FACTORS INFLUENCING THE YIELD AND QUALITY OF SOYBEAN HAY

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Ernest L. McPherron
1938

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THESIS

RESPECTFULLY SUBMITTED

IN PARTIAL FULFILLMENT

OF THE REQUIREMENT FOR THE

DEGREE OF MASTER OF SCIENCE

AT

MICHIGAN STATE COLLEGE

OF

AGRICULTURE AND APPLIED SCIENCE

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Farm Crops Department

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INTRODUCTION

Soybeans, because of their high yield and feeding value, are considered an important emergency hay crop in the lower peninsula of Michigan. Additional recent interest has developed in the culture of this crop because of advances in the industrial uses of the soybean in plastics, oils, glues, etc.

According to the United States Department of Agriculture, the acreage of soybeans in Michigan has increased during the past ten years from 7,000 acres in 1927 to 44,000 acres in 1937. In March, the indicated acreage of soybeans in Michigan for 1938 was 42,000 acres. It has been estimated that about two-thirds of the total soybean acreage is cut for hay and one-third cut for grain.

It is the object of this problem to study the influence of leafiness, color, size of stem, percent of protein and proportion of leaves, pods and stems in the total crop upon the yield and quality of soybean hay, under Michigan conditions. Field studies were made of varieties, stage of maturity at harvest time, rate of planting and depth of planting.

REVIEW OF LITERATURE

There are several publications dealing with the production and utilization of soybeans. Literature dealing with soybean hay many times includes work in combination with feeding trials. The best time for cutting is largely influenced by the purpose for which the crop is intended.

Maximum yields of dry matter are reported, by Stemple (13), Thatcher (15), Willard (17) and others, to occur when the hay was harvested after the pods were well filled and the lower leaves were beginning to yellow but had not fallen. The maximum yield of green material may occur before the highest yield of dry matter is produced. In some years it was observed that the highest air dry yields were obtained when the seeds started to ripen.

Uhland (16) reports an average of four years work with the variety Virginia in which he obtained maximum hay yields when the pods were well formed and about one-third to one-half filled. At this stage of plant growth, there was a minimum of woody stems and a maximum of protein in the hay as leaves. He also, found that this time of maximum yield was best for the most uniform distribution of protein through the hay and for the greatest protein yield.

Thatcher's (15) work showed a steady decrease of leaves and an increase of woody stems as maturity was approached. Willard (17) reported that hay was 60 percent leaves when beans were well formed and 50 percent leaves when beans appeared half grown. His data further showed that weight of stems remained fairly constant after beans were well formed but the percent of stems increased rapidly as one-half or more of the leaves fell. The weight of beans increased sharply with a decrease in leaves giving about 40 percent of the mature crop as seed.

Averaging three years' results, Hilton, Wilber and Epple (5) found that soybean hay cut when the pods were completely formed, the beans practically fully developed in the pods, and the lower leaves turning yellow, was superior for both milk and butterfat production to hays cut in an earlier stage of maturity.

Several workers have studied the influence of rate of seeding upon

quality and yield of soybean hay. Nevens (10) found that the yield of hay increased with the increase in rate of seeding per acre. Thickly planted soybeans were found to give less coarse stems and smaller amounts of hay were refused by cattle than when the soybeans were not planted so thickly. Stemple (13) found very little difference between hay yields from either row or solid plantings. The stems were coarser when the beans were planted in rows but less seed was used and cultivation to control weeds could be practiced. Four pecks per acre in solid plantings were considered to be most economical when planted as early as possible but thicker rates gave finer stems. Borst and Thatcher (1) working in Ohio found that rate of planting influenced the growth habit of the plant and a higher yield was secured from the thick rate of planting. The rate of planting apparently did not influence the proportion of stems and leaves or the nitrogen and fiber contents of the plants. They also found in the time of seeding test that planting from April 20 to June 1 did not seriously affect the forage yields of Manchu.

Nelson and McClelland (9) report a lack of marked variation in results secured from rates of planting of 7 to 63 pounds per acre in 3-foot rows. There was a slight indication of higher germination and larger seed being produced in the thinner rates of planting.

Little has been written dealing with depth of planting soybeans. Stitt (14) reports that satisfactory stands were secured from plantings as deep as four inches in fine sandy loam and two inches in clay soil, although reduced stands were obtained from seedings deeper than two inches in loam and one inch in clay; germination was prolonged with increased depth of planting.

The chemical composition of whole soybean plants as well as for separate plant parts has been studied by many workers. Erdman (2) concludes that seed varieties are richer in protein than hay varieties and that in the early

stages of growth of all varieties there is a gradual decrease in the percentage of nitrogen in soybean tops but that during September the percentage of nitrogen begins to increase and usually reaches a maximum at maturity.

Borst and Thatcher (1) report a high percentage of nitrogen in the leaves. This percentage decreased to about half the initial percentage when plants became mature. They also found from analyses that the leaves of soybean hay are rich in calcium and, in the stage of development prior to seed formation, in potassium. In analyzing samples of soybean hay, Thatcher and Park (15) found a decrease in the percentage of protein in the stems and threshed pods as the seeds developed. Also, stems of soybean hay, harvested when the seed is well developed, may contain only four to five percent of crude protein and are relatively high in crude fiber.

Together with other analyses Morrison (7) lists oat straw as containing 4 percent crude protein, 36 percent crude fiber and 44 percent total digestible nutrients, while soybean straw contains 4 percent crude protein, 41 percent crude fiber and 36.5 percent total digestible nutrients. At the Illinois Agriculture Experiment Station, the soybean stems left in mangers during a dairy cattle feeding experiment were found to contain 3 to 5 percent crude protein and 50 percent fiber.

Hayden (4), Hilton, Wilber and Epple (5), Morrison (7) and others report 3 percent to 20 percent of hay as coarse stems refused by livestock, but that was largely influenced by the quality of the hay and the method of feeding.

EXPERIMENTAL PROCEDURE

The field trials were located on an area of Hillsdale sandy loam and Hillsdale loam, to which super phosphate was applied at the rate of 750 pounds per acre and worked into the seed bed.

The soybeans were drilled on June 2, 1937. All plots were 300 feet long and 3 rows wide with 28 inches between rows. The planting order of the plots is shown in Figure 1. These plots were cross cultivated with a rotary hoe upon emergence of the beans and cultivated three times during the season at intervals of ten days, the weeds being pulled from the row following the second cultivation.

Duplicate rod-row samples were taken for forage yields at various intervals from July 26 to the end of the season, one from section A and one from Section B, (Figure 1). Samples were weighed in the field, after which, they were taken to the laboratory and separated into component parts of stems, leaves and pods. These parts were air-dried at 85° and dry weights recorded. The sum of the dry weights of the component parts was used to calculate the air-dry yields of all plots after raising them to a common basis of 14% moisture.

This crop was grown under more rainfall with a little more cloudiness than is average for this section of the state, as may be seen by the weather data given in Table 1.

Table 1. Normal and 1937 precipitation at East Lansing, Michigan.

Month	Jan. to Apr. Inc.	May	June	July	Aug.	Sept.	Jan. to Sept. Inc.	Sunshine % of possible
1937 precipitation	10.47	3.43	6.77	1.64	4.42	1.28	28.11	49
Normal precipitation.	8.65	3.42	3.51	3.10	2.82	2.91	24.41	55

In the date of harvest test of Manchu (check) the samples were first taken when the plants were in blossom and every week thereafter during the growing season regardless of the stage of plant growth. The dates of harvest and plant conditions are given in Table 2, and the degree of bean

Fig. 1 Order of planting soybeans 3-row plots. Drawn to scale 3/16" to 7'.

