.

Source	D.F.	M.S.	F
Dates of planting	3	2.35	1.14
Replications	3	26.51	12.81++
Error (a)	9	2.07	
Varieties	3	9.62	5.29++
Varieties x dates	9	1.35	0.74
Error (b)	36	1.82	

Table 13. Analysis of variance for oil percentage in seeds of soybeans.

Source	D.F.	M.S.	F
Dates of planting	3	1.66	2.99
Replications	3	1.17	2.10
Error (a)	9	0.56	
Varieties	3	2.56	7.46++
Varieties x dates	9	0.45	1.31
Error (b)	36	0.34	

++ Denotes F value significant at the 1% level.

Table 14. Analysis of variance for plant height in soybeans.

Source	D.F.	M.S.	F
Dates of planting	3	505.82	0.78
Replications	3	1382.61	2.12
Error (a)	9	651.14	
Varieties	3	6801.82	46.04++
Varieties x dates	9	192.69	1.30
Error (b)	36	147.75	

Table 15. Analysis of variance for number of days from planting to flowering of soybeans.

Source	D.F.	M.S.	F
Dates of planting	3	1574.97	122.28++
Replications	3	212.72	16.52++
Error (a)	9	12.88	
Varieties	3	975.43	69.43++
Varieties x dates	9	56.59	4.03++
Error (b)	36	14.05	

++ Denotes F values significant at the 1% level.

Table 16. Analysis of variance for 1000 seed-weight of soybeans.

Source	D.F.	M.S.	F
Dates of planting	3	325.98	0.68
Replications	3	116.06	0.24
Error (a)	9	477.40	
Varieties	3	571.25	5.04++
Varieties x dates	9	126.53	1.12
Error (b)	36	113.44	

Table 17. Analysis of variance for number of pods per plant of soybeans.

Source	D.F.	M.S.	F
Dates of planting	3	221.61	7.10++
Replications	3	221.61	7.10++
Error (a)	9	31.23	
Varieties	3	26.22	1.24
Varieties x dates	9	30.69	1.45
Error (b)	36	21.19	

++ Denotes F values significant at the 1% level.

Table 18. Analysis of variance for number of seeds per pod of soybeans.

Source	D.F.	M.S.	F
Dates of planting	3	0.022	1.10
Replications	3	0.027	1.35
Error (a)	9	0.020	
Varieties	3	0.227	13.59++
Varieties x dates	9	0.020	0.12
Error (b)	36	0.0167	

++ Denotes F value significant at the 1% level.

Table 19. Average monthly temperatures and precipitation at the Agricultural Research and Education Center, Hoch Sneid, Lebanon, from March to October for 1964 and eight years average 1956-63.

Months	Temperature °C		Rainfall (mm)	
	1964	1956-63	1964	1956-63
March	9.1	8.1	52.8	47.6
April	9.6	12.3	13.9	24.4
May	12.8	16.4	23.7	11.6
June	20.5	20.1	0.0	0.7
July	23.1	22.5	0.0	0.0
August	23.2	23.5	0.0	0.0
September	20.2	20.6	0.0	1.1
October	17.8	16.8	0.0	8.0

*Agricultural Research and Educational Center meteorological data, Hoch Sneid, Lebanon by S. Abu Shakra, F. Malouf, H.G. Nasr and H. Amirmokri.

Table 20. Total cumulative temperatures (°C) for the days from planting to maturity for four varieties of soybeans in 1964*.

Variety	Date of planting				Variety Mean
	April 4	April 18	May 3	May 18	
Clark	3317	3257	3187	3128	3222
Linderin	2768	2921	2820	2718	2807
Perry	3492	3542	3328	3168	3382
Wabash	3377	3429	3187	3168	3290
Date mean	3238	3287	3130	3046	

*Calculated from the Agricultural Research and Education Center meteorological data, Hoch Sneid, Lebanon, by F. Malouf, H.G. Nasr and H. Amirmokri.