North	Section A	Section B
Check		
30# Virginia		
Check		
30# Cayuga		
Check		
30# Deep		
30# Medium depth		
Check		
30# Shallow depth		
90# per acre		
Check		
60# per acre		
45# per acre		
Check		
30# per acre		
15# per acre		
Check		

South

development is shown in Plate 1.

Table 2. Showing stage of growth of plants at different dates of harvesting

Date of Harvest	August 14	August 20	August 27	September 3
Plant Condition	Majority of plants in blossom and few pods beginning to form.	Plants were from blossom to pods one-half inch in length.	Blossoms all fallen and pods formed up to two inches in length.	Pods completely formed and contained small beans.
Date of Harvest	**September 10**	**September 17**	**September 24**	**October 1**
Plant Condition	Pods were considered to be about one-half filled.	Beans well formed, lower leaves started to Yellow.	About one-third to one-half of the leaves yellowed and falling. Some frost damage.	Most leaves had fallen but pods were still green.

In the comparison of early (Cayuga), medium (Manchu) and late (Virginia) varieties of soybeans for hay, samples were taken of all three types when any one of the types was in blossom, had beans one-third to one-half formed, had lower one-third of leaves yellowed and falling, and was fully ripe. The dates are given in Table 3.

Table 3. Showing the stages of growth for the various dates of harvesting the early, medium and late varieties.

Date of harvest	July 26	July 31	August 14	August 20
Condition of plant.	Early variety in blossom. No pods started.	Medium variety in blossom. No pods showing.	Pods on early variety were half filled.	Late variety in blossom. No pods developed.
Date of harvest	**August 27**	**September 10**	**September 16**	**September 22**
Condition of plant.	About half the leaves on the early variety had turned yellow. Pods well filled.	Pods on the medium variety were about half filled.	Early variety completely ripe. No leaves on plants.	Half the leaves on medium variety turned yellow. Pods of late variety about one-half filled.

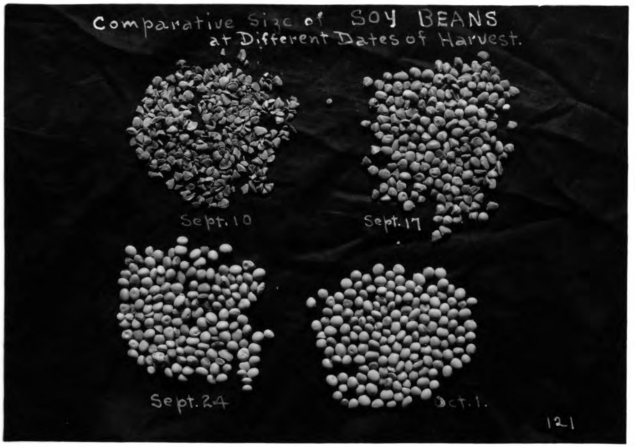


Plate 1. Samples of Manchu soybeans from dates of harvests as indicated above.

The calculated spacing of seeds in the rows for the different rates of planting is shown in Table 4. The check rate was 30 pounds per acre.

Table 4. Calculated distance between plants at different planting rates.

Rates of planting	Distance between plants
15 pounds per acre	4.5 inches
30 " " "	2.25 "
45 " " "	1.5 "
60 " " "	1.125 "
90 " " "	.75 "

Three depths of planting were compared; at the shallow depth the seed was placed on an average of one-half inch, the medium depth two inches, and the deep planting three and one-half inches below the surface of the soil.

Since Manchu was the only variety used in the rate and depth of planting comparisons, the first harvest was made when the majority of plants were in blossom and no plants were showing pods; the second, when the beans in the pods were from one-third to one-half developed and no leaves had started to yellow or fall; the third and final harvest, when about half of the leaves on the lower part of the plant had yellowed and were falling. By this time the plant tops had been subjected to a light frost but little damage was apparent.

Samples were taken of each harvest to represent the different stages of plant growth. After grinding, the samples were analyzed by the Chemistry Section of the Experiment Station for crude fiber, crude protein, ether extract and ash.

EXPERIMENTAL RESULTS

Time of Cutting.

The use for which the plant is intended influences the stage of maturity at which a plant should be harvested. Maximum yield of hay is desirable but a leafy hay is also important from a feeding standpoint. The condition of the plant at time of harvest has a marked influence on its nutritional

value as well as its palatability.

The trends of total yield and the yield of plant parts for weekly harvests are shown in Figure 2 and the tabulated results are given in Table 5. There was a steady increase in total yield up to September 17 as shown in Figure 2, at which time the pods on the plants were well filled. The maximum yield of leaves occurred at this stage of harvest but the yield of pods continued on an upward trend, reaching the highest point in yield when the plants became nearly mature. Soon after September 17 the fall of leaves became accentuated and there was a rapid decrease in yield until all leaves had fallen. After the pods started growth, the amount of stems did not fluctuate markedly during the remainder of the season. No explanation is available concerning the drop in yield of the stems in the next to the last harvest.

There was a steady gradual decrease in the percentage of leaves in the total crop, until near the end of the growing season when the percentage of leaves dropped rapidly due to the leaves falling from the plants in large numbers. There was a slight decrease in the percentage of stems to total plant yields up to the time the leaves began to fall rapidly, and then the percentage of stems increased to a maximum at the time when all the leaves had fallen. The decreases in leaf and stem percentages were counterbalanced by the increasing growth of pods up to maturity. On September 17 when the pods were filled and a few lower leaves were yellowing, the crop consisted of 47 percent of leaves, 29 percent of pods and 24 percent of stems, while two weeks later when the plants were near maturity the crop consisted of 3 percent of leaves, 54 percent of pods and 43 percent of stems.

The maximum yield of leafy hay with a high protein yield may be obtained when the crop is harvested between the stages of pods half filled and lower leaves beginning to turn yellow. Delayed harvest brings increased yields

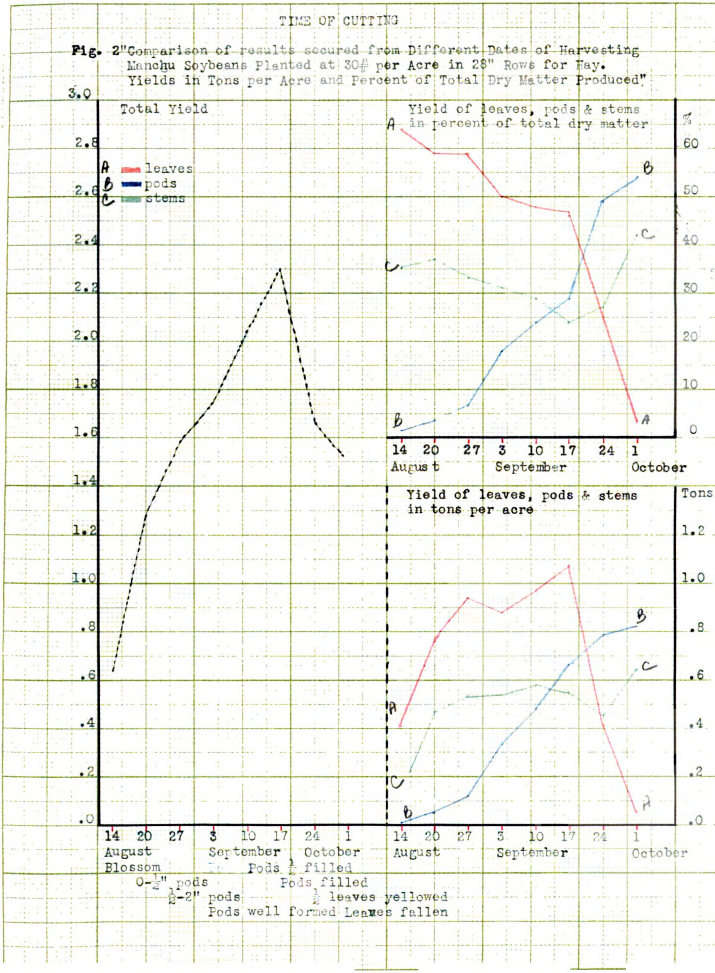


Fig. 2 "Comparison of results secured from Different Dates of Harvesting Manchu Soybeans Planted at 30# per Acre in 28" Rows for Hay. Yields in Tons per Acre and Percent of Total Dry Matter Produced"

Table 5. Yield of hay from cuttings at different stages of maturity and the yields of the component plant parts (14% moisture).

Harvested	Total	Leaves		Pods		Stems	
	Tons per acre	Tons per acre	% of total yield	Tons per acre	% of total yield	Tons per acre	% of total yield
Aug. 14 blossoming few pods showing.	0.64	0.41	64	0.01	1	0.22	35
Aug. 20 pods forming	1.28	0.76	59	0.05	4	0.47	37
Aug. 27 pods formed	1.59	0.94	60	0.12	7	0.53	33
Sept. 3 beans forming	1.76	0.88	50	0.33	19	0.54	31
Sept. 10 beans 1/2 formed.	2.04	0.98	48	0.48	24	0.58	28
Sept. 17 lower leaves yellowing	2.30	1.07	47	0.67	29	0.56	24
Sept. 24 1/3-1/2 leaves fallen.	1.66	0.41	25	0.80	48	0.45	27
Oct. 1 most of leaves fallen.	1.52	0.05	3	0.82	54	0.64	43

up to a certain point but when the lower leaves start to turn yellow and fall, feeding value is lost by waiting for further bean development.

Comparison of Early, Medium and Late Varieties

Because of the many varieties which are adapted to different growing conditions, the soybean crop may be grown over a wide range of climatic conditions. The varieties may be separated roughly into early, medium and late maturing types. An early maturing or short season type will not respond the same as a later maturing or long season type would under the same conditions. Representatives of these three types were harvested at several different stages of growth (Table 3) and the total yield and yields of the components, leaves, pods and stems, are given in Table 6, and Figure 3.

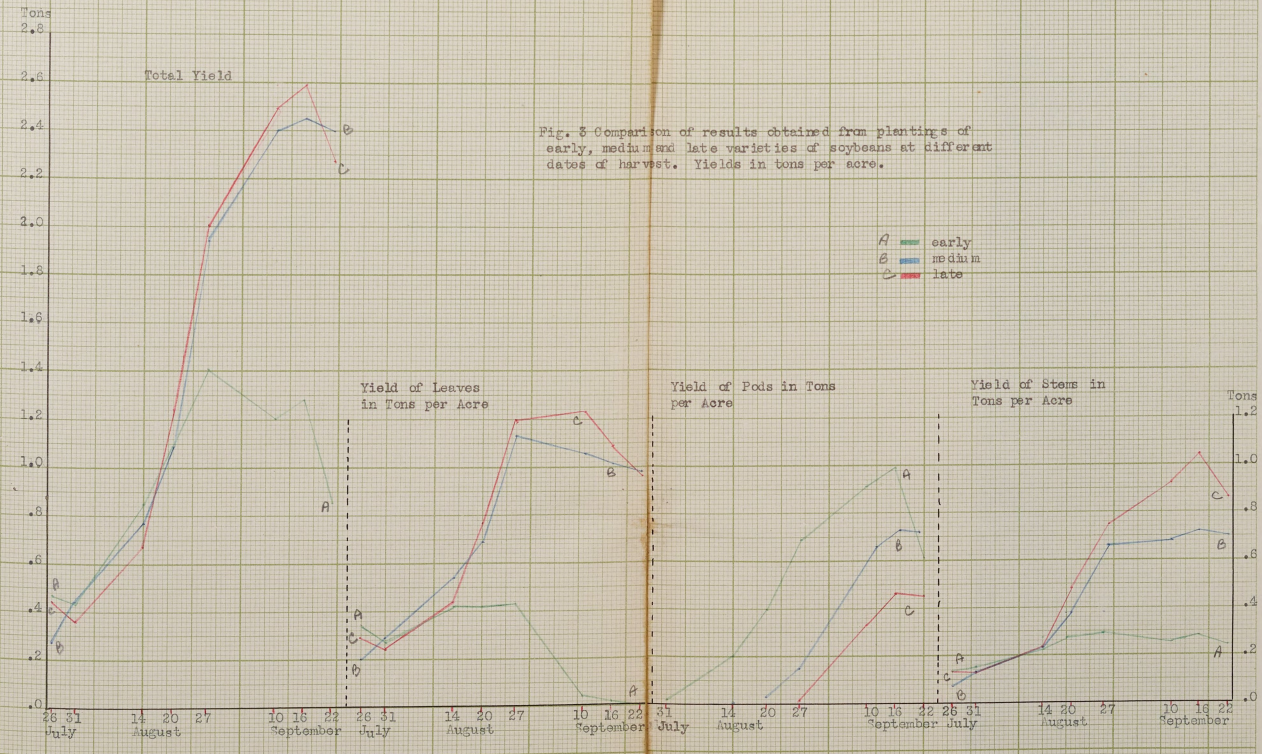


Fig. 3 Comparison of results obtained from plantings of early, medium and late varieties of soybeans at different dates of harvest. Yields in tons per acre.

A — early
B — medium
C — late

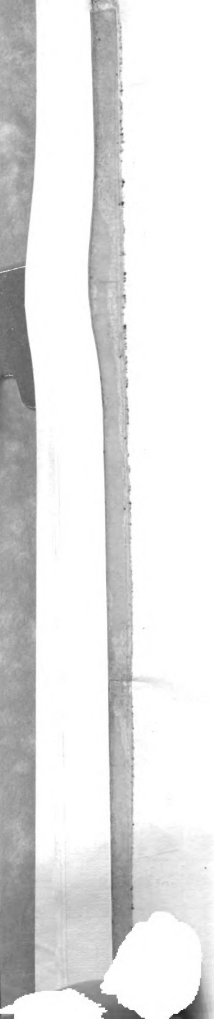


Table 6. Yield of hay from cuttings at different stages of maturity to compare early, medium and late varieties and the yield of the component parts (14 percent moisture).

Harvested	Variety	Total Yield	Leaves		Pods		Stems	
		Tons per acre	Tons per acre	% of Total yield	Tons per acre	% of total yield	Tons per acre	% of total yield
July 26	Early	0.47	0.34	73	0.00	0	0.13	27
Early variety	Medium	0.27	0.20	74	0.00	0	0.07	26
blossoming	Late	0.42	0.29	68	0.00	0	0.13	32
July 31	Early	0.43	0.27	63	0.01	2	0.15	35
Medium variety	Medium	0.43	0.29	69	0.00	0	0.13	31
blossoming	Late	0.37	0.24	65	0.00	0	0.13	35
August 14	Early	0.85	0.42	50	0.20	24	0.22	26
Early variety	Medium	0.77	0.54	69	0.00	0	0.23	31
podded	Late	0.67	0.44	65	0.00	0	0.23	35
August 20	Early	1.09	0.42	39	0.40	37	0.27	24
Late variety	Medium	1.09	0.67	63	0.03	3	0.38	34
blossoming	Late	1.24	0.77	62	0.00	0	0.47	38
August 27	Early	1.41	0.43	30	0.69	49	0.30	21
Early variety	Medium	1.95	1.13	58	0.15	8	0.66	34
yellowed	Late	2.00	1.20	60	0.01	1	0.79	39
September 10	Early	1.20	0.04	3	0.91	76	0.25	21
Medium variety	Medium	2.40	1.06	44	0.66	28	0.68	28
podded	Late	2.49	1.23	50	0.33	13	0.93	37
September 16	Early	1.28	0.01	1	1.52	77	0.28	22
Early variety	Medium	2.45	1.01	41	0.73	30	0.71	29
ripe	Late	2.60	1.09	42	0.46	18	1.04	40
September 22	Early	0.85	0.00	0	0.61	71	0.24	29
Late variety	Medium	2.40	0.98	41	0.72	30	0.69	29
podded	Late	2.27	0.96	42	0.45	20	0.86	38

The early, medium and late varieties required 84, 101 and 113 days respectively from the time of planting to reach as near as possible a comparative stage of pods half filled. At the final date of cutting, the pods of the Virginia were not as mature as were those of the Manchu variety at the stage of pods half filled. The late variety Virginia had only 32 days from the time it blossomed to reach a stage of maturity to compare with the stage of pods half filled for the early and medium varieties. The periods between blossom date and pods half filled were 19, and 41 days

respectively, for the early and medium varieties. This indicates that the early variety Cayuga matured very rapidly regardless of conditions and therefore did not fully utilize the growing season to which it was subjected at this station. In contrast to this, the medium and late varieties grew very rapidly throughout most of the season reaching their maximum hay yields near the end of the season. Although Manchu had more days between blossom and hay cutting stage (pods half filled) than Cayuga, it more fully utilized the growing season and at the same time matured seed.

The growth of the stems, as shown in Figure 3, shows the comparative growth through the season for the early, medium and late varieties. The stem growth of the early variety after a gradual increase, leveled off and never reached a very large yield. The medium variety grew most rapidly for a period of about two weeks and then leveled off with a slight decline in yield while the late variety continued to grow to the end of the season.

The late variety, Virginia, grew the full season but barely reached the proper hay cutting stage before frost. Examination of Figure 3 shows the comparative growth of the medium and late varieties. The total yields follow each other very closely throughout the season with a maximum rate of growth between the stages of blossom and pods half filled. When the growth of the separate plant parts was considered for the same period, a very rapid increase in the weight of leaves and stems was noticed which would indicate that a period of very rapid vegetative growth occurred between the stages of blossom and pods half filled. The corresponding growth period for the Cayuga was at least two weeks earlier than the same period for the medium variety. The Cayuga seemed to maintain its growth of leaf and stem during the time of rapid growth for the medium and late varieties, but the

weight of leaves declined rapidly after this growing period.

The early variety, Cayuga, gave its highest total yield, 1.4 tons, when the pods were well filled and the leaves had started to yellow. A similar tonage was produced by the medium and late varieties at an earlier stage of maturity. The maximum yield for the medium variety Manchu was 2.5 tons about a week after the pods were half filled. On this same date the late variety reached its maximum yield of 2.6 tons. At the final harvest all varieties showed a lower yield than their respective previous yields. The decline in hay yields was due to the maturing of the plants and the dropping of the leaves. The green succulent late variety appeared to suffer more frost damage than did the more mature early and medium varieties. Frost injury did not show on the Manchu variety as this variety began to mature and lose leaves previous to the last harvest when frost was becoming a factor.

The yield of leaves and stems of the medium variety tended to drop after August 27, while the late variety continued to grow and increase in stems and leaves. Following the rapid vegetative growth period of the medium variety, the pods began to grow and accounted for the increased total yield even though the yield of leaves and stems dropped slightly. The pods on the plants of the late variety also started growing at this time. The pods on the early variety increased quite gradually throughout the season and reached a yield of a ton per acre of pods which was the maximum pod yield for all varieties. The high yield of pods on all varieties occurred near the end of the growing season and the highest yield of pods for all varieties occurred next to the last harvest.

The percentage yield of the various plant parts for the early, medium and late varieties is shown in Figure 4. The percentage of leaves begins

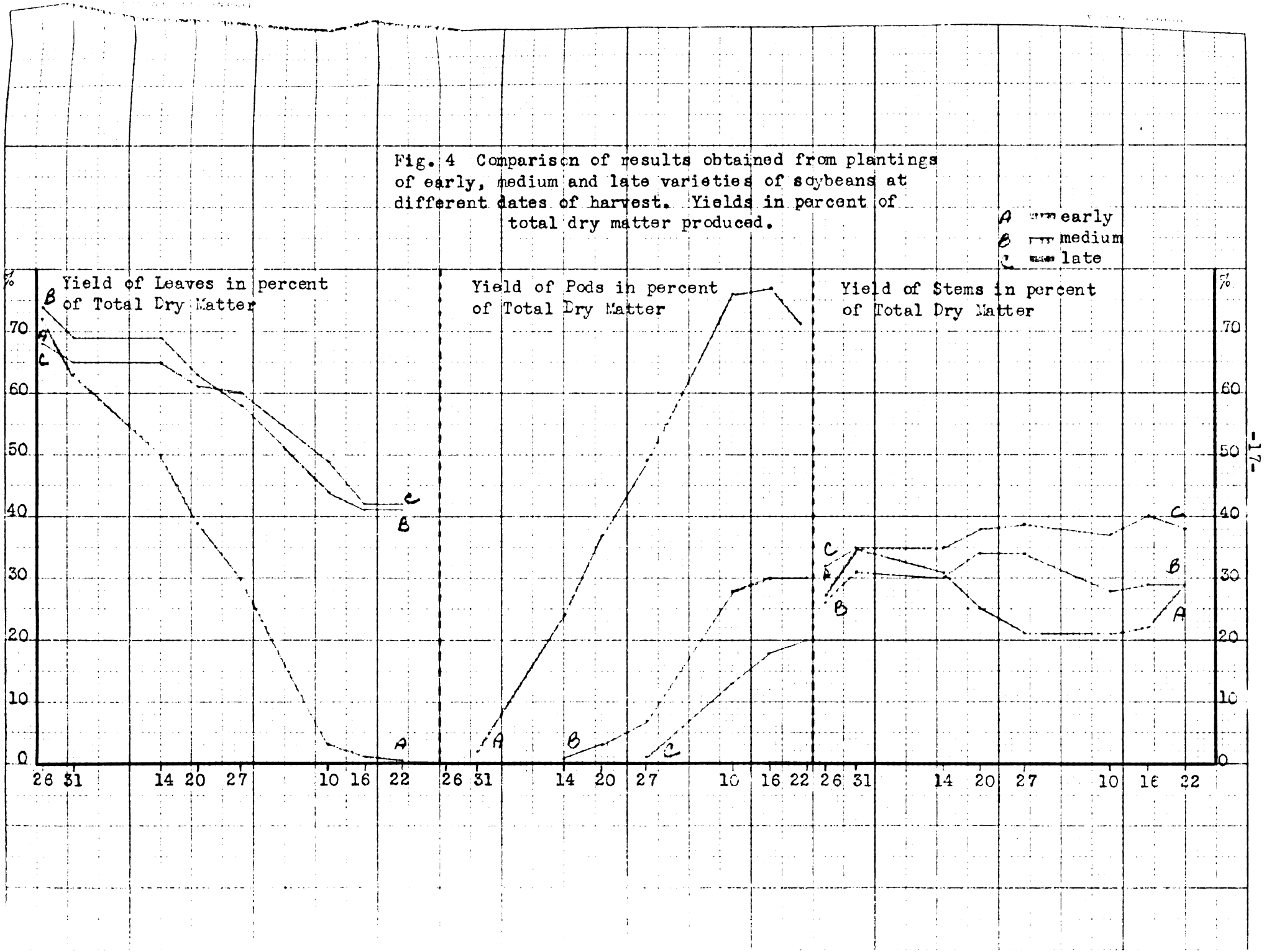


Fig. 4 Comparison of results obtained from plantings of early, medium and late varieties of soybeans at different dates of harvest. Yields in percent of total dry matter produced.

a steady decrease at about the blossom stage which is counterbalanced by an equally steady increase in the percentage of pods. Regardless of the stage of maturity, the percentage of stems does not change as markedly as do the percentages of pods and leaves. It is quite evident that the drop in percentage of leaves is due and is in direct proportion to the increase in percentage of pods. This is especially noticeable in the case of the early variety which matured during the growing season. The leaf percentage fell from 70% to 0% while the pods increased from 0% to 75% over the corresponding period of growth.

Rate of planting

Thick plantings gave finer stems with higher yields but there are limitations to which the rate of planting may be increased economically. Decreasing the rate of planting causes the stems to become increasingly woody and more undesirable from a feeding standpoint. In Table 7 and Figures 5 and 6 are given the results from Manchu soybeans sown at five different rates and harvested at three different stages of maturity. Plate 2 gives a view of this portion of the field.

Of the three conditions at harvesting, the highest yields from all rates of planting were obtained when the pods on the plants were half filled. However, a slightly later date of harvest would have given a higher yield of dry matter as may be seen when the data on time of cutting are compared with the data from the rate of planting series.

In the final harvest, as maturity was approached, the lowest yield was from the thin (15 pound) rate of planting but the largest proportion of this cutting was in the form of leaves. The results in Table 7 show that the higher yields of stems were from the high rates of planting. These rates gave a high percentage of the total crop in the form of stems, while the low yield

Table 7. Yield of hay from cuttings of different stages of maturity of five rates of plantings and the yield of the component parts; all containing 14 percent moisture (Manchu variety).

Harvested	Rate	Total Yield	Leaves		Pods		Stems	
	lbs. per acre	Tons per acre	Tons per acre	% of total yield	Tons per acre	% of total yield	Tons per acre	% of total yield
August 5* blossoming	30#	0.38	0.26	67	0.00	00	0.13	33
	45#	0.39	0.26	66	0.00	00	0.14	34
	60#	0.56	0.39	70	0.00	00	0.17	30
	90#	0.65	0.40	61	0.00	00	0.25	39
September 7 pods half filled	15#	2.11	1.02	48	0.43	25	0.57	27
	30#	2.13	1.00	47	0.50	23	0.64	30
	45#	2.34	1.14	49	0.55	24	0.65	27
	60#	2.15	1.05	49	0.46	21	0.64	30
	90#	2.64	1.27	48	0.54	21	0.83	31
September 22 1/3 to 1/2 leaves yellowed and fallen	15#	1.37	0.50	37	0.59	43	0.28	20
	30#	1.87	0.56	30	0.80	43	0.50	27
	45#	2.08	0.51	25	0.87	42	0.70	34
	60#	2.08	0.65	31	0.84	40	0.59	29
	90#	1.99	0.53	27	0.84	42	0.62	31

* No sample taken at this stage of maturity for 15# rate.

from the 15-pound rate was made up of coarser stems.

The 90-pound seeding rate gave the highest total yield when the pods were half filled. The higher yields of leaves and stems were from the 90-pound seeding, but the percentage of stems and leaves was not markedly changed from those of the lighter rates. The yield of pods was very much the same for all rates of planting, at this date of harvest, but the percentage of pods was compared to total dry matter became lower with the increased rate of planting.

Much finer stems were produced with the 90-pound rate than with the 15-pound rate while the 30-pound, 45-pound and 60-pound rates were not outstandingly different from each other. The increased rates of planting gave proportionately finer stems when compared with the thin planting of

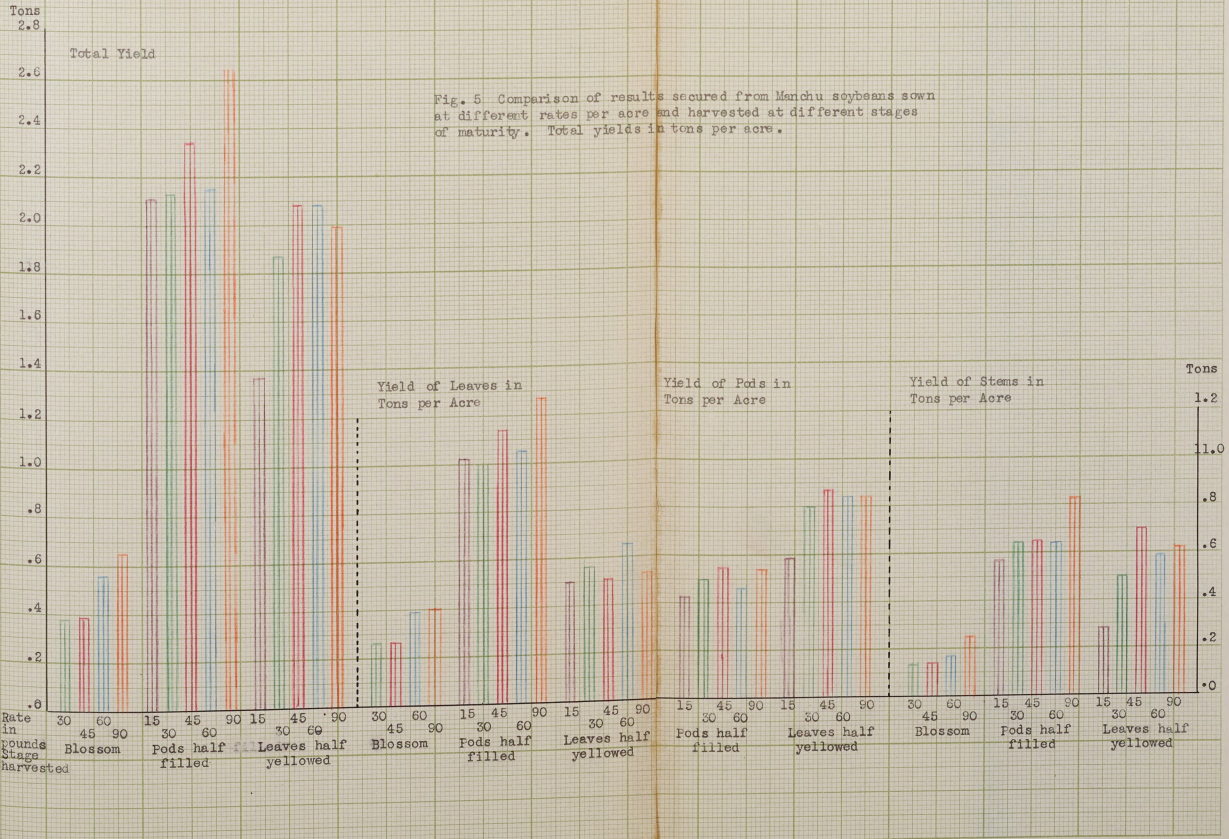


Fig. 5 Comparison of results secured from Manchu soybeans sown at different rates per acre and harvested at different stages of maturity. Total yields in tons per acre.

Figure 6 Comparison of results secured from Manchu soybeans sown at different rates per acre and harvested at different stages of maturity. Yields in percent of total dry matter produced.

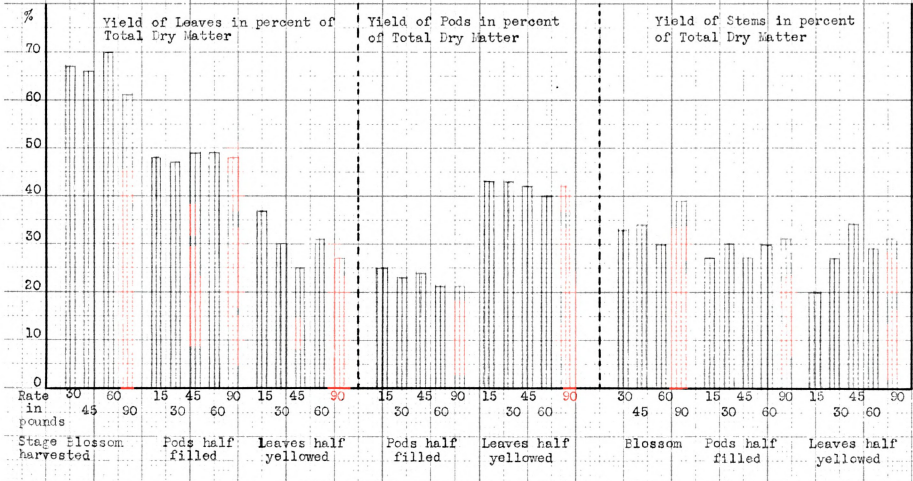


Plate 2. July 19. Manchu plants. (7-weeks old).

30-pound rate (check) in the immediate foreground with 15-pound rate and increasing rates to the right.

15 pounds per acre. Individual plants, or plants bordering vacancies in the row, produced larger stems and formed spreading branches nearer the ground than did those plants growing in close competition with each other.

A rate of planting which gives an even stand without blank spaces in the row is most desirable. For the medium-sized soybean seed this would probably be at least 30 pounds per acre. Rates for smaller seed might be lower while for the larger seeded varieties the rate should be increased accordingly. There is not an exact rate of planting for all conditions as the size of seed will vary but excessive amounts of seed are not warranted by the increased yield secured over the yields which may be obtained from an even stand over the field.

Depth of planting

Since the soybean must push the cotyledons up through the soil, it is possible to plant the seed too deep. If planted too shallow, a lack of moisture may cause a very poor stand.

As may be seen in Figures 7 and 8 or Table 8 there appears to be no consistant variation in the yields from the depths of planting when any one date of harvest is considered. The shallow planting is shown in plate 3. When cut at the blossoming stage, the harvest of the shallow planting gave the lowest yield which was mostly due to less leaves. This gave a higher percentage of stems than was received from the other depths. In the intermediate harvest, the highest yield was from the shallow planting, although the percentage composition of the shallow and medium depth plantings were similar. The yield from the deep planting showed the same amount of leaves, but there were more pods and less stems than were harvested from the other depths of planting. The highest yield in the late cutting was from the

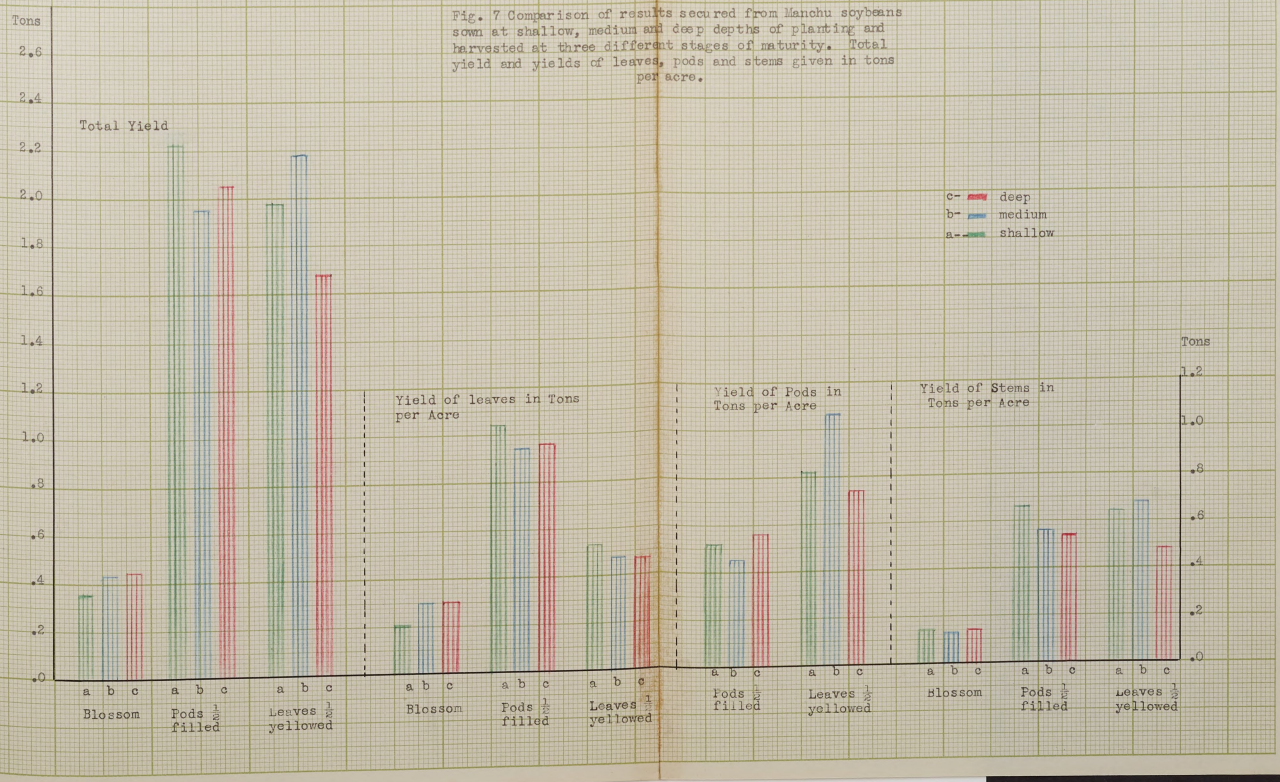
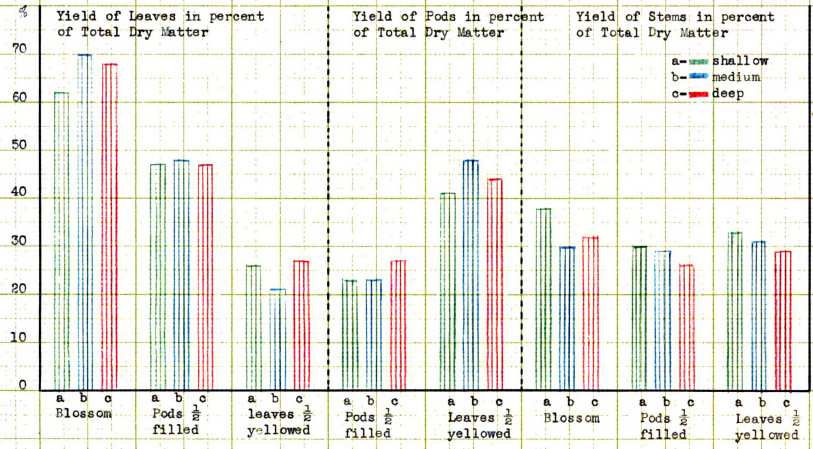


Fig. 7 Comparison of results secured from Manchu soybeans sown at shallow, medium and deep depths of planting and harvested at three different stages of maturity. Total yield and yields of leaves, pods and stems given in tons per acre.

Fig. 8 Comparison of results secured from Manchu soybeans sown at shallow, medium and deep depths of planting and harvested at three different stages of maturity. Yields in percent of total dry matter produced.



medium depth of planting but the yield was composed of less leaves and more pods and stems when compared with shallow and deep planting. The harvests from deep plantings at the intermediate and late stages gave fewer stems in both cases for their respective harvests than did the other depths of planting.

Table 8. Yield of hay from cuttings at different stages of maturity from three depths of planting and the yields of the component plant parts; all containing 14 percent moisture. (Manchu variety).

Harvested	Depth	Total Yield	Leaves		Pods		Stems	
		Tons per acre	Tons per acre	% of total yield	Tons per acre	% of total yield	Tons per acre	% of total yield
August 5 blossoming	Shallow	0.35	0.22	62	0.00	00	0.13	38
	Medium	0.42	0.29	70	0.00	00	0.13	30
	Deep	0.45	0.30	68	0.00	00	0.14	32
September 5 podded half filled	Shallow	2.22	1.05	47	0.51	23	0.66	30
	Medium	1.95	0.94	48	0.46	23	0.56	29
	Deep	2.06	0.96	47	0.60	27	0.54	26
September 24 one-half yellowed	Shallow	1.98	0.52	26	0.82	41	0.64	33
	Medium	2.19	0.46	21	1.06	48	0.67	31
	Deep	1.68	0.47	27	0.74	44	0.48	29

Deep planting did not seriously effect the germination of the seed. The deep planted plots might be considered a day later in emerging than either the medium or shallow planting in the conditions of this test. There was plenty of moisture at the time of planting and immediately after which gave the shallow planting every opportunity to germinate. The sandy type of soil with a moist surface did not hinder the beans in coming up, so that under the prevailing conditions the depth of planting had no direct influence. Deep planting in heavy soils of heavy texture should be avoided because the seed may rot before emergence. Shallow planting in light soils should not be practiced where moisture is a limiting factor. The best depth within limits is to put the seed in moist soil of a firm seed bed. Excessive depths to enable one to place the seed in moist soil is not advised but this depends somewhat on the soil texture.

Plate 3. July 19. Manchu Plants. (7 weeks old).

Shallow depth plot in middle, 90-pound rate to the right and check plot to the left.

CHEMICAL COMPOSITION

Time of Cutting

Whole plants were ground and samples analyzed for crude protein, crude fiber, ether extract and ash. The different stages of harvest and the analyses are given in Table 9. These analyses indicate a lowering of the protein percentage from the blossom stage to the time when the pods were about half filled after which time there was an increase as the beans became more mature and made up a larger percentage of the plant yield. There was

Table 9. Chemical analysis of samples from time of cutting test.

Date of harvest	Protein %	Ash %	Ether Extract %	Crude Fiber %
August 14 pods showing	12.88*	8.74	1.78	31.69
August 20 pods formed	13.72	8.95	2.45	30.54
August 27 pods well formed	14.41	8.75	1.89	29.36
September 3 beans forming	12.21	7.83	3.09	28.55
September 10 pods half filled	11.50	7.54	4.28	25.82
September 17 lower leaves yellow	13.40	7.07	5.39	25.52
September 24 half leaves fallen	14.19	6.70	6.81	27.33
October 1 most all leaves fallen	14.78	6.04	8.04	27.81

*This percentage appears too low in comparison with other analyses for plants of the same age. This sample was moldy.

a rather steady decrease in percentage of ash as maturity was approached. Contrasting this is a rather decided increase in the ether extract accompanying the increase in seed formation, particularly at the end of the growing season for the Manchu variety.

The harvest on September 17 when the pods were about half filled gave the highest yield of protein per acre and the highest yield of leaves although the percent of protein in the crop was higher when the plants were in a more mature condition. The date of maximum protein yield also showed a minimum of about 25 percent crude fiber in the crop when compared with other dates of harvest.

The analyses of the checks cut at three different stages of maturity showed about the same trends as the analyses from the time of cutting tests. The averages of the checks shown in Table 10 gave the highest percentage of protein, ash and crude fiber when the plants were in blossom stage. The protein percentage dropped during the season but increased slightly at the end of the season when the crop was mature. The percentage of ash became lower with the maturity of the crop, while the ether extract percentage increased throughout the season. The crude fiber of the plant became lower during the seasons growth but increased again at the end of the season although not to the maximum which it reached during the early stages of growth.

Table 10. Chemical composition of the checks from the test.

Date of harvest	Check Number	Protein %	Ash %	Ether Extract %	Crude Fiber %
August 5 blossoming	Average	18.76	12.42	1.57	30.47
September 7 pods half filled	Average	10.38	7.05	2.72	28.50
September 22 leaves mostly fallen	Average	11.84	6.86	6.37	29.29

Early, Medium and Late Varieties

Table 11 shows the chemical composition of early, medium and late varieties when harvested at different dates. These analyses for each

Table 11. Comparison of Chemical Composition of Early, Medium and Late Varieties.

Variety	Date of Harvest	Protein %	Ash %	Ether Extract %	Crude Fiber %
Cayuga Early Variety	July 26 blossoming	20.22	10.58	0.84	27.34
	July 31	18.32	10.05	2.41	28.02
	August 14 pods half filled	16.90	9.06	1.93	26.69
	August 20	15.57	8.18	4.14	28.31
	August 27 half leaves yellowed	10.71	7.34	6.53	26.68
	September 10	17.47	7.05	8.30	23.38
	September 16 ripe	16.82	6.34	8.87	26.78
	September 22	12.22	6.72	5.64	31.49
Manchu Medium Variety	July 26	21.57	10.98	1.40	29.26
	July 31 blossoming no pods	18.13	10.23	1.61	28.84
	August 14	16.35	9.89	1.61	31.60
	August 20	13.04	7.59	1.71	31.28
	September 10 pods half filled	13.58	8.40	4.36	22.13
	September 16	11.25	7.02	3.76	27.40
Virginia Late variety	July 26	20.71	11.39	1.68	29.70
	July 31	19.92	11.60	1.41	30.58
	August 14	13.76	9.23	1.67	32.63
	August 20 blossoming	14.75	7.00	2.11	33.36
	August 27	15.32	8.45	3.14	32.05
	September 10	10.38	6.86	3.49	29.96
	September 22 1/3 - 1/2 podded	11.42	5.84	2.94	29.33

variety show the trends in the percentage composition of protein, ash, ether extract and crude fiber. The early variety Cayuga was the only variety which reached a completely ripe stage during the growing season. The Cayuga blossomed at a much younger age and had a higher protein content at the blossoming stage than either the medium or late season varieties. The late maturing variety was older when it blossomed and showed the lowest protein content of the three varieties at this one stage of maturity.

The percent of protein fell with an increase in the age of the plant until the beans were well formed, then a slight raise followed with an increase in matured beans. The maximum yield of protein for the Cayuga was secured from the ripe plants after the seed had matured. At this stage of growth, there were practically no leaves on the plants. When the ripe plants were allowed to stand in the field, some shattering occurred and a decrease in protein was evident.

The percentage of ash for the Cayuga dropped steadily with an increase in the age of the plants and the percentage of ether extract increased with age, although, the percentage of ether extract dropped when the plants were allowed to stand in the field after ripening. The percentage of crude fiber did not fluctuate markedly but did reach a low of 23 percent when most of the leaves had fallen and pods were nearly ripe as compared with a high of 31 percent after the ripe plants were allowed to stand for two weeks.

The medium and late varieties showed these same trends for the various analyses. The protein content was high in the younger plants and decreased with maturity as shown in Table 11. The late variety Virginia does not mature at this station so the chemical analysis of the matured plants cannot be given. The analysis of the Manchu variety in a nearly mature con-

dition is shown in Table 5. The last harvest of Manchu on October 1 showed an increased percentage of protein over the preceeding analyses. The decreasing ash percentage and increasing ether extract percentage was evident for both medium and late varieties. The Medium variety gave its maximum yield of protein when the pods were half filled and at this same stage the lowest percentage of crude fiber. The late variety gave its maximum yield of protein at the blossom stage and about three weeks before the medium or early varieties reached their maximum protein yields. This relation might be changed if all the varieties grew to maturity but that was not possible under the existing conditions. All varieties had about the same percentage protein and percentage ash when taken at the same age. It should be remembered that the varieties were not at the same stage of maturity nor did they have the same total yield when their ages were identical with the exception of very young plants. The percentage of ether extract was higher in the early variety when compared with plants of the same age from either the medium or late varieties. The late variety appeared to have a higher percent of crude fiber throughout the season than either the early or medium varieties.

Rate of planting

Data for the chemical composition of samples from different rates of planting are given in Table 12. Most of the samples follow the same trends as do those from other treatments. In the early stage of harvest the 30-pound rate showed a higher percentage of protein than the 90-pound rate of planting. In comparing percentage of crude fiber, the 90-pound rate of planting was the highest recorded. This larger percentage of crude fiber

Table 12. Chemical composition of samples from different rates of planting.

Date of harvest	Rate of planting	Protein	Ash	Ether Extract	Crude Fiber
	%	%	%	%	%
August 5	30 pounds per acre.	17.69	10.19	1.31	30.19
	45 pounds	15.49	12.26	2.06	33.51
	60 pounds	13.65	10.15	1.64	33.69
	90 pounds	12.32	9.21	1.41	36.30
September 7	30 pounds	11.60	7.28	2.81	31.07
	45 pounds	10.41	6.93	3.66	29.53
September 22	15 pounds	14.26	6.91	5.81	25.43
	30 pounds	11.60	6.76	3.87	28.39
	45 pounds	13.41	6.22	6.60	26.95

comes with the larger percentage of stems, produced by the thick rate of planting, in the early stages of growth. The higher percentage of leaves in the total yield from the thin rate of planting gave it a high percentage of protein at the blossom stage of harvest. Usually a high percentage of stems and a low percentage of leaves gave a low protein percentage.

SUMMARY

Hay yields.

The purpose of the problem was to study the influence of leafiness, color, size of stem, percent of protein and proportion of leaves, pods and stems in the total crop upon the yield and quality of soybean hay under Michigan conditions.

Samples were taken at various intervals from July 26 until October 1. The early plants were in blossom at the first date and all plants had lost

most of their leaves by the final harvest.

The yields of hay from the Manchu variety, (containing 14½ percent moisture), at different stages of maturity ranged from 0.64 tons per acre at blossom time to a maximum of 2.3 tons when the lower leaves were turning yellow (September 17), which was 108 days from time of planting. Total yields of leaves, pods and stems were also reported for each harvest.

The maximum yield of leaves per acre occurred on the same date as the maximum total yield. Leaves constituted 64 percent of the total yield at the blossom stage and gradually decreased to 47 percent at the stage when the pods were well filled and lower leaves were turning yellow. This stage was followed by a rapid drop of leaves to 0 percent during the remaining two weeks of the season. The percentage of pods gradually increased but the increase was more marked near the end of the season. The total yield of stems did not increase markedly after the pods were well formed while the percentage of stems in the total yield was higher in the younger plants than in plants after the pods were well formed. An increase in the percentage of stems in the total yield was shown at the final date of harvest.

Cayuga, Manchu and Virginia were selected as the representatives of early, medium and late varieties, respectively. The Cayuga plants grew to full maturity. At the final harvest, September 22, about half the leaves on the medium variety plants had turned yellow and the pods on the late variety plants were about half filled.

All varieties made a rapid growth increase in total yield during the two-week period, August 14 to August 27. This was approximately 74 days after the varieties were planted. During the two-week period, the early variety changed from pods half filled to the stage when half the leaves were yellowed, the medium variety developed from the stage of very small pods

to pods less than half filled and the late variety came into blossom about the middle of the period.

Up until and through the very rapid growth period all varieties made yield increases due to the growth of stems and leaves, except the Cayuga variety which made pod growth during this time. Following August 27, pod growth accounted for yield increases in the early and medium varieties, whereas the late variety made gains in leaves, stems and pods. During the entire season the percentage of stems in all varieties remained practically constant. The highest percentage of leaves was obtained at the first harvest which gradually decreased as the plants matured. After blossoming, the percentage of pods compared to total yield increased rapidly.

Manchu soybeans were planted at five different rates per acre in 28 inch rows. The higher rates of planting gave the highest forage yields. The thick 90-pound rate produced taller plants with more stems and leaves than the lower rates at the second harvest date. The thinner rates produced larger stemmed plants of a more bushy type. The percentage composition of the total yield for the plant parts was not influenced to any great extent by the rates of planting.

Manchu soybeans were planted one-half, two, and three and one-half inches deep. An abundant supply of moisture at planting time allowed the shallow planted beans to come up immediately after planting. The different depths of planting apparently did not influence the growth of the soybeans during the season under the conditions of this test.

CHEMICAL ANALYSIS

Samples of the entire plants from the different harvests were taken for grinding and analyzing. The percentages of protein, ash, ether extract and fiber are shown. Regardless of the treatment, in general, the following

were found:

1. Younger plants were high in percentage of protein. This percentage decreased up to the stage where the pods were about half filled and then an increase was shown.
2. Percentage of ash was quite high in young plants and decreased gradually with an increase in the age of the plants.
3. The percentage of ether extract increased as the beans became mature.
4. The percentage of crude fiber did not change markedly over the entire season.

Plants of early, medium and late varieties showed approximately the same percentage of protein and ash when all plants were at the same age. Total yield of protein per acre varied with the percentage of protein in the crop and the total yield of hay. The early variety Cayuga gave its highest percentage of protein at the last harvest while the highest percentage of protein for the medium and late varieties occurred at an earlier date when pods were half filled. Rate of planting showed no influence on the chemical composition of the crop.

CONCLUSIONS

For the maximum yield of leafy palatable hay per acre, soybeans should be cut anytime after the beans are about half formed in the pods and before the lower leaves begin to turn yellow. Maximum total yield of protein, combined with a low percent of crude fiber, was obtained from hay cut at this stage of plant maturity and the hay contained a high percentage of leaves and a low percentage of stems.

A variety which will utilize the growing season to good advantage should be used for hay production. The early variety, Cayuga, matured

before the season at East Lansing was fully utilized and was a low yielder of forage. The medium variety, Manchu, matured, utilized the full season, and produced good yields of forage. The late variety, Virginia, made good forage yields but did not mature at this station. It produced more stems with a viny type of growth than the Manchu and did not stand up as well.

Seeding rates may be varied considerably without materially influencing hay yields. A desirable uniform stand was obtained with a seeding rate of 30 to 45 pounds per acre when medium sized beans were planted in 28-inch rows. Heavy rate of planting gave increased yields but these were not sufficient to pay for the cost of the extra seed. The low rate of seeding produced low yields of forage when compared with thick rates of planting.

Planting soybeans as deep as three and one-half inches in moist sandy soil did not have any damaging effects upon the ensuing crop.

Stage of maturity influenced the chemical composition more than did the variety, rate of planting or depth of planting. Total yields of protein per acre increased until the leaves turned yellow and fell. At this stage, the percentage of protein in the crop was low.

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ACKNOWLEDGEMENT

The author wishes to express his appreciation to Dr. C. R. Megee and other members of the Michigan State Experiment Station for their assistance in gathering data and preparing this manuscript